



PHOTONICS PUBLIC PRIVATE PARTNERSHIP



Insights into the dynamic photonics market (2019–2022)

European prowess, emerging trends, and the
path towards global photonics advancements

Market Research Study Photonics 2024

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Executive Summary

The market for photonics components and systems worldwide expanded rapidly during 2019–2022 and outpaced global GDP growth significantly:

- ✔ **Global volume of the photonics market:** The global market for photonics components and systems accounted for \$865 billion in 2022.
- ✔ **Global growth of the photonics market:** The market grew at a CAGR (Compound Annual Growth Rate) of 6.8% during the last three years (between 2019 and 2022) (4.3% when taking inflation into account), exceeding global GDP growth.
- ✔ **Forecast global photonics market:** This growth is expected to continue, leading to a global photonics market of \$1.2 trillion in 2027.
- ✔ **The fastest-growing photonics segments worldwide** are *Photonics for Environment, Energy and Lighting, Photonics for Industry 4.0, and Photonics for Agriculture and Food*.
- ✔ *Photonics for Agriculture and Food* is a **strongly growing emerging market, which – at a small level with a segment share of only 1% - demonstrates a high CAGR of 11.8%.**

The European photonics industry experienced significant growth and development between 2019 and 2022:

- ✔ **European photonics industry production volume:** The European photonics industry grew from €103 billion in 2019 to reach €124.6 billion in 2022, comprising more than 5,000 companies and contributing around 3% of Europe's entire manufacturing output. It provided around 1.5% of total manufacturing employment, with a turnover of around €280,000 per employee.
- ✔ **The growth rate of the European photonics industry:** The revenue growth rate of the European photonics industry was 6.5% per year (2019-2022), outpacing the entire European GDP growth (2%/year) even when accounting for inflation.
- ✔ **Forecast growth for the European photonics market:** The European photonics industry is expected to continue growing, amounting to around €175 billion by 2027.
- ✔ **Europe's position in the global photonics market:** From 2019 to 2022, Europe maintained its second position in the global photonics market, with a 15% share, behind China at 32%. Europe is slightly ahead of the US. The European industry grew at the same pace as the global market, but exchange rate differences reduced its market share slightly.
- ✔ **European strengths:** Europe is particularly strong in the following segments: *Photonics for Industry 4.0* (global market share: 38%), *Photonics Instrumentation* (incl. Agro-food and space) (32%), *Photonics for Defence and Security* (24%) and *Photonics for Healthcare* (21%).
- ✔ Since 2019, Europe has become more dominant in Photonics Components, Photonics for Industry 4.0, *Photonics for Healthcare, and Photonics for Defence and Security*.
- ✔ However, over the past decade, China has actively pursued a leading position in the world photonics market, recognising its pivotal role in

strengthening its economic prowess in emerging digital markets and enhancing its defence, security and space capabilities. China's world market share in photonics has skyrocketed from about 10% in 2005, over 26% in 2015, to 32% in 2022, signifying a notable ascent. Notably, China is penetrating sectors traditionally dominated by Europe, such as laser manufacturing, sensing, optical components and systems, showcasing its determination to expand its influence across diverse segments of the industry.

- **Employment growth:** Europe's photonics industry created around 35,000 jobs in the period 2019-2022, representing an annual growth rate of 2.5%. This growth is much higher than the growth of employment in European manufacturing as a whole. By 2022, the photonics industry employed more than 430,000 people.
- **Exports:** The European photonics industry exported around half of its products (in value). When compared with all manufactured products, European photonics industry exports are significantly higher: 51% of production vs. 27%, i.e. almost twice as much.

Research and Innovation capacity of the European Photonics industry:

- **R&D intensity:** Research and Development (R&D) spending in the European photonics industry is significant. The average R&D intensity was 10.5%, more than double the average (4%) in other sectors.
- **R&D intensity (14%)** is particularly high for **European photonics SMEs**.
- **Globally competitive research and innovation:** Although lagging in the two biggest photonic markets (Displays and PV), Europe's share has been maintained, stressing the huge dynamism of other photonics segments in Europe, especially photonic components and materials as well as photonics systems for industry and healthcare. **Thanks to a world-leading research capacity, European companies have maintained and expanded their businesses – capturing shares of this rapidly expanding market.**
- **Widening countries:** Photonics in widening countries are mainly oriented towards capital-intensive applications. Four segments account for 67% of total production: *Mobility, Environment, Lighting & Energy, Consumers & Professionals*. (vs. share of European production: 32%).
- **Innovation ecosystem and related investments:** The European photonics research industry has a strong ecosystem for innovation and startups. However, there is a **notable gap in capital investment in Europe compared to other regions like the US and Asia, indicating a need for greater financial support for European photonics companies. Europe is able to foster innovation at the seed level to create and find photonics startups, similar to the case in Asia or the US. However, scaling-up innovation activities still appears to be a weakness: Europe's companies lack resources to expand further, for example, with factories.**

In summary, the European photonics industry experienced significant growth from 2019 to 2022. This expansion was marked by job creation, revenue growth, and a strong position in the global market. However, the European industry faces challenges such as lower capital investment compared to other regions.

1. Introduction

Market intelligence data is needed to speak with “one voice” about the photonics industry, its achievements and its impact. It also needs to help validate public and private funding activities to public and private investors and citizens as taxpayers. It should also reflect the impact of photonics in securing and enhancing Europe’s economic growth and competitiveness.

The purpose of this report is to provide data on photonics industry segments, components, systems, and product groups while allowing for time series analysis to monitor progress. It will also give a forecast for the end of the Horizon Europe period in 2027. Indeed, an accurate assessment of the photonics industry is crucial for positioning and sustaining the technology and the industry vis-à-vis strategic stakeholders such as value chain partners, public and private investors, governmental and non-governmental representatives, as well as support agencies, associations and citizens.

The economic impact along the value chain and the importance of the photonics industry are difficult to quantify. This is due to the wide range of applications of photonics technologies and the diversity of photonics products and systems in the various application areas and different customer industries.

The photonics industry is a global industry with many large businesses, but most of the companies are SMEs. If you look at the newest photonics technologies available today, photonics is a powerful fuel for the international and European economic growth engine. It has gained increasing importance in the global economy over the last two decades.

This report aims to provide an in-depth quantitative assessment of the size of the global and European photonics industry based on sound methodologies and recognised data sources. The methods employed aim to extract the contribution made by photonics from scattered (and sometimes hidden) industry data. The many different applications of photonics in industry and the different sectors affected by these technologies are also analysed in detail.

1.1 Definitions

What is Photonics?

Photonics is the science of harnessing light for the benefit of humankind. It encompasses the sciences and technologies that generate, emit, detect, collect, transmit, modulate and amplify photon beams from the terahertz band (from 300 gigahertz or 1000 μm) to gamma and X-rays. By this definition, optics and optoelectronics are part of photonics.

Behind this definition lies a wide range of applications. The extent to which photonic technologies fulfil basic needs in everyday life and are used in almost all sectors of industry is often unclear. This report describes and quantifies the applications of photonic technologies.

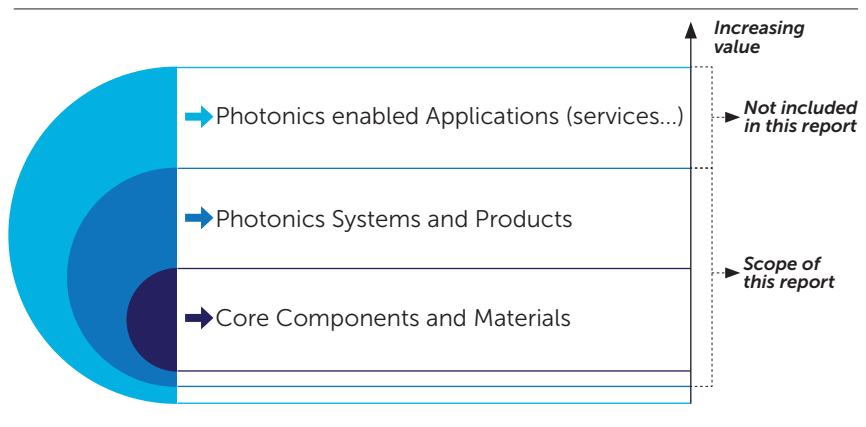
Other definitions used in this report:

- "Photonics Company": company targeting the development and manufacturing of photonics core technologies (components and modules) as well as the development and manufacturing of whole products and systems that rely, for the most part, on photonics components or employing photonics technologies as core differentiators.
- the term "photonics industry" refers to the collection of these Photonics companies as described above (that develop, manufacture, and sell optics and photonics components and systems).
- EU27: current European Union
- EU28: EU27 + United Kingdom
- Europe (in this report): EU28 + Switzerland + Norway (European countries participating in the Framework program Horizon Europe).
- widening countries are EU countries with low participation rates in FP7 and H2020 projects. There are 15 widening countries in the EU, including: Bulgaria, Croatia, Cyprus, Czechia, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia.

The photonics value chain

It is essential to take the entire photonics value chain into account when evaluating the photonics industry. This value chain is the process of taking raw materials and adding value to them through various methods to create finished products that can then be utilised in end-use applications (see Figure 1).

Figure 1 – Global Photonics-related value chain, including enabled applications
Source: Tematys/Photonics21, 2023.



The **photonics value chain** starts with raw materials like glass and semiconductor substrates and progresses through photonic components to photonic products and systems such as cameras or lasers.

The **global value chain** is based on both photonics products and systems (hardware products such as laser machines, medical devices, etc.) and a wide range of **services and products enabled by photonics**, such as the internet, which relies on optical fibres to transmit its data or smartphones which include various photonic modules.

Each stage of the value chain has a higher value than the previous one, so, for example, the total revenues associated with enabled services are much higher than those of the basic components. Throughout the value chain, other industrial sectors can, therefore, benefit and develop thanks to the associated opportunities.

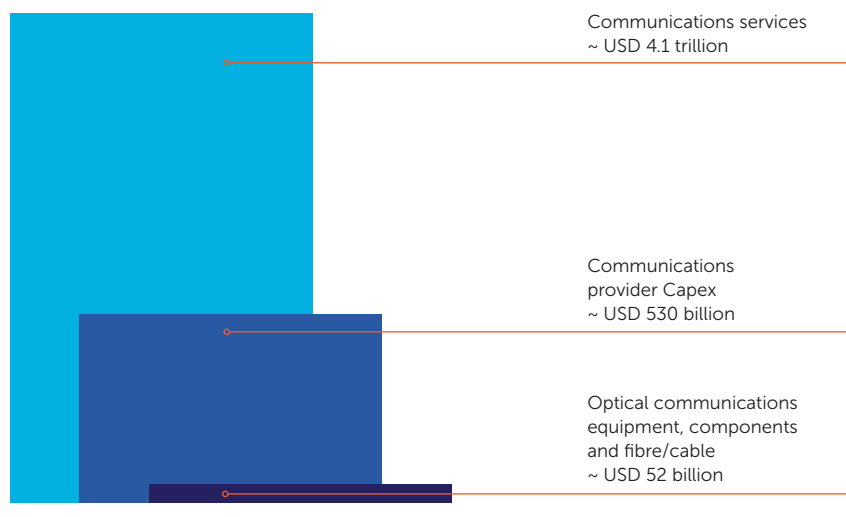


Figure 2 – Example of global value chain including photonics-enabled products and services
Source: Tematys/Photonics21, 2023 adapted from OPTICA¹.

It is important to note that this report focuses on quantifying the market and production of Components & Materials and Photonics systems (or modules in the case of smartphones). The final market value of photonics-enabled products and services like smartphones, communications services, e-commerce, etc., is out of the scope of the report (see Figure 1).

Quantifying the photonics market and industry

There is no universally accepted definition of the photonics market or industry. However, thousands of companies use optical and photonic technologies. Similarly, many users of light-based technologies do not consider themselves photonics businesses. In addition, economic tracking codes in the US (NAICS) and Europe (NACE) do not have a category for photonics. As a result, more than 100 different NAICS or NACE codes must be used to characterise photonics products and companies.

Although market estimates and economic impact assessments are essential tools for understanding and promoting the photonics industry, these estimates can vary widely for the reasons outlined above. It is, therefore, important to be as clear as possible about the methodology used in this report to estimate the photonics industry.

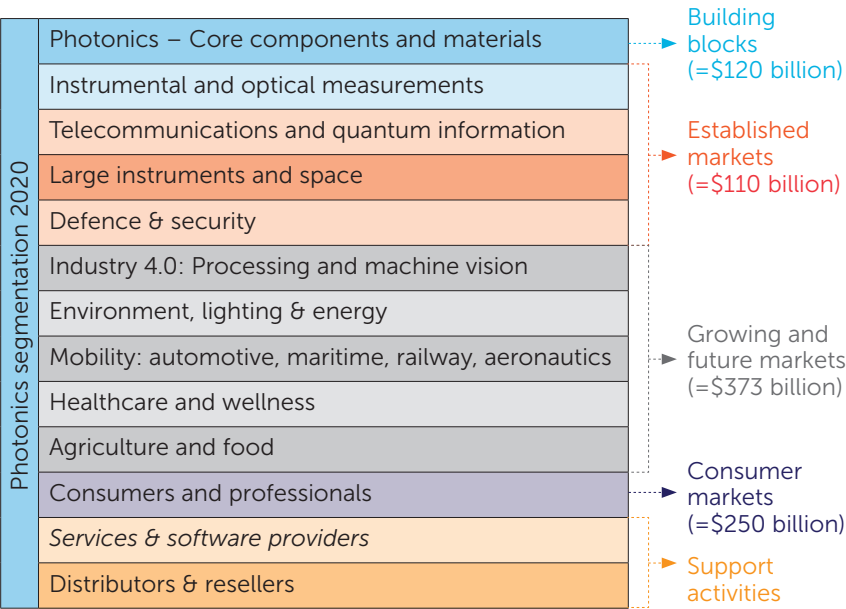
It would be helpful if other organisations around the world used similar types of segmentation and methodology to that presented below. A major benefit of this approach to a common classification would be the increased comparability of studies carried out by different institutions and organisations. This approach would allow for an even more consistent assessment and representation of the industry on a global scale.

¹ Optics and Photonics: The Impact on a Global Economy, OPTICA, 2022.

1.2 Segmentation based on end-users and applications

To support Photonics21’s ambition to improve the visibility of photonics in its application markets with actionable data, the new segmentation used in 2020 remains unchanged for this report (see Figure 3). This segmentation is oriented towards end-users and application markets. It is also in line with the evolution of applications. Moreover, it reflects the working group structure of Photonics21.

Figure 3 – New Photonics Segmentation used in this report
Source: Tematys/Photonics21, 2023.



Note: Support activities are not included in the statistics of photonics industry

This segmentation allows us to define, in the European photonics industry, the manufacturers involved in the core part of the development of photonic objects and products (optical components and materials, laser modules, optical surface treatment) and those that manufacture complete products with a targeted use. For example, a manufacturer of laser modules that can be integrated into the final manufacture of a LIDAR will be listed in the “Core Components and Materials” segment. In contrast, a manufacturer of a LIDAR for a specific need will be listed in its application category (a manufacturer of “wind LIDAR” will be listed in the “Environment” segment, and a manufacturer of automotive LIDAR will be listed in the “Mobility” segment).

Full details of what is included in each segment can be found in the Appendix. There are 11 segments, 30 sub-segments and more than 125 types of products.

1.3 Methodology of the study

The photonics industry does not have its own standard industry classification(s). This is a challenge that hampers efforts to quantify this industry precisely.

Several other factors add to the complexity of the analysis, as many companies involved in the manufacture of photonics products also manufacture non-photonics products. Additionally, a significant number of photonics companies are SMEs and often report only abbreviated financial statements.

To meet these challenges, the methodology used for this report is based on a similar approach originally developed to describe the French photonics industry and has been slightly adapted to take into account the specificities of the economy and related databases in various countries throughout Europe.

This methodology is similar to that used in the UK to estimate the UK photonics Industry². Apart from the selection of companies, it also shares similarities with the methodology used by SPIE to estimate the size of the photonics components industry³.

This is a welcome first step to providing reliable global statistics on the world's photonics industry and facilitating international comparisons.

1.4 Methodology for the European photonics industry

The methodology is summarised in the following figure.

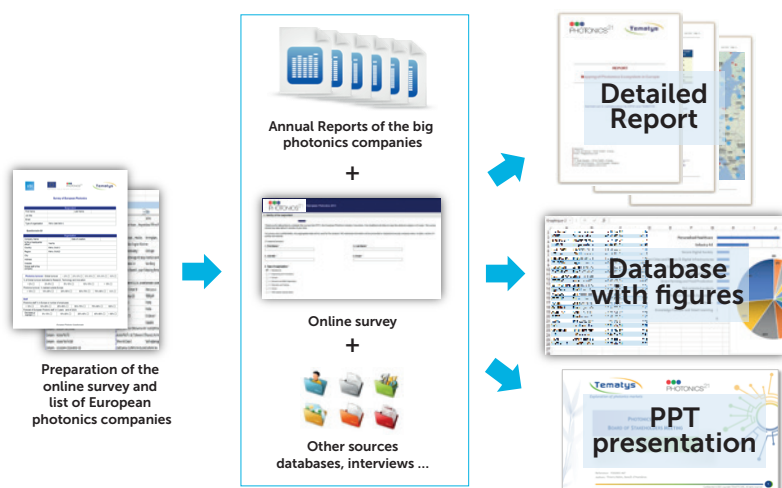


Figure 4 – Overview of the methodology for the study
Source: Tematys/Photonics21, 2023.

² https://photonicsuk.org/wp-content/uploads/2018/05/UK_Photonics_The_Hidden_Economy.pdf

³ https://spie.org/Documents/Industry%20relations/IR_Methodologies_2019.pdf

The main steps are:

1. Listing the European photonics companies
2. Using annual reports, databases like D&B (Dun & Bradstreet) and interviews to evaluate the revenues of photonics companies
3. Evaluating the proportion of photonics-related activity for diversified companies
4. Analysing more than 50 big companies in detail
5. Online Survey

In order to complete the collected data (on R&D investment, exports, expected growth, etc.), an online survey was carried out.

This methodology, which combines different approaches, provides a reliable assessment of the size and other characteristics of the European photonics industry. Full details of the methodology can be found in the annexe to this report.

Note 1: The turnover for each country is based on the location where the products are manufactured, as opposed to a count based on the nationality of the companies (location of headquarters).

Note 2: The analysis excluded companies that are considered photonics users but not explicitly photonics manufacturers. This analysis also applies to service companies such as consultancies, engineering firms, or those offering laser-based services for material processing.

1.5 Methodology for global photonics markets

In total, more than 125 different types of products were taken into consideration to evaluate the global market. The methodology is presented below.

1: Breakdown of each segment in various product lines

For example, split category 6.1 (telecom components and systems) into subcategories:

- Telecom transceivers
- Datacom transceivers
- Optical switches & routers
- Datacenter Interconnects
- Others

2: Compilation of market data and data reliability analysis

To estimate market size, the base year used is 2022 while the forecast period for the CAGR is 2023–2027. Various market reports were compiled for each item.

The reliability analysis has the following steps:

- Listing of key players on each sub-segment (worldwide players)
- Analysis of annual report of 1 to 2 key players to compare its revenue and estimated market share with market report data
- Analysis of investors presentation of some key players to compare with market report data
- In our example, analysis of II–VI, Huawei, Infinera ...

2. Global photonics market

2.1 Overview – market size and growth

The global photonics industry has shown great resilience and sustained growth over the past three years, with a CAGR of 6.8% despite the COVID-19 decline in 2020. The global photonics market was valued at \$710 billion (€634 billion) in 2019 before reaching \$865 billion (€820 billion) in 2022. It is expected to reach around \$1200 billion in 2027 (See Figure 5).

Compared to the global GDP growth rate, which grew at an average of 2% per year between 2019 and 2022 (in constant 2015 USD, taking account of inflation), the photonic industry showed a CAGR of 6.8%. Applying the photonics industry revenues to the same deflator as the global GDP, we obtain a CAGR of 4.3%, or more than double global GDP growth.

Between 2019 and 2022, the global Photonics industry has shown steady growth exceeding global GDP (2%): it has a CAGR of 6.8% in revenues (4.3% when accounting for inflation).

Photonics worldwide market size

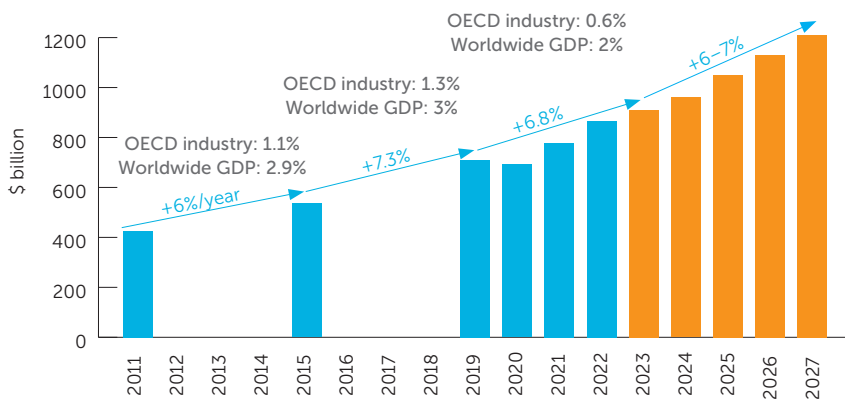


Figure 5 – Photonics worldwide market (\$ billion) from 2011 to 2027 –

Source: Tematys/Photonics21, 2023.

OECD industry index and World GDP in constant 2015 US\$⁴

* Note: CAGR 2019–2022: 4.3% with deflator

This growth result is in line with other studies. The most recent SPIE market study used a different perimeter but highlighted a growth of 6.55% in the previous eight years⁵. OPTICA also reported the global optics and photonics market grew at a CAGR of 6.4% from 2016 to 2021⁶.

⁴ OECD Industry index: <https://stats.oecd.org> – World GDP and Deflator: <https://data.worldbank.org>

⁵ Optics & Photonics Industry Report, SPIE, 2022.

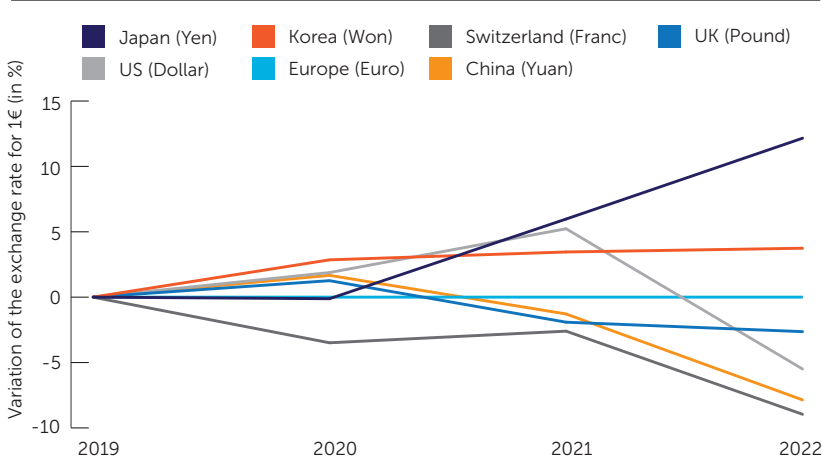
⁶ Optics and Photonics: The Impact on a Global Economy, OPTICA, 2022.

Figure 6 – Exchange rates of major currencies versus Euro from 2019 to 2022
Variation in % of the exchange rate for 1€
Source: Tematys/Photonics21, 2023 –
Data: European Central Bank
(<https://data.ecb.europa.eu>)

Notes on exchange rates and inflation of prices

International market data are often reported in US dollars, but photonics production in Europe is obviously reported in Euros. The exchange rates are important, especially when looking at the annual growth rate (of a market segment or a country's production), as these rates can be different according to the currency used.

For the period relative to this report (2019–2022), the variations are given in the figure below.



One point is not simplifying the analysis for the period: the variation of the USD/EUR exchange rate between the beginning and the end is about 6%. The EUR/USD exchange rate was 1.12 in 2019 vs. 1.05 in 2022. This means that market data expressed in dollars or euros will not vary in the same way over the period. Where appropriate, we will mention the impact on results.

From 2019 to 2022, the Japanese yen (JPY) depreciated by 13% against the euro (after appreciating by 9% against that same currency during the 2015 to 2019 period). The EUR/JPY exchange rate was 122 in 2019 vs. 138 in 2022.

Compared to the euro, the Chinese currency appreciated by 8.5% from 2019 to 2022 after depreciating by approximately 12% from 2015 to 2019. The EUR/CNY exchange rate was 7.74 in 2019 vs. 7.08 in 2022.

From 2019 to 2022, The Korean won (KRW) depreciated by about 4% against the euro. The EUR/KRW exchange rate was 1305 in 2019 compared with 1358 in 2022.

Finally, the British pound (GBP) did not change significantly during the last three years after a great depreciation following Brexit. The pound rebounded by 2.8% from 2019 to 2022 against the euro. The EUR/GBP exchange rate was 0.88 in 2019 vs. 0.85 in 2022.

Note on inflation of prices

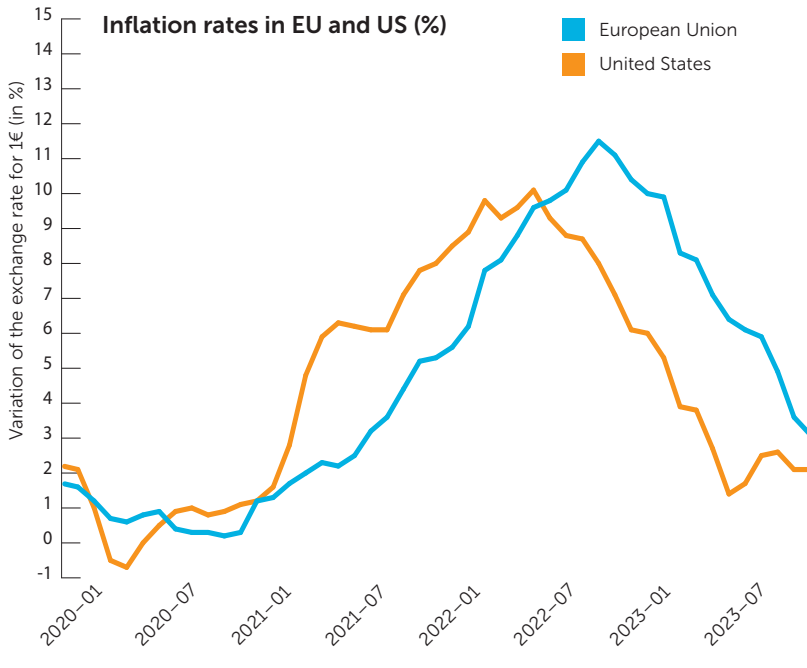


Figure 7 – Inflation rates in the EU and US from January 2020 to October 2023
HICP* – monthly data – annual rate of change
Source: Tematys/Photonics21, 2023 –
Data: Eurostat (<https://ec.europa.eu/eurostat>)

Compared to the 2020 photonics industry report, inflation has complicated this growth analysis. The curves demonstrate that inflation started to take hold in the months following the COVID-19 crisis, as the post-pandemic economic recovery led to increased demand for goods and services.

In response to the economic downturn caused by the pandemic, the European Central Bank, like many other central banks, adopted a policy of low interest rates and quantitative easing. This increased the money supply and potentially contributed to inflation.

The pandemic also caused significant disruptions in global supply chains, resulting in problems such as shortages of raw materials, transportation bottlenecks, and labour shortages. These issues, together with energy prices, led to increased costs for production and shipping. The significant increase in energy prices was reinforced by geopolitical tensions, particularly the Russia-Ukraine conflict. The EU, heavily reliant on Russian gas, was especially affected by these dynamics.

It is important to note that the impact and relative importance of these factors varied across different EU countries, depending on their economic structure and policies.

The impact of inflation on results will be highlighted where appropriate.

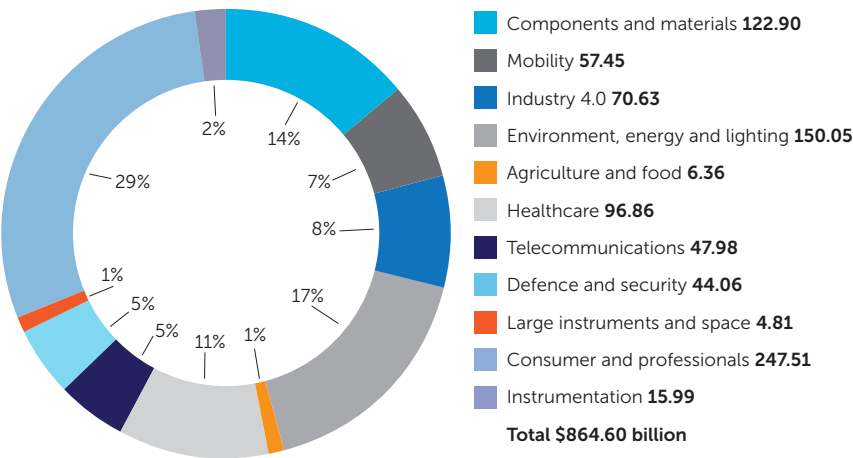
* HICP: Harmonised Index of Consumer Prices

2.2 Global market by application segment

The worldwide Photonics market, valued at \$865 billion (€820 billion) in 2022, is segmented by application. Figure 8 below shows the breakdown of Photonics components and systems.

Figure 8 – Breakdown of the global market (\$ billion – 2022) by application segment
Source: Tematys/Photonics21, 2023.

Global photonics market (\$ billion)



The market for photonic components and materials increased from \$99.3 billion in 2019 to \$122.9 billion in 2022. The remaining segments comprise photonic systems and subsystems, which account for \$742 billion, or 86% of the total. By comparing the market size of the 'Photonic Systems & Subsystems' segments to the 'Photonic Components & Materials' segment, we can see that the value-added ratio is a little over 6 (i.e., \$742 billion / \$123 billion).

The largest segment, which accounts for approximately 30% of the total photonics market, consists of photonic products primarily used by consumers and is valued at \$247.5 billion. The global market reached \$121 billion for stand-alone displays, \$92 billion for modules and devices embedded in smartphones, and approximately \$34 billion for various consumer and professional IT products such as optical mice, laser printers, and projectors in 2022.

The segment representing photonic devices and systems for healthcare and wellness accounts for \$97 billion in 2022 – or 11% of the total market. This market includes two main segments: spectacles and contact lenses, which account for \$48 billion, and biophotonics devices and systems, which account for \$49 billion. Another major segment is photonics systems for the environment, energy and lighting. This segment accounts for \$148.5 billion (17% of the total) and includes photovoltaic modules (\$74 billion) and lighting systems (\$66 billion).

Photonics products used in industrial manufacturing accounted for \$70.6 billion. This includes \$41.5 billion of production technology products,

such as industrial laser systems and semiconductor manufacturing systems, and about \$26.5 billion of optical metrology and machine vision products.

Photonics products used for mobility accounted for \$57.5 billion, which represents 7% of the total. The market for sensors used in Advanced Driver Assistance Systems (ADAS), including cameras and lidars, amounts to \$8 billion. Automotive lighting represents a market of \$26 billion, while displays account for about \$22 billion.

Optical systems for telecommunications make up almost 5.5% of the total market, with a value of nearly \$50 billion. This category includes optical network systems and optical cables.

The remaining 10% of the photonics market consists of photonics products for defence and security (6%), optical instrumentation (2%), large instruments and space ($\approx 1\%$) and agri-food systems ($\approx 1\%$).

Figure 9 below shows the evolution of the main application segments in the global market between 2019 and 2022.

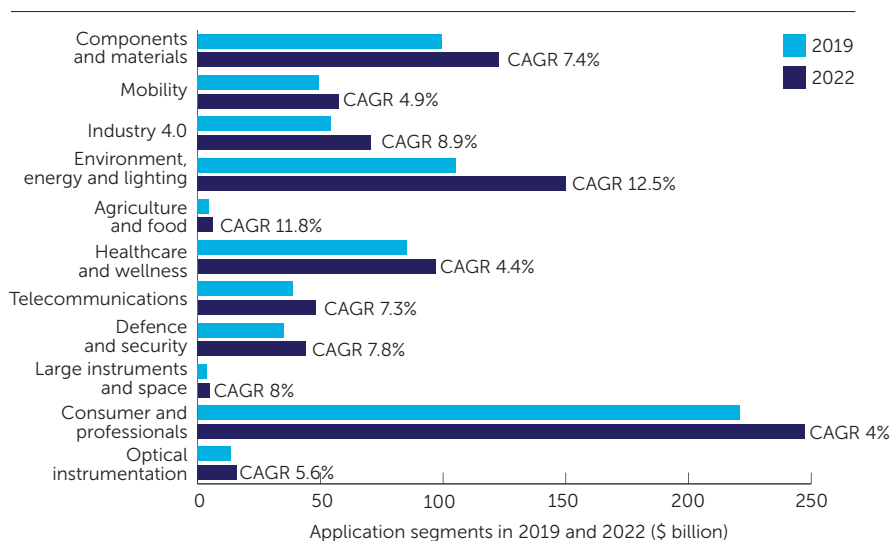


Figure 9 – Growth of the application segments from 2019 to 2022 (\$ billion)
Source: Tematys/Photonics21, 2023.

From 2019 to 2022, the market grew at a CAGR⁷ of 6.8%. The demand for photonic components and materials rose at a CAGR of 7.4%. It should be noted that the value of components increased at a slightly higher rate than the total. This was not the case in the previous years (2015–2019) when the growth was lower due to the fall in prices of some components during the period. In recent years, the trend has reversed for a number of reasons. Firstly, component supply chain issues have kept prices high. Secondly, some components have become more complex (free-form lenses, metasurfaces, PICs, micro-projectors, etc.). And finally, the use of photonics technologies in systems is increasing.

⁷ All CAGR and growth rate in this paragraph are related to markets in USD.

The market for Consumers and Professionals (information technology and displays) is growing at a CAGR of around 4% from 2019 to 2022, well below the global market, as predicted in our previous report. The explanation for this could be the saturation of the market for flat screens and mobile phones. This trend is likely to be confirmed over the next few years, depending on the rate of replacement by consumers.

The healthcare and wellness photonic systems segment grew by 4.4% CAGR over 2019–2022. This relatively low growth could be due to the different CAGRs of the main sub-segments: spectacles and contact lenses with a low CAGR (around 3%), medical laser systems with a low CAGR due to the Covid crisis (funds were used for other purposes) and biophotonics devices and systems, growing more strongly at around 7.5% per year.

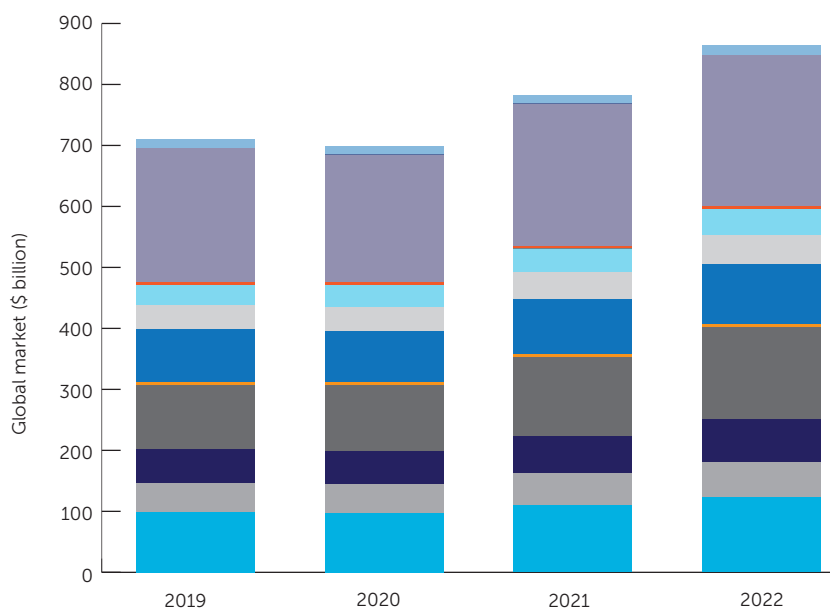
The market for industrial photonic systems grew at a CAGR of 8.9%, comprising production systems (CAGR of around 11% due to strong growth in photolithography systems) and instrumentation & machine vision (CAGR of 7%).

Photonics for agriculture and food is still an emerging market but is clearly one of the most rapidly growing, with a CAGR of around 12%.

The market for photonics products in other segments has increased as follows: environment, energy and lighting (12.5%), mobility (4.9%), and defence & security (7.8%). For details about the growth of segments and sub-segments, please see part 5.

Finally, Figure 10 shows the evolution of the global photonics market from 2019 to 2022, along with the breakdown by application segment.

Figure 10 – Global Photonics Market Evolution from 2019 to 2022 (\$ billion)
Source: Tematys/Photonics21, 2023



2.3 Production by geographical area

Photonics manufacturing is mainly located in Asia. China, Japan, Korea, Taiwan and a few other Asian countries (such as Vietnam, Malaysia, Singapore, Thailand and India) account for more than 65%. Europe and North America are almost the same size. Other photonics manufacturing countries include Israel, Turkey, Australia, New Zealand and Brazil.

China is the leading producer, with a share of almost 32%, followed by Europe (15%), North America (15%), Japan (11%), Korea (8%) and Taiwan (7%). Europe is currently the second-largest producer of photonics. These production shares are based on the country where the products are manufactured, as opposed to a count based on the nationality of the companies (location of headquarters).

Asia is particularly strong in displays, PV and LED production. In contrast, Europe leads in optical components and photonics for industry and healthcare. By excluding displays and PV products, Europe leads with more than a 20% share in 2022.

Global Photonics market

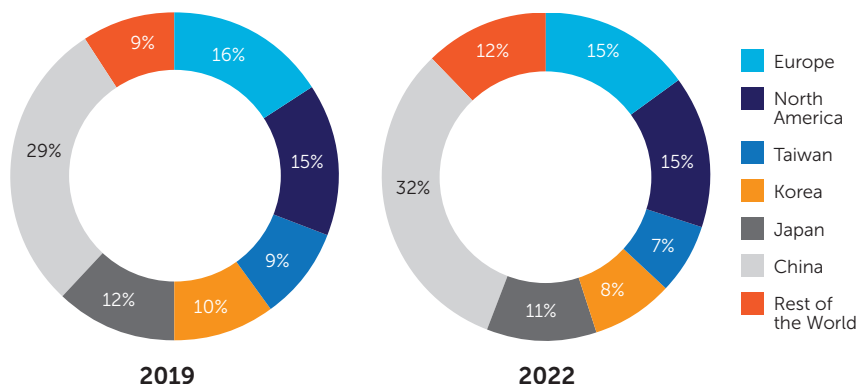


Figure 11 – Global Photonics industry – Breakdown by geographical area (2019–2022)
Source: Tematys/Photonics21, 2023.

Over the past three years, there has been a shift in the market shares of several photonics-producing countries. Both Korea and Taiwan have lost market share, while China has steadily increased its share.

Europe has managed to maintain its second position, although Europe and US market shares are now almost equal. Europe's market share has technically declined slightly over the last three years.

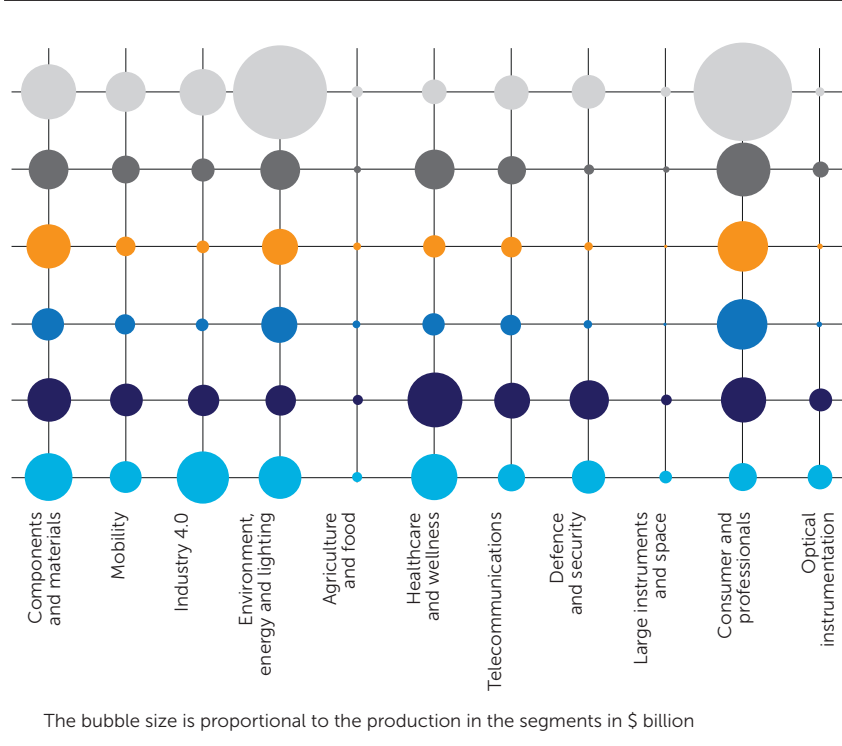
Note: The growth (in €) of the European photonics industry is almost the same as the growth (in \$) of the global market, but due to the difference in exchange rates between 2019 (\$1.12/€) and 2022 (\$1.05/€), Europe's share decreases slightly from 16% to 15%.

Europe's photonics market ranked 2nd globally over the last three years. By excluding displays and photovoltaics products, Europe leads with more than a 20% share in 2022.

Figure 12 – Market shares of photonics segments in leading geographical areas (2022)
Source: Tematys/Photonics21, 2023.



The market shares of the leading countries and geographical areas in the photonics segments (2022) are presented below, followed by details of their strengths, weaknesses and evolution.



A long-term perspective reveals that China has actively pursued a leading position in the world photonics market since the early 2000s, recognising its pivotal role in strengthening its economic prowess in emerging digital markets and enhancing its defence, security and space capabilities. China's world market share in photonics skyrocketed from around 10% in 2005 to 32% in 2022, marking a considerable ascent. In contrast, the market shares of Europe and North America stagnated in the same period (cf. figure 13). Notably, China is penetrating sectors traditionally dominated by Europe, such as laser manufacturing, sensing, optical components and systems, showcasing its determination to expand its influence across diverse segments of the industry.

Share of Europe, North America, China in the global photonics market – Comparison over time

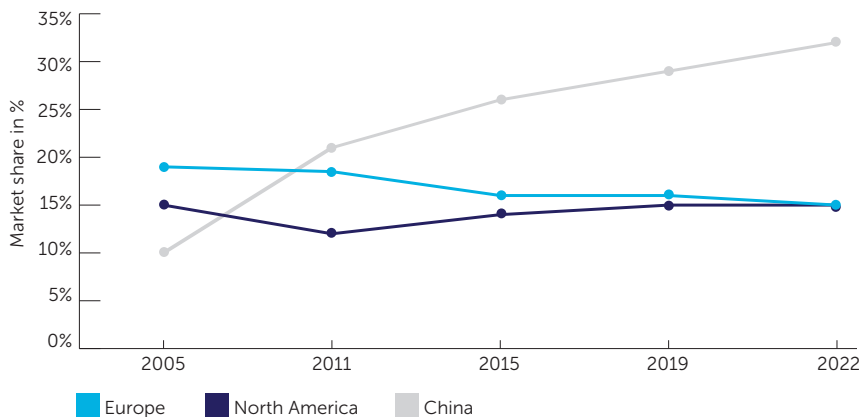


Figure 13 – Evolution over time of the share of Europe, North America and China in the global photonics market

Source: Tematys/Photonics21, 2023.

Data: Photonics21/ Tematys, Market Study 2024 & Market Study 2020 / Photonics21 Market Research Study 2017 / BMBF, SPECTARIS, VDMA, ZVEI, Branchenreport Photonik 2013.

2.4 China

The rapid containment of the coronavirus in 2020 mitigated the economic consequences of the pandemic outbreak before a strong rebound in 2021. In early 2020, the outbreak of the COVID-19 pandemic caused a double shock to demand and supply, resulting in negative growth in Q1 (-6.8% y/y) for the first time since 1992. The rapid control of the circulation of the virus enabled a return to growth in Q2 2020, accompanied by support measures (increased public deficit and local government emission quotas for investment projects, stimulation of credit supply to SMEs, etc.). In 2020, China was the only major economy to post positive annual GDP growth (+2.3% y-o-y), driven by strong export growth and expanding industrial activity. In 2021, the sustained rise in industrial production (+9.6% vs. +2.8% in 2020), very dynamic exports (+29.7% vs. +4% in 2020) and investment (+4.9% vs. +2.9% in 2020) drove activity, which also benefited from a catch-up effect in retail sales (+12.5%, after -3.9% in 2020). China recorded a growth rate of +8.4% in 2021.

In 2022, the active circulation of the virus and the maintenance of severe sanitary restrictions until the end of the year weighed heavily on economic activity. China recorded growth of 3%, far from the target of 5.5% set at the beginning of the year. The economic performance in 2022, the worst since 1976 (apart from 2020), is largely attributable to the Zero-Covid policy, which notably led to the confinement of Shanghai in the spring of 2022.

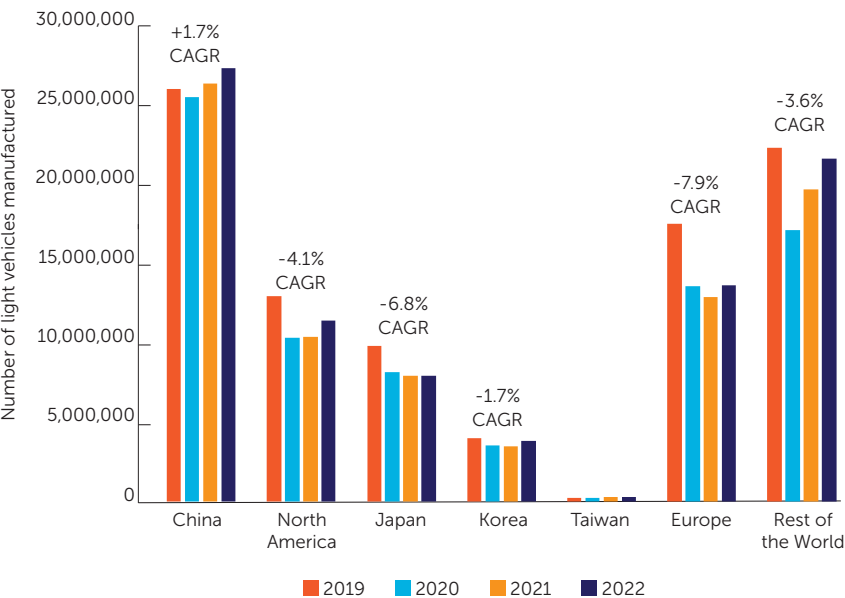
In photonics, China is consolidating its positions across the entire value chain, with a global industry worth \$277B in 2022. In core photonics, past and current plans for advanced materials, fibres and metasurfaces have made China the world leader in basic components, from passive components (prisms, windows, filters, fibres) to chips (LEDs). China supplies 24% of the world's photonics core components.

In terms of applications, China’s dynamic telecom infrastructure and automotive markets have also driven the growth of players in the field (fibre optics, headlights, LIDAR, display manufacturers). Last but not least, highly supported industries such as photovoltaics have so far managed to capture a large part of the photovoltaic market’s growth, limiting European, Japanese and American attempts to regain a foothold in this sector to a trickle.

While in 2020 and 2021, China gained market share thanks to sustained domestic growth and industrial facilities that were less severely impacted than those of Western countries, the industry, like the rest of the country, experienced a difficult 2022. This was in part due to restrictions being maintained at a time when the rest of the world was regaining momentum beyond 2019. Generally, over the period 2019–2022, by excluding photovoltaics, China’s growth was in line with the global average. The arrival of competitors in the ASEAN zone (Vietnam, Philippines, Malaysia) for the most standard products (LEDs, CMOS, fibre) also limited growth in the Chinese photonics industry.

Figure 14 – Light vehicles manufactured (from 2019 to 2022)
Source: Tematys/Photonics21, 2023
Data: OICA (<https://www.oica.net>)

Light vehicles manufactured (from 2019 to 2022)



Interesting prospects for the Chinese photonics industry lie in the automotive sector. On the one hand, the photonics budget per vehicle increased (with the number of cameras installed, dashboard screens, LIDAR sensors, upgrade of headlights, and integration of photonics products in new mid-range and low-range models). On the other, vehicle production in China rose sharply and, it seems, sustainably (Source OICA).

In defence and security, the current geopolitical tensions and rapidly developing skills in infrared should provide the fuel for a powerful local infrared industry for the years to come. China is also positioning itself in the laser weapons segment, which could be a major growth driver for defence photonics over the next 5 to 10 years. Interestingly, in the security market, the investments made during COVID-19 in China make the country ten times more equipped than its counterparts (in terms of cameras per capita), which could lead to a slowdown in its local market.

In the telecom sector, the strong Chinese market share in fibre production from 2010 to 2015 started to erode in the second half of the 2010s. Chinese fibre production accounted for around 60% of world production in 2017, declining to 55% in 2022, and analysts see this share still declining to less than 50% by 2027.

US and Asian Pacific countries are major competitors in this field, the US by industrial policies revival and APAC as new low-cost countries. In terms of demand, major Chinese infrastructure plans have pulled the fibre industry forward in China in the 2019–2022 period and supported the national telecom industry at a time when other countries are restricting access to Chinese products. Smaller players (ZTE, YOTF) were ultimately able to grow under this regime. In contrast, giants with greater international exposure (Huawei) were unable to prevent overall declines in their business revenues. Nevertheless, growth drivers remain numerous and varied, both in terms of network infrastructure (5G+: 6G), space telecoms (emerging and requiring non-telecom solutions (power lasers, large collection optics, optical channel cleaning solutions), as well as in new markets for optics with the development of fiber-to-the-room (FTTR), a deployment ahead of Western countries in Asia.

In terms of industrial production, the development of lasers and laser machines is also underpinned by strong domestic demand, which continues to this day. Finally, as we have noted, PV is benefiting fully from the CO2 mitigation plans adopted by most Western countries. A number of countries (USA, Japan, Korea) are trying to revive their local industry by taking advantage of the arrival of new PV technologies such as perovskites, but China maintains its strong leadership in this industry.

In the consumer sector, like its neighbours, China has had to contend with falling demand for home screens and smartphones. China is looking ahead, in particular with its grand plan for metasurfaces, to the next devices required to enter the Metaverse.

The segments in which China remains in reserve are healthcare (apart from dermatology/dental) and Optical Instruments.

2.5 Japan

Due to the country's demographic decline of 800,000 people per year, potential growth has remained close to zero and has not exceeded 1% since 2000. The Abenomics reforms have only been partially implemented and have

not created the desired confidence shock, resulting in an average growth of 0.9% between 2010 and 2019, compared to 0.6% between 2000 and 2010. The population of the country is projected to decrease by 35 million over the next 40 years, accelerating the demographic decline. Japan's long-term stagnation of wages and consumption is mainly caused by weak productivity and business investment, combined with a deflationary environment.

In its historical photonics market, Japan has lost competitiveness with China and Korea, resulting in a reduction of domestic production from 4 billion yen 20 years ago to 1 billion yen 10 years ago. Since 2019, Japanese production in this slowly growing market has increased by 25% in three years, driven by SONY's technological leadership. In April 2021, Sony Semiconductor Solutions extended CMOS imager production on the production lines of the Nagasaki Technology Center. This manufacturing site is already undergoing a second expansion to bring additional facilities online as early as 2024. In January 2023, Sony plans to construct a new factory in Kumamoto, Japan, to manufacture image sensors for smartphones. The chips will be sourced from TSMC's upcoming plant in the region. Sony's investment in the new plant could amount to several billion dollars, and volume production is anticipated to begin in 2025. Sony commanded 44% of the CMOS image sensor market by value in 2021 and expects to reach 60% market share by 2025.

In the display market, weak consumer demand and price wars between China, Taiwan, and Korea have prevented the Japanese industry from regaining market share.

Photovoltaic energy production has decreased significantly from around 3.5 trillion yen in 2014/2015 to 1.2 trillion yen in 2022, following Japan's attempt to revive its PV industry after the Fukushima accident in 2011. China remains the main player benefiting from the industry's growth. The Japanese case should also be studied in the context of European policies aimed at revitalising the PV industry. This will help to understand the obstacles that have prevented the sector from establishing itself over the long term despite vast government aid schemes. In retrospect, the conjunction of these three trends made 2019 a low point for domestic optoelectronic component production. Production levels in 2019 (in yen) were at 2001 levels, with a 25% drop (in yen) from the 2014–2015 ceiling.

The niche segments of the Japanese industry (laser and industrial, measurement and instrumentation, optical communications), on the other hand, are mostly on an upward trend in the 2019–2022 period. Laser processing, in particular, is showing a significant annual growth rate of 17%, surpassing the growth rate of these markets.

Additionally, the defence budget is set to increase to €48.6 billion, which is a historic rise of 26% from 2022 and the highest annual increase in military spending since 1952. The government aims to increase military spending to 2% of GDP by 2027. These choices should support Japan's developing defence photonics industry.

2.6 South Korea

Korea's economic strength lies in its industry, which, according to the World Bank, will still account for 25% of its GDP in 2020, one of the highest shares among developed countries (20% for Japan and 18% for Germany). The country's industrial sector is dominated by large conglomerates known as chaebols, which have undergone significant transformation in recent decades. Korea was initially a workshop country but later shifted its focus to heavy industry. This change is evident in the continued importance of its shipbuilding, construction, and automotive sectors. The electronics industry, represented by world-class companies like LG and Samsung, has since become the main driver of growth for the Korean economy.

Initially, the Korean electronics industry focused on consumer goods such as screens and smartphones. However, as production lines of major groups were relocated, the industry shifted towards producing high-value-added intermediate goods that are used throughout the world's production chains. In 2021, Korea recorded \$128 billion in exports of semiconductors, with integrated circuits being the main product. Korea is the world leader in memory chips and cards. Korea's dynamism is supported by a significant R&D effort, with the country being the world's second-largest spender as a proportion of GDP in 2021 (4.6%). In fact, Samsung was the world's largest R&D spender, with almost \$20 billion spent in 2021.

Backed by this industrial strength, South Korea enjoyed an average growth of over 3% during the 2010s. Despite the pandemic, the Korean economy contracted by only 1% in 2020 before rebounding by 4.0% in 2021. Thanks to this economic dynamism, Korea's fundamentals are solid today, with structurally low unemployment, a strong trade surplus (current account surplus of 4.9% of GDP in 2021), and contained public debt (47.3% in 2021 for the central government).

Productivity gains in the Korean economy have plateaued, with total factor productivity (TFP) having reached only 60% of US TFP for several years, while industry still accounted for 25% of Korean GDP. This is due to the low productivity of services, which only reached 45% of industry productivity in Korea, compared with an OECD average of 90%. Korean industry is losing price competitiveness in the face of competition, particularly from China, in many sectors at the heart of its industrial base, such as consumer electronics, automobiles and steel.

In our scope of analysis for 2022, the Korean photonics industry was valued at \$72B, with 77% of the industry concentrated in the semiconductor and consumer electronics sectors. This valuation includes active and passive materials, imagers, sensors, and displays for smartphones and lighting.

Unfortunately, the industry has experienced sluggish growth over the past three years due to weak global demand for smartphones and PCs, which has affected the two driving forces of displays and consumer optics. The emergence of new generations of microLED-based displays indicates that these markets are ready for a resurgence.

Likewise, in the LED industry, the production of basic products has moved to other ASEAN countries in recent years. However, the advent of micro LEDs should allow for the revival of more advanced production in the country.

SK Korea established itself as an innovative operator in the telecoms sector, with plans to deploy quantum products as early as 2020. However, growth is slowing due to shrinking domestic demand for 5G and strong competition from neighbouring countries.

In the photovoltaics industry, South Korea installed the newest generation capacity for solar energy between 2018 and 2022, with around 4,100 MW installed in 2020 and a local production of 8.6 MW. The newly generated annual capacity has decreased to around 3,000 megawatts in 2022. Domestic production, led by Hanwha Solution, LG Electronics, and Hyundai Energy Solution, is between 8 and 9 GW. The production outlook for the period 2022–2027 shows a slight decrease compared to the strong expected growth worldwide.

2.7 Taiwan

The photonics industry in Taiwan reached nearly \$53B in 2022, with a significant portion of the country's business focused on producing Flat Panel Displays (50%). This industry experienced strong growth just after COVID-19 (+20% between 2020 and 2021) but contracted violently in 2022 (at -30%). Similar to Korea, the commercialisation of microLED screens is eagerly awaited to revitalise the display market, which has not seen a technological revolution in many years. The second major area is core photonics, which accounts for 20% of Taiwan's annual production. Although TSMC has not previously been involved in photonics components, the company recently announced its intention to enter the Silicon Photonics market in September 2023, particularly for AI applications. With TSMC's strength in this field, significant growth in this segment of Taiwanese photonics is expected over the next few years.

Components for optical communications and photovoltaics are showing positive growth in Taiwanese production. At the same time, medical photonics (imaging and corrective lenses) also shows strong signs of growth. However, the output of light sources, including LEDs, complete lighting, or lasers, is on a long-term downward trend.

By 2022, Taiwan's local photonics production reached pre-COVID levels in a market that has grown by 6.7% worldwide.

The main growth prospects are in silicon photonics, with upcoming investments by TSMC; in the photovoltaic industry, with anticipated breakthroughs in perovskites to counter the strong domination of the Chinese silicon industry; and in the consumer sector, with the deployment of AR/VR/MR products and related optical components such as lenses, gratings, combiners, and filters.

2.8 United States

The United States has made a swift recovery from the pandemic, and the latest projections for the years 2023–2025 exceed pre-Covid estimates. The strategic competition with China, the COVID-19 pandemic, and the climate crisis have reignited the industrial policy debate in the USA. American elites are recognising that they are not playing by the same rules as China in the competition between the two countries. In strategic areas, Beijing can utilise all industrial policy tools, such as preferential bank loans, subsidies, collaboration, and standardisation. In contrast, the United States has refrained from using some of these tools.

This post-Covid observation challenges the liberal dogma inherited from the Reagan presidency and the exaggerated belief in the ability of self-regulating markets to solve economic and social problems. However, the federal government has continued to implement policies to support industries, such as protecting the steel and semiconductor sectors from foreign competition. These policies were pursued by the Clinton, Bush, Obama, and Trump administrations (steel tariffs). In 1987, the Defense Advanced Research Project Agency (DARPA) created Sematech, a consortium aimed at enabling American semiconductor manufacturers to share certain R&D costs. This initiative was in response to the growing power of Japanese semiconductor manufacturers.

Additionally, increased defence spending and advanced weapons projects, such as the Space Defense Initiative, directed large volumes of public funds towards the development of emerging technologies. For many years, defence and space initiatives have supported photonic giants and start-ups. These initiatives have led to the development of laser weapon technologies, adaptive optics, LIDAR, VCSELs, atomic clocks, silicon photonics, and manufacturing and control methods for large-scale optics, such as those used in the James Webb telescope.

The director of the White House National Economic Council will use these outcomes as the guiding principles for an 'industrial policy for the 21st century.' This policy will focus on supply chain resilience, targeted public investment, smarter public procurement, climate resilience, and equity. This direction, presented to the Atlantic Council in June 2021, has been translated into numerous legislative initiatives (Infrastructure Investments and Jobs Act, CHIPS and Science Act, Inflation Reduction Act) or mobilising executive powers (use of the Defence Production Act, supply chain review, etc.). These laws, which were passed in 2022, will free up nearly \$1,000 billion in new credits over the next five to ten years. The Biden administration now needs to demonstrate its ability to ensure America's reindustrialisation. The effects have quickly been felt, with private investment in industrial structures reaching unprecedented levels as early as 2023⁸.

North American Photonics is taking full advantage of this environment in our 2019–2022 analysis period.

⁸ <https://www.jean-jaures.org/publication/la-politique-industrielle-sous-biden-une-nouvelle-doctrine-economique-pour-le-parti-democrate/>

At the federal agency level, photonics companies receive nearly \$0.8 billion in annual contributions from DoD and DARPA funds (P21 study – October 23), providing a powerful tool for the development, industrial validation and maintenance of these technologies.

The United States continues to benefit from a highly dynamic private innovation financing system and investors' proven expertise in the fundamentals of deep tech. This high-performance financial ecosystem has enabled the rapid and dynamic funding of numerous projects in the fields of quantum computing, AR/VR, and biophotonics.

The US government is collaborating with local authorities to establish 'Manufacturing Initiatives' modelled after the Sematech initiative created in 1987 for the semiconductor industry. These initiatives target various fields and key regions, including bio-fabrication, textiles, additive manufacturing, and robotics, in parallel with federal and private-sector efforts. AIM Photonics, centred around the historic Rochester cluster, is the most well-funded of the 12 clusters selected by the federal government among these initiatives.

These post-COVID effects are boosting US market share worldwide. They include changes in industrial policy, a refocusing on private investment in the industrial sector, the involvement of local authorities, venture capital, and expertise available over the long term for deep tech. Additionally, the historic interactions between photonics and the US aerospace-defense ecosystem are contributing to this growth.

The United States is solidifying its dominant position in the defence and space industries, with major prime contractors such as Lockheed Martin, Raytheon, Boeing, Teledyne, and numerous small and medium-sized companies, including Ball Aerospace. Additionally, the US is expanding its market share in innovative components such as flat optics, freeform optics, and light optics, as well as in datacoms/telecoms with major players in Silicon Photonics. Manufacturing is also a growing sector. The USA is a leader in biophotonics and biomedical instrumentation, driven by demand from its domestic healthcare market for both ophthalmic corrections and more sophisticated systems.

In the PV industry, the USA attempted to regain dominance in the 2010s through major bank financing of PV companies. From 2015–2020, ARPA-E, the DoE's funding agency, also heavily invested in second and third-generation technologies such as thin films, dyes, and surface nanostructuring. However, like Europe and Japan, these initiatives have not yet been successful.

3. European photonics industry

3.1 Introduction

The total European photonics production reached €124.6 billion in 2022, comprising more than 5,000 companies and contributing about 3% of the total manufacturing in Europe. It provides around 1.5% of total manufacturing employment, with a turnover per employee of around €280,000.

Note: It is important to note that these figures only concern the manufacture of photonic components, products and systems. It does not include services (engineering, fibre installation, laser-based cutting/welding, etc.) or distribution sales offices/services. It is estimated that this adds around 20–25% to the photonics ecosystem.

European photonics growth: exceeding GDP and overall industry

A Key Enabling Technology (KET) can be assessed by its dynamism beyond its size (which is the reference indicator for a traditional industry). European Photonics Industry has grown from €103 billion in 2013 to €124.6 billion in 2022, with a growth rate of 6.5% per year and a share of 15% of the global market.

For over ten years, photonics has been growing faster than many other European high-tech industries (for example, MedTech: 5.7%/year⁹, microelectronics: 5.4%/year¹⁰) and also much quicker than the EU GDP (see Figure 15).

What is noteworthy is that the recent growth of the European photonics industry for the period 2019–2022 is roughly in line with the global rate since 2005, as can be seen in Figure 15 (see also Figure 5). This is despite various crises (COVID-19, energy, war in Ukraine). Europe has also been able to maintain its market share over the last three years and defend its number 2 global position.

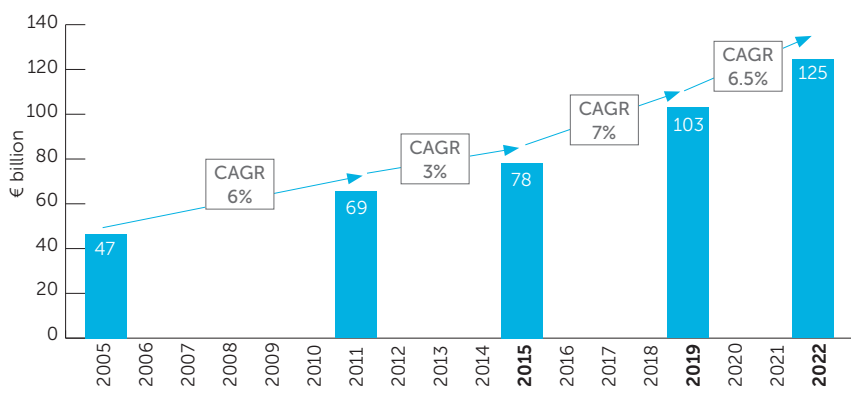
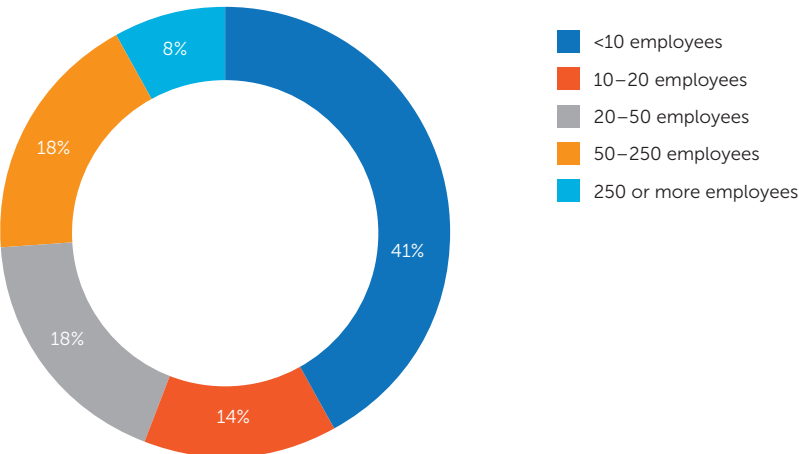


Figure 15 – Long-term evolution of the production of the European photonics Industry (€ billion)
Source: Tematys/Photonics21, 2023.

⁹ Over the past 10 years – Source: <https://www.medtecheurope.org/datahub/market>

¹⁰ From 2016 to 2019 (7% for Photonics) – Source: Positioning of France and the EU in the global semiconductor ecosystem (In French, as part of the interim evaluation report of the Nano 2022 program), DGE, 2021.

Figure 16 – Breakdown of the European photonics companies by company size
Source: Tematys/Photonics21, 2023.



Small enterprises, defined as those with fewer than 20 employees, represent 55% of the total number of enterprises and are an important driver of expected growth. Medium-sized enterprises, defined as those with 20–250 employees, account for 36% of enterprises and around half of expected growth. Large companies, defined as those with more than 250 employees, provide a stable base for the sector, representing only 8% of enterprises but almost 70% of total employment.

The distribution of turnover by company size is shown in Table 1 below. Companies with less than 50 employees account for 73% of enterprises but 6% of turnover. On the other hand, large companies (> 250 persons employed) represent 8% of the total number of companies but 73% of the turnover.

Table 1 – Distribution of the revenues according to the size of photonics companies (2022)
Source: Tematys/Photonics21, 2023.

Employees	Number of companies	Total revenue (€b)
<10 employees	41%	= €10 billion
10–20 employees	14%	
20–50 employees	18%	
50–250 employees	18%	= €25 billion
250 or more employees	8%	= €90 billion
Total	= 5,000 companies	

The photonics industry remains in the long term in a growing dynamic of business creation. Around 60% of the photonic companies are less than 20 years old. This industrial sector has experienced near-constant growth in terms of the creation of new companies since 1990.

3.2 Production value and growth of European photonics industry

The next table displays the breakdown of European photonics industry by country.

Country	Domestic production (€ billion)
Germany	48.1
France	16.8
UK	14.5
Netherlands	8.4
Italy	6.3
Switzerland	5.6
Sweden	2.6
Spain	1.8
Rest of Europe	20.5
Total	124.6 billion

Table 2: Production in the European Photonics Industry (2022).

Source: Tematys/Photonics21, 2023

The comparison of the evolution of the EU photonics industry, GDP and production are shown in Figure 17 below. The evolution of the EU photonics industry is also shown with deflator (the same used for the GDP: -6.5% in 2022)¹¹.

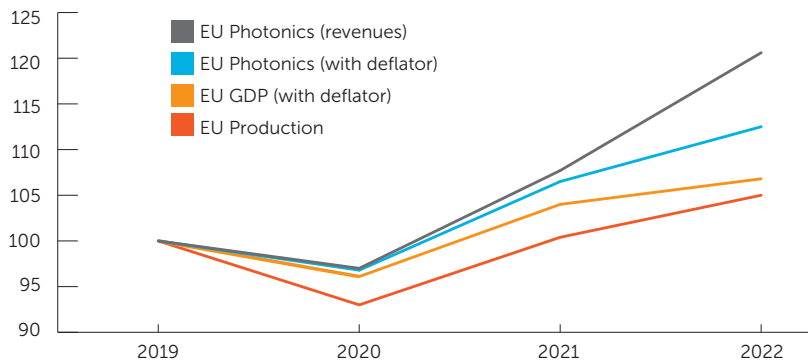


Figure 17 – Evolution of EU photonics industry, GDP and production (base 100 in 2019)

Source: Tematys/Photonics21, 2023 – Data for GDP and production: World Bank and Eurostat¹²

It is important to note that the introduction of price inflation makes comparisons much more complicated. It is common for GDP to calculate “real” growth by taking into account the rise in prices through the application of a “deflator”. When price inflation is low, there is little difference between GDP before and after the deflator is applied. For the year 2022, the World Bank indicates the application of a deflator of 6.5%. To support our comparison with GDP, we have used the same deflator for the photonics industry, but to be perfectly accurate, we would have to apply the corresponding rate for photonics products. This rate is very difficult to calculate. It is reasonable to assume that it is lower than the GDP deflator because the latter takes into account energy price inflation, which is higher than that of manufactured goods.

¹¹ See <https://data.worldbank.org> for more information on the deflator

¹² Data for GDP from <https://data.worldbank.org> and for production from: <https://ec.europa.eu/eurostat>

EU photonics grew at more than twice the rate of EU GDP, with remarkable dynamism and resilience in the face of global crises.

It is noteworthy that, despite the various crises, the European photonics industry is expected to experience three times the revenue growth of the EU GDP from 2019–2022 and twice the growth when adjusted for inflation. Although modest in size, the photonics industry in Europe has demonstrated **remarkable dynamism and resilience in the face of crises.**

Europe may have lost the battle for the display market to Asia's titans in Japan, Korea, and China and watched China aggressively corner the photovoltaic industry over the last two decades, but it's a different story in the other segments of photonics. Despite not leading the world's two largest photonic markets, Europe's photonic industry has held its ground for good reasons.

It is important to note that photonics is a vital driver for countless applications. The photonics market is a diverse universe, spanning hundreds of smaller markets. Some are lucrative, small-scale niches, perfect for SMEs, while others are mid-sized, churning out thousands of units. Innovation and cutting-edge technology are key to thriving in these varied markets.

Although Europe is lagging in the two largest photonics markets, displays and PV, its share has been maintained, highlighting the huge dynamism of other photonics segments in Europe.

Europe remains competitive through continuous research and innovation. Its strong research infrastructure enables European companies not only to survive but also to expand and capture significant portions of the rapidly growing market. These companies lead the way in Industry 4.0 technologies, such as laser machining, semiconductor production, and machine vision, as well as in instrumentation, microscopy, optical measurement, and photonics-based medical and healthcare technologies.

3.3 Employment in European photonics industry

In general, the dynamics of industrial employment in Europe remain weak despite the growth in production. This is true for the entire industrial sector and may be exacerbated by the fact that the manufacturing industry is undergoing a structural change towards digitalisation, generating new turnover with a lower impact on industrial employment. The photonics industry is not immune to this trend, but its strong economic dynamism has a significant impact on employment growth, as shown in this section.

Table 3: Employment in the European Photonics industry – Breakdown by country (2022).
Source: Tematys/Photonics21, 2023

Country	Number of employees
Germany	188,000
France	60,000
UK	58,000
Netherlands	24,000
Italy	16,000
Switzerland	14,000
Sweden	6,000
Spain	7,000
Rest of Europe	≈57,000
Total	430 000

The European photonics industry created approximately 35,000 jobs between 2019 and 2022, with an annual growth rate of 2.5%. This growth rate is significantly higher than that of employment in European manufacturing as a whole.

The difference between the growth rates of European photonics in terms of turnover and employment is due to significant productivity gains. The manufacturing processes of European photonics are currently transforming, moving from small-scale workshops to industrial factories. This shift has important implications for jobs, skills, and the digitisation of the industry.

However, the growth in European photonics employment is not without recruitment challenges, particularly among SMEs. According to a 2023 survey, only 35% of photonics companies reported having easy access to the necessary skills and training. Additionally, companies require a diverse range of skills, from R&D to production, including IT and marketing.

It is worth noting that universities and RTOs face similar recruitment challenges, with response rates to the survey mirroring those of companies.

3.4 European photonics industry R&D and Capex

R&D spending in photonics is substantial, given the competitive nature of this highly innovative industry. In addition, photonics companies make capital expenditures (capex), which are investments in PPE (property, plant and equipment), mainly in expansion and modernisation measures related to infrastructure, production facilities and equipment.

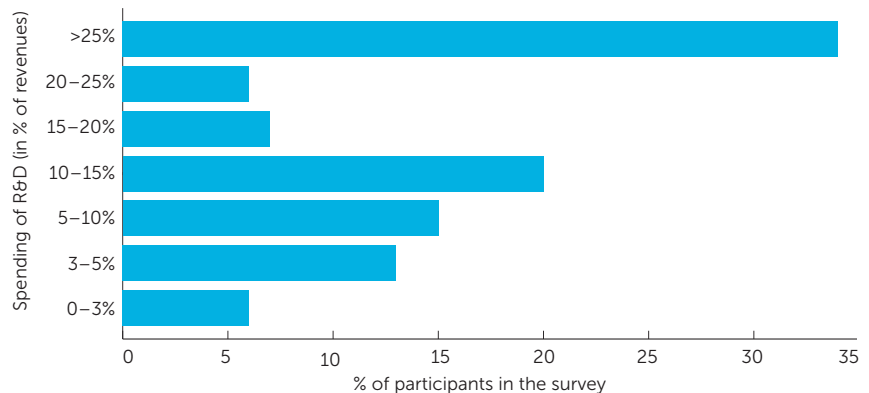
In order to give as clear a picture as possible of the statistics on R&D and investment intensity, two complementary measures have been used:

- On the one hand, about 50 photonics companies from different countries operating in all segments were selected, and the information on R&D and Capex was extracted from the financial reports. These companies are either large groups or medium-sized companies (there is no published information on small companies). It should be noted that in order to ensure that the statistics are representative of photonics, we have selected companies whose main activity is in photonics or large groups where we had figures on R&D in the main photonics division, as is the case for Philips, for example.
- On the other hand, questions on R&D spending were included in the internet survey made at the end of 2022. This made it possible to obtain figures for small enterprises and start-ups and to compare them with larger enterprises.

For the selection of large companies, a simple average of the percentages resulted in an R&D intensity of 10.3%. Weighted by the turnover of the companies, the average is 10.2%, which corresponds to an R&D intensity of more than 60 billion euros in total turnover and is, therefore, significant for the photonics sector in Europe in 2022. This figure is almost the same as that obtained for 2019. With regard to Capex, the figures obtained are 5% in 2019 and 5.4% in 2022. There is an increase, albeit small.

Figure 18 – Results of the survey about R&D spending (as a percentage of the revenues)
Source: Tematys/Photonics21, 2023.

The results of the survey are presented in Figure 18.



Regarding the survey results, it is astonishing to see a response rate of more than 30% for an R&D intensity > 25%. This high figure comes from the responses of small companies (84% of companies responding >25% for R&D spending have revenues < €10 million). Many of these small companies are start-ups. For a start-up, it is not surprising to have these figures and, especially at the beginning of the activity, the R&D spending can be well above 25% (and even 100%!).

Taking into account the size of the companies, the following figures were obtained from the survey:

- For SMEs (turnover < €50 million), the average R&D intensity is about 14%. This figure is close to the one obtained from 2020.
- For large companies (turnover > €50 million), the average R&D intensity is about 11%. However, considering the small number of these companies in the answers, we calculate that our estimation of 10.2% for the selection of companies is more accurate.

Finally, the average R&D intensity is estimated at 10.5% for the whole photonics industry in Europe.

The average ratio of total investment in the European photonics industry (R&D + Capex) is around 16% in 2022 well above the average of the EU Industrial Investment.

In short, the average ratio of total investment in the photonics sector (R&D 10.5% + Capex 5.4%) is around 16% in 2022 compared to 15% in 2019 (14% in 2015), an increase of around one point.

For comparison, for the 1,000 companies in the EU with the largest R&D¹³, the average R&D intensity is almost 4%, and the Capex is 6.5%, i.e. a total investment of just over 10%. The photonics industry is well above in terms of total investment.

The intensity of R&D in other parts of the world is of the same order of magnitude as in Europe, as obtained from a selection of companies in the US and Asia. On the other hand, Capex is often higher, especially for companies that manufacture components such as CMOS sensors, which require very significant investments.

¹³ The EU Industrial R&D Investment Scoreboard, European Commission, Joint Research Centre, 2022.

The figure below shows an evaluation of R&D Intensity for the photonics industry in the US.

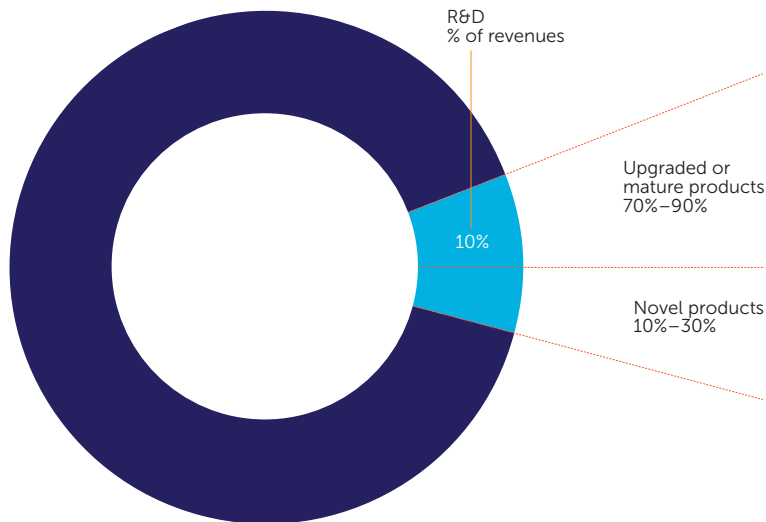


Figure 19 – Evaluation of R&D Intensity for the photonics industry in the US
Source: Tematys/Photonics21, 2023 adapted from OPTICA¹⁴.

It is important to note that these average figures may vary significantly between companies. In Figure 20 below, the R&D intensity shows a wide range of values and varies from 3 to almost 20% for analysed companies.

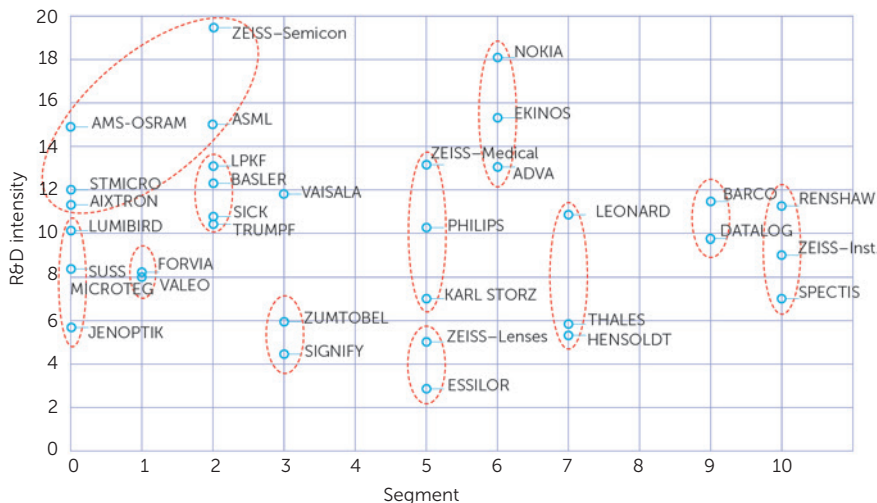


Figure 20 – R&D Intensity vs. segment for some European photonics companies.
Source: Tematys/Photonics21, 2023 – Data from The EU Industrial R&D Investment Scoreboard¹⁵.

0	Components and materials
1	Mobility
2	Industry 4.0
3	Environment, lighting and energy
4	Agriculture and food
5	Healthcare and wellness
6	Telecommunication
7	Defense and security
8	Large inst. and space
9	Consumers
10	Optical instruments

The level of R&D investment varies significantly across different application segments. For instance, the spectacle and contact lenses segment has a relatively low R&D intensity of around 4%. In comparison, telecommunications has an average R&D intensity of 15%. The manufacture of semiconductors has an average R&D intensity of 15–16% (12 to 20%).

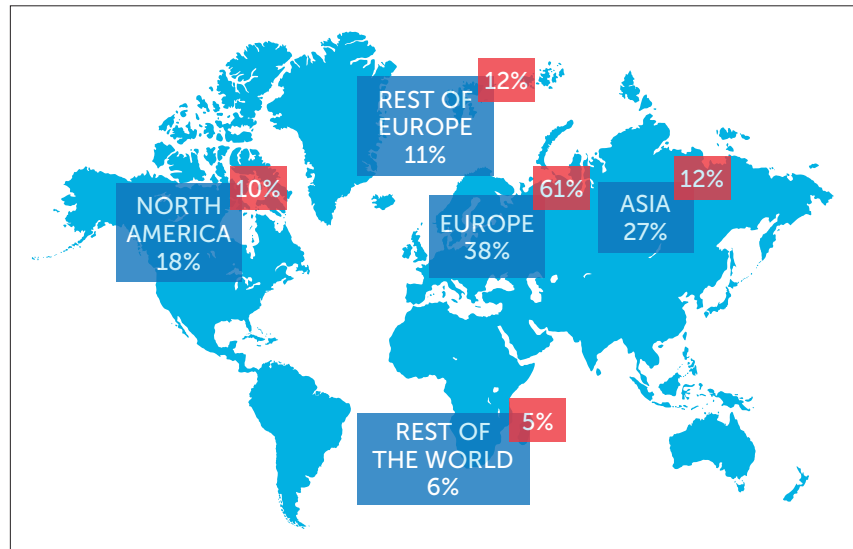
¹⁴ Source: OPTICA, Optics and Photonics – The Impact on a Global Economy, 2022.

¹⁵ Data: The EU Industrial R&D Investment Scoreboard, European Commission, JRC, 2022.

3.5 Analysis of photonics industry exports

The European photonics industry's sales by geographical area are presented in Figure 21 below.

Figure 21 – European photonics sales by geographical areas in 2022 (in blue squares) and for comparison, the statistics for all manufactured goods (in the upper right red squares)
Source: Tematys/Photonics21, 2023.



The above figures are based on the results of the Photonics21 survey on supply chains conducted at the end of 2022. We cross-referenced these results with the sales figures achieved by major European photonics companies. These results are also consistent with the statistics published by SPECTARIS for Germany (Trend Report Photonics 2023/2024), with minor differences for the EU (44% vs. 38%) and the US (13% vs. 18%).

The European photonics industry exports approximately half of its products by value. The European photonics industry has maintained a stable export figure for the past decade. In comparison to all manufactured products, photonics exports are significantly higher, accounting for 51% of production compared to 27% – almost double. This difference is particularly noticeable in Asia, where photonics exports account for 27% compared to 12%.

The breakdown by geographic region remains consistent across segments, with two exceptions. In the 'Lighting, Environment, and Energy' segment, which mostly pertains to lighting in Europe, the European share increases from 49% to 69%, resulting in a decrease in exports to approximately 30%. Conversely, in the 'Photonic Systems for Industry' segment, Europe's share decreases to 38%, while exports increase significantly to 62%, with a rise in the percentage of sales to Asia and the rest of the world.

3.6 Analysis of the impact of recent crises on European photonics industry

Summary of the European economy during the period (2019–2022) with a focus on crises and events impacting the industry

Europe's economy experienced significant shifts and challenges between 2019 and 2022, marked by a series of unprecedented events and transformations.

2019 – Pre-COVID relative stability

In 2019, the economy was relatively stable, albeit with modest growth. Countries were focusing on issues like trade, internal market strengthening, and addressing the Brexit implications. The United Kingdom's exit from the EU, formally completed on January 31, 2020, had widespread economic consequences. It affected trade, labour mobility, and regulatory frameworks. Industries that relied heavily on trade with the UK, such as automotive, agriculture, and fisheries, experienced particular challenges due to new trade barriers and uncertainty.

2020 – COVID Pandemic onset

The arrival of the COVID-19 pandemic early in 2020 had a seismic impact on the EU economy. Governments implemented lockdowns and restrictions to control the virus spread, leading to a sharp contraction in economic activity. Sectors like tourism, automotive, and aviation were particularly hard hit. The EU's GDP saw a significant decline, marking the worst recession in its history.

The industrial production index, a key indicator of business cycles, showed a sharp decline in 2020 due to the COVID-19 pandemic, with an 8% fall reflecting decreased output in all manufacturing types. This downturn was more severe compared to the 2009 financial crisis.

The pandemic exacerbated pre-existing vulnerabilities in global supply chains. Industries such as automotive, electronics, and manufacturing faced shortages of key components like semiconductors, leading to production delays and increased costs.

2021 – Economic stimulus and gradual recovery

In response to the economic downturn, the EU and its member states introduced substantial fiscal stimulus measures. The landmark agreement was the Next Generation EU (NGEU) recovery fund, amounting to €750 billion, aimed at supporting recovery and resilience. This plan focused on digitalisation, green transition, and bolstering the internal market.

In 2021, as vaccination campaigns accelerated and restrictions eased, there was a gradual economic recovery. The economy started to show signs of growth again, although the recovery was uneven across member states.

2021/2022 – Inflation and Geopolitical Tensions

Despite the recovery, Europe faced new challenges, such as rising inflation, partly driven by supply chain disruptions and increased energy prices. Energy prices soared due to a combination of factors, including increased demand as economies reopened post-pandemic, limited supply, and geopolitical

tensions. This crisis particularly affected energy-intensive industries, leading to higher production costs and challenges in maintaining operations.

The Russo-Ukrainian War, beginning in February 2022, led to further disruptions in energy supplies and global commodity markets. It heightened geopolitical tensions, increased energy prices, and caused additional disruptions to the supply of very specific components, as well as raw material shortages (e.g. palladium, platinum, and nickel).

A mix of unprecedented challenges and ambitious policy responses characterised the period (2019–2022). The EU's ability to coordinate across its member states played a crucial role in managing these challenges and setting a path for future growth and stability. Throughout the period, the EU continued to emphasise its long-term goals, in particular, digital transformation and the Green Deal, which aimed for a sustainable and resilient economy.

Summary of recent crises and events impacting the photonics industry

Between 2019 and 2022, several crises and events significantly impacted the photonics industry in the EU and other European countries:

COVID-19 Pandemic (2020–2022): The pandemic had a profound effect on the EU economy. Lockdowns and social distancing measures led to business closures, supply chain disruptions, and significant declines in demand in some sectors like automotive healthcare (spectacle lenses and lasers).

Supply Chain Disruptions: the photonics industry faced shortages of key components like semiconductors, leading to production delays and increased costs. Photonics also relies on specific raw materials, like rare earth elements and high-purity silicon. Disruptions in their supply impacted the manufacturing of photonic components.

Rising Energy Prices (2021–2022): Energy prices soared due to a combination of factors, including increased demand as economies reopened post-pandemic, limited supply, and geopolitical tensions. This increase directly impacted the operational costs of photonics companies, especially those with high energy demands, such as clean room environments used in photonics manufacturing and research.

Russo-Ukrainian War (Starting in 2022): The conflict, beginning with Russia's invasion of Ukraine in February 2022, led to further disruptions in energy supplies and global commodity markets. It heightened geopolitical tensions, increased energy prices, and affected some components and devices imports and exports.

Inflation and Economic Uncertainty: The period saw rising inflation rates across the EU, partly driven by supply chain disruptions and energy price hikes. This inflation led to increased production costs and uncertainty in investment.

Skilled Labor Shortages: The shortage of qualified professionals in photonics hindered innovation and growth in the Photonics industry.

Survey and study of the impact of recent crises on Photonics industry

Photonics21 has carried out two surveys on the problems faced by the photonics industry in the wake of COVID-19 and other crises and events that followed. The first, at the end of 2022, was dedicated to supply chain issues (which was the subject of a report in early 2023)¹⁶. The second, at the end of 2023, was devoted to the impact of the various crises on the photonics industry and to the European industry's dependence on advanced materials¹⁷.

With regard to the impact of the various crises, the results are presented in the two figures below.

Events/crises impacting your company

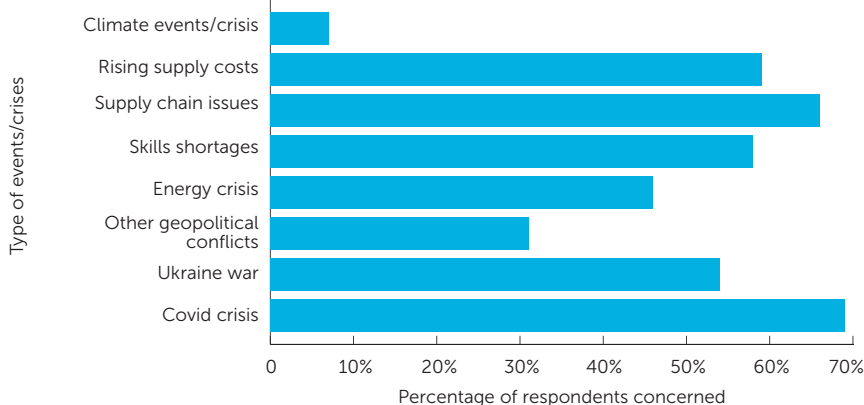


Figure 22 – Results of the survey about the events and crises impacting photonics companies
Source: Tematys/Photonics21, 2023.

Type of impact on your company

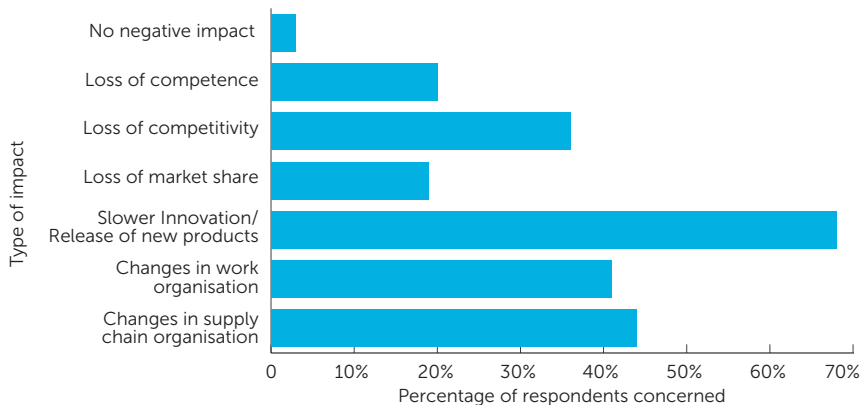


Figure 23 – Results of the survey about the type of impacts of crises on Photonics companies
Source: Tematys/Photonics21, 2023.

Figure 22 shows the crises with the greatest impact by the end of 2023, according to respondents. The Covid crisis is still considered to have the greatest impact. While the Covid crisis is still fresh in people's minds, it is the issues and changes it has caused or highlighted that are having the greatest impact on companies. It is unlikely that the epidemic will still have a major direct impact on companies.

¹⁶ Photonics21/EPIC, Photonics Industry Supply Chain Survey 2023, April 2023, 230421_Supply_Chain_Report_Final_C3.pdf (photonics21.org)

¹⁷ Photonics21 internal report, not published.

Supply chain issues

Supply chain problems are next in line, impacting 66% of companies. This figure is down on the result obtained a year earlier: At that time, the report highlighted that European photonics firms heavily rely on overseas supply chains, particularly on key sources of goods from China. This dependency was perceived as a significant risk, with more than 80% of European photonics companies experiencing major supply-chain issues, including shortages and delivery delays.

Despite the slight reduction in the number of companies affected, this remains a major problem, along with the rising supply costs.

The former report also highlights that the key choke points for European photonics companies on the supply input side are Semiconductors and Optical components.

One of the most significant shortages in photonics was in optical fibres, which are used in a wide range of applications, including telecommunications, medical devices, lasers and scientific instruments. With countries implementing lockdowns and restrictions on manufacturing and shipping, the supply of fibre optic cables was disrupted¹⁸, leading to delays in digital setups.

There have been and still are shortages of other optical and photonic components, such as optical lenses¹⁹, mirrors, filters, and LEDs²⁰, which are used in a variety of industries, including lighting, healthcare, defence, and aerospace.

The COVID-19 pandemic has clearly demonstrated the risks related to dependency on value chains: the pandemic itself, as well as the political decisions applied in various countries all over the world to cope with the COVID-19 pandemic, led to the collapse of global value chains in no time at all.

In fact, nobody would doubt today that the fragmentation of value chains can create highly problematic situations of dependency, namely related to the access to raw materials, supply of critical technologies or components within a specific value chain, external policies or standards which may prevent trade or limit access to goods.

Other factors impacting photonics companies

The geopolitical landscape in 2022, including the war in Ukraine and tensions involving China and Taiwan, has raised concerns about the stability of supply chains and the sourcing of critical components and materials. These political and economic uncertainties pose significant threats to the photonics industry.²¹

¹⁸ "Global shortage of fibre optic cable threatens digital growth", The Financial Times, 2022.

¹⁹ <https://www.visionmonday.com/business/labs/article/optical-labs-get-creative-about-supply-chain-disruptions-and-shortages>

²⁰ <https://spie.org/news/seeking-balance-the-photonics-industry-grapples-with-global-semiconductor-shortage?SSO=1>

²¹ <https://www.electrooptics.com/analysis-opinion/supply-chain-among-biggest-challenges-2023-say-photonics100>

Geopolitical instability is also a concern. Tariffs and trade disputes between major economies can disrupt the global trade of photonic products and components. Also, political tensions in key regions can affect the supply chain and market access.

Rising energy costs, partly due to global inflation and regional instability, have focused attention on the need for energy-efficient photonic technologies. The energy crisis also affects research and development activities, particularly in Europe, where high energy prices might limit the operation of key laboratory areas, impacting the development of photonic projects.

Shift towards localisation

To mitigate these challenges, a majority of the industry players expressed a willingness to pay higher prices to source components within Europe, suggesting a shift towards more localised and dependable supply chains. This is seen as a strategic move to secure supply chains and ensure the availability of advanced photonic components and systems.

These factors collectively demonstrate the photonics industry's vulnerability to various crises, especially to supply chain disruptions, and the necessity of strategic responses, including diversification of supply sources and investment in localised production capabilities.

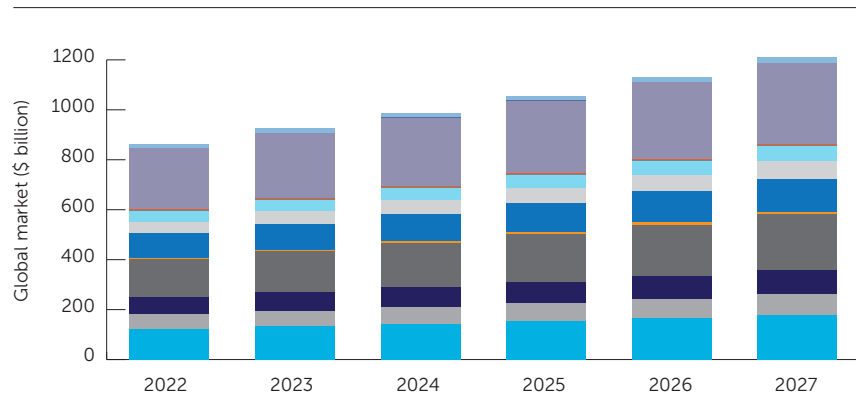
Impact on Photonics Companies

These issues must be taken seriously. Figure 22 shows the impact on photonics companies in multiple ways. For example, first and foremost, there is a slowdown in innovation and new product releases, but also a loss of competitiveness and market share.

3.7 Forecast for global and European photonics industry growth

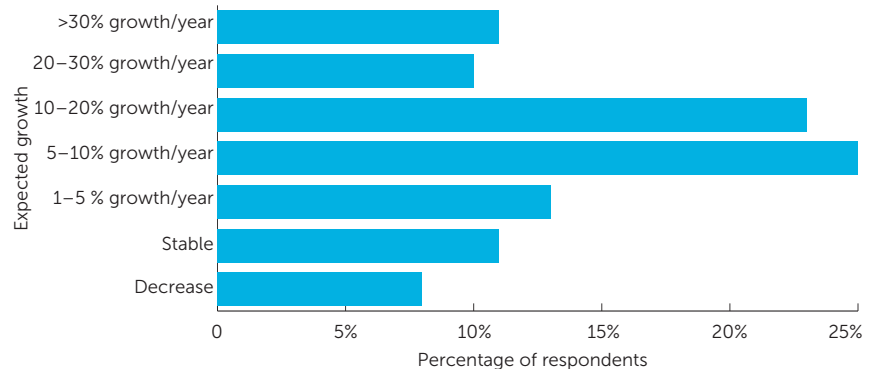
According to our evaluation, the global photonics market will reach about \$1.2 trillion (around €1.09 trillion at 2021 exchange rate) by 2027. Of course, making forecasts is always challenging. In particular, we have seen that there are some uncertainties due to a number of crises and events that are still ongoing, but we are confident about the mid-term and long-term growth (around 6 to 7% per year). For an analysis of the impact of crises on global and European photonics, please see part 3.5.

Figure 24 – Forecast for the photonics global market by segment (\$ billion)
Source: Tematys/Photonics21, 2023.



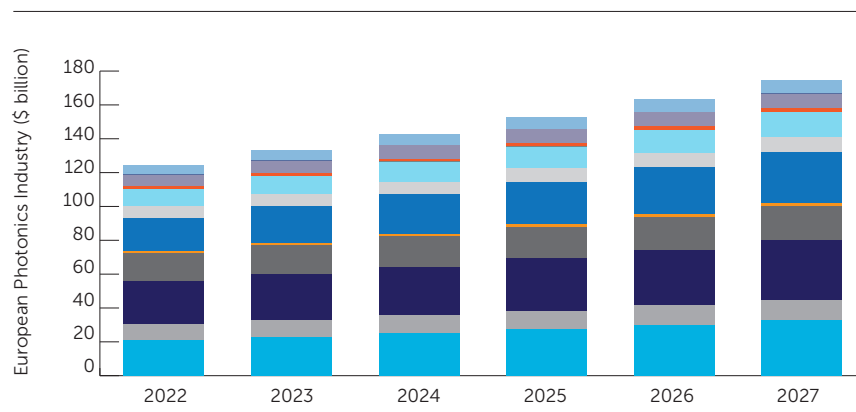
The results of the survey were used to assess the perspective in Europe. The results are presented in Figure 25. The wide range of responses (from decrease to growth of >30%) is an indication of the uncertainty that still surrounds economic factors.

Figure 25 – Results of the survey concerning the expected growth in the three next years (in % per year)
Source: Tematys/Photonics21, 2023.



According to our evaluation, the European photonics industry will reach about €175 billion by 2027. The forecast by segment is presented in the figure below.

Figure 26 – Forecast for the European photonics market by segment (\$ billion)
Source: Tematys/Photonics21, 2023.



4. European photonics industry by application segment

4.1 Breakdown by segment

The total European photonics production in 2022 is estimated at **€124.6 billion**, with a CAGR of 6.5% from 2019 to 2022. The breakdown by segment is shown in Figure 27 below.

Looking at Figure 8, it is clear that the distribution of the European photonics industry is different from that of the global picture.

European Photonics Production (2022) = €124.6 Billion

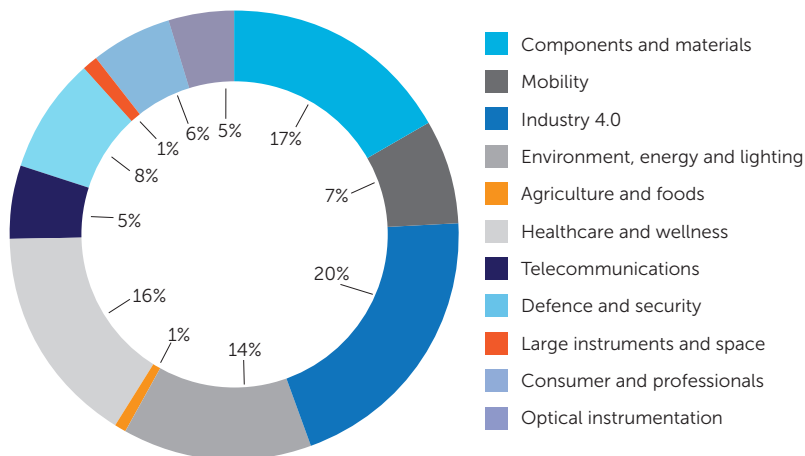


Figure 27 – European photonics industry 2022
– breakdown by application segment
Source: Tematys/Photonics21, 2023.

The segment covering photonic components and materials was worth €21 billion in 2022 (17% of the total). Europe needs to remain strong in photonic components and materials, as these are the building blocks of all photonics systems. This segment is directly linked to the procurement of photonics, and a strong production figure leads to a purchasing rate for European photonics companies of over 50% in Europe.

The largest segment (20%) consists of photonics products used in industrial manufacturing and accounted for €25.2 billion. This includes production technology products (industrial laser systems and semiconductor manufacturing systems) worth €18.2 billion and optical measurement & machine vision products worth about €7 billion.

The second segment, photonic devices and systems for healthcare and wellness accounted for a European production volume of €19.75 billion, or 16% of European photonics production.

The third segment consists of photonic systems for the environment, energy and lighting. It accounted for €17 billion (14% of the total), the majority of which was for lighting systems.

Photonics products for mobility have the lowest CAGR due to a decline in car production. This is only partly compensated by the increasing rate of

4 European photonics industry by application segment

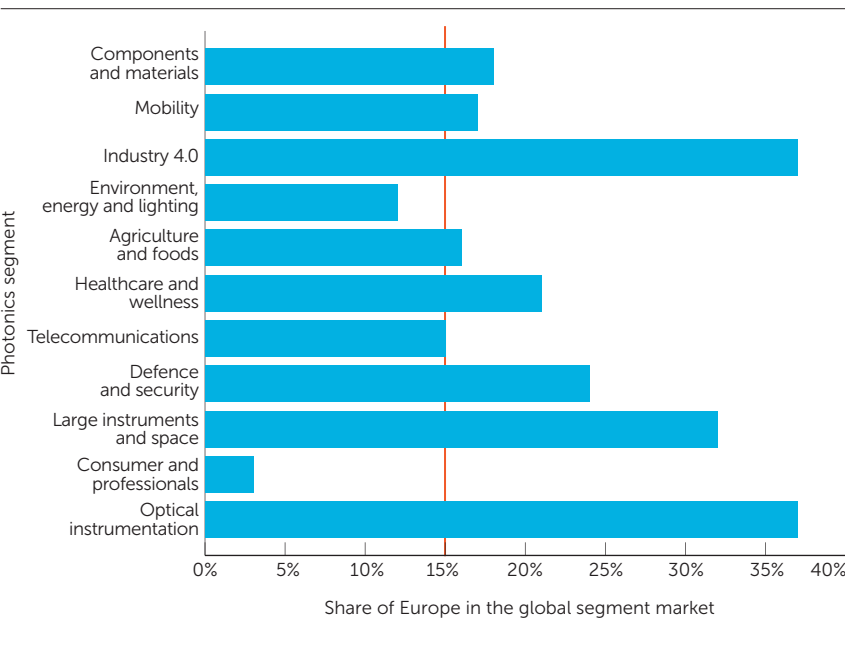
adoption of photonics in cars. They accounted for a European production volume of €9.3 billion, or 7.5% of European photonics production. Optical systems for telecommunications accounted for a total market of €6.9 billion (5.5% of the total). They included optical network systems and optical cables.

The remaining 20% of the European photonics industry consists of photonics systems for Defence & Security (8%), Consumers (6%), Optical instrumentation (4%), as well as Large instruments and Space (≈1%) and systems for agro-food (≈1%).

Market share of the European photonics industry by segments

Following the detailed segmentation of the European photonics industry, it is essential to identify the segments in which European photonics has a large market share and those in which it is lagging behind the leaders. Indeed, this analysis is the first building block of a strategy for the successful development of European photonics in the future.

Figure 28 – European photonics industry – market share by segment
(The vertical red line indicates the average market share of European Photonics)
Source: Tematys/Photonics21, 2023.



The largest segment in Europe, Photonics Systems for Industry, also represented the largest share in the global markets: 38%. Europe has a significant market share in the production of photonic systems, i.e., industrial laser systems and semiconductors manufacturing (42%) and machine vision (32%).

Three other segments accounted for significant production volumes and important global market shares: Healthcare & Wellness, Components & Materials and Environment, Lighting & Energy. This is clearly shown in Figure 29 below.

4 European photonics industry by application segment

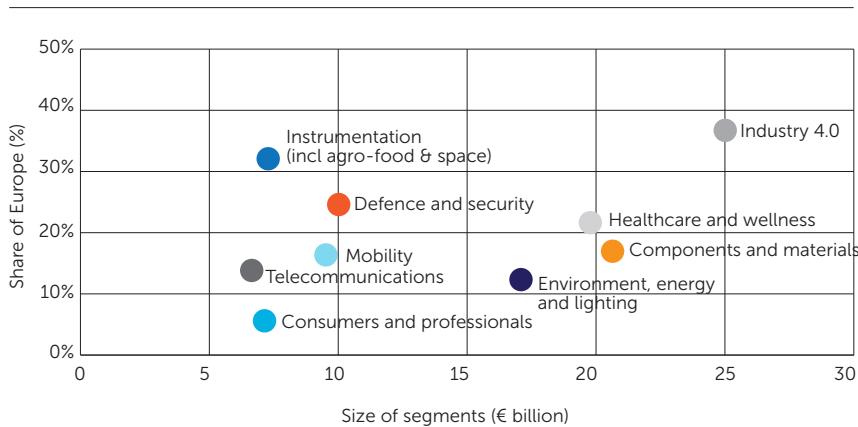


Figure 29 – Size of the main segments (€ billion) versus market share (%) of Europe
Source: Tematys/Photonics21, 2023.

With a production volume of €19.8 billion in 2022, photonic devices and systems for healthcare and wellness accounted for a global market share of 21% in 2022: 26% for instruments & devices and 14% for lenses for vision correction.

In the global market for photonic components & materials, European production accounted for €21.1 billion, a market share of 18%. Europe has a significant market share in laser sources, infrared imagers and 3D sensors. However, European production of CMOS sensors remains low.

In photonics systems for Environment, Lighting and Energy, European production accounted for a global market share of 12% in 2022. This is a significant decrease in market share compared to 2019. This is mainly due to the huge increase in PV module production in China. Europe still has a substantial market share in lighting (20%) and environmental monitoring (around 30%). However, the European market share for PV modules is less than 2%.

The telecommunications segment accounted for €6.9 billion, representing a 15% share of the world market. European photonics production increased between 2019 and 2022 at a lower CAGR than the global market, but there is a recovery compared to the previous period, mainly related to 5G.

In the global market for photonic systems for the mobility sector, European production accounts for €9.3 billion, representing a global market share of 17%. Of the top 5 international manufacturers of automotive headlights (Koito, Valeo, Marelli Automotive Lighting, Forvia and Stanley), three are European, and innovation in this segment remains high in Europe.

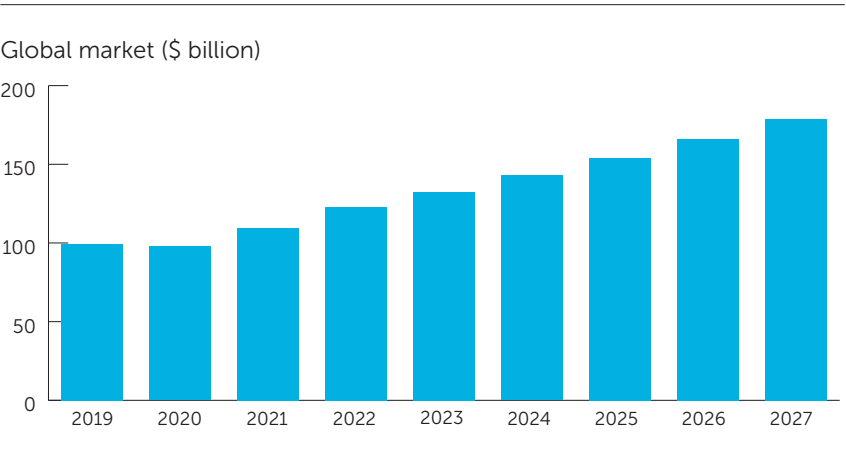
In the consumer and professional photonics segments, the European industry has a small market share. It plays a niche role in products such as display materials, high-end digital cameras, and high-end laser printers.

4.2 Photonics – core components and materials

World Market (2022)	\$122.9 billion
CAGR 2019–2022 (\$)	7.4%
European production (2022)	€21.1 billion
CAGR 2019–2022 (€)	8.5
% of Global Market (\$)	18%
Main sub-segments	
Passive Components and Fibres	
Sources (LED and Lasers)	
Image sensors and detectors	
Materials and Equipment	

Figure 30 – Forecast for the photonics global market: Segment Photonics – core components and materials
Source: Tematys/Photonics21, 2023

World market evolution



World market summary

The market for photonic components, modules, and materials was valued at \$122.9 billion in 2022, with a compound annual growth rate (CAGR) of 7.4% between 2019 and 2022.

- In 2022, the market for passive optical components, including coatings, was valued at \$38 billion. Visible range components make up the largest share of this total, accounting for over 80%. In comparison, infrared components account for around 15% and UV components for 4%.
- The combined value of all sources was around \$33 billion, with \$14 billion attributed to LEDs and \$19 billion to laser sources.
- Optical fibres make up approximately \$11 billion (including preforms).
- The sensor market as a whole was valued at \$33.4 billion, with CMOS image sensors accounting for around \$23 billion.
- Lastly, materials and equipment accounted for approximately \$7 billion.

European production summary

In 2022, European production accounted for €21.1 billion, representing an 18% market share (17% of the total output in Europe) in the global market of components and materials.

Europe has a significant market share in the field of laser sources, LEDs, infrared sensors, and 3D sensors. However, European production of CMOS sensors is relatively low.

Germany holds over 40% of the share in European production due to a robust manufacturing base for optical components. France and the UK each hold 15%. Other significant producing countries are Italy, Switzerland, the Netherlands, Sweden, Belgium, and Austria.

The primary producing companies are Aixtron, AMS Osram, Berliner Glas, Coherent, Corning, Gooch & Housego, Heraeus, IQE, Jenoptik, Laser Components, Lumentum, Lumibird, Lumileds, Lynred, Prysmian, Qioptiq, Saint-Gobain, Schott, Soitec, ST Microelectronics, and Umicore.

Sub-segments and main products

Optical components consist of unmounted and mounted components such as lenses, prisms, and polarisers. These components have a wide range of applications, from consumer electronics to industrial laser equipment, measurement, imaging, and analytical equipment. This segment also includes optoelectronic components like LEDs, sensors, detectors, and laser modules. For instance, although laser systems for materials processing fall under the Industry segment, we include laser sources in this segment.

Note: Lenses for vision correction are included in the Healthcare segment.

The global market for photonics components and modules was \$115 billion in 2022 (not including Materials/Equipment). The main component types are given below.

Categories	Components description	\$ billion (2022)
Passive Components	Mirrors, prisms, lenses, gratings, filters (including optical coatings)	38.0
Sources	LEDs	14.0
	Semiconductor lasers	8.0
	Other laser sources (Solid-state, fibre)	11.0
Image sensors & detectors	CMOS image sensors	23.0
	IR Image sensors (Incl. Microbolometers)	2.0
	X-ray detectors	2.1
	Others (CCD ...)	2.0
Fibres	Preforms & Optical fibers	11.0
Other components	Mainly detectors: Thermopiles, PIR, thermodiodes, Photodetectors ...	4.0

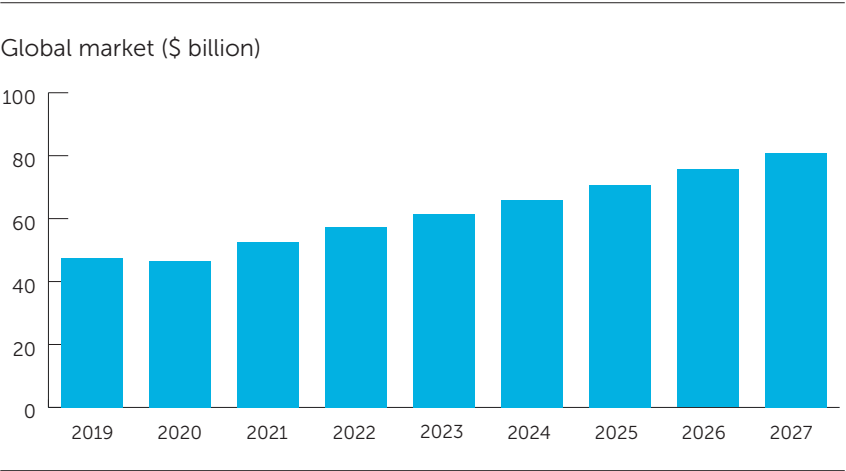
Table 4 – Sub-segments of the segment "Core components and materials" and product typology
Source: Tematys/Photonics21, 2023

4.3 Mobility: automotive, maritime, railway, aeronautics

World Market (2022)	\$57.5 billion
CAGR 2019–2022 (\$)	6%
European production (2022)	€9.3 billion
CAGR 2019–2022 (€)	4.5%
% of Global Market (\$)	17%
Main sub-segments	
Lighting systems	
Displays	
Sensors: Cameras, LIDARs	

Figure 31 – Forecast for the photonics global market: Segment Mobility: automotive, maritime, railway, aeronautics
Source: Tematys/Photonics21, 2023

World market evolution



World market summary

All photonic systems for the mobility sector (automotive, railway, aeronautics, etc.) account for a market of \$57.5 billion in 2022. This market has been growing at a CAGR of 6% since 2019. The decline in vehicle production has been compensated by the increasing adoption of photonics in the automotive sector.

The most important part is made up of lighting systems (around \$26 billion with a very low CAGR), with car headlights being the most important. This is followed by displays, with a total market of \$22 billion. This last sub-segment has grown strongly, especially in the automotive sector.

However, the fastest growing sub-segment is clearly automotive sensors, with a CAGR of more than 10% in recent years due to the growth of ADAS systems and the emergence of autonomous vehicles. The camera market is around \$7 billion. The lidar market is still small at around \$0.7 billion but is expected to grow strongly in the coming years.

European production summary

In the global market for photonic systems for the mobility sector, European production accounted for €9.3 billion in 2022, representing a global market share of 17%.

Germany is the largest producer of photonic systems for mobility in Europe, with a share of around 40%. Widening countries host a number of factories and together have a share of around 25%. Several other countries hold a share of between 5% and 10%, including Italy, France, Sweden and the UK.

Of the top five international manufacturers of automotive headlamps (Koito, Valeo, Marelli Automotive Lighting, Forvia and Stanley), three are European. Innovation in this field is very high in Europe. European headlights are true photonic systems with free-form optics, light guides and, increasingly, cameras for adaptive front lighting.

Valeo is the European leader in sensors and the only company producing Lidar in large quantities for the automotive industry. There is currently no company in Europe capable of challenging its leadership in Lidars. However, there are many SMEs and start-ups in this field in Europe.

Sub-segments and main products

Sub segments	Product typology
Imaging & sensors	Cameras module for automotive
	Night vision imaging
	Speed and distance optical sensors
	Automotive LIDAR, LIDAR for other mobility means
Lighting	Automotive LED lighting, Maritime, Railway and aeronautic lighting
	Laser Headlights
Displays	Automotive displays systems
	Automotive display panels
Connecting and Datacom	MOST components and systems
Projectors, HUD & AR/VR	HUD in automotive and aeronautics, AR/VR in aeronautics and other mobility means

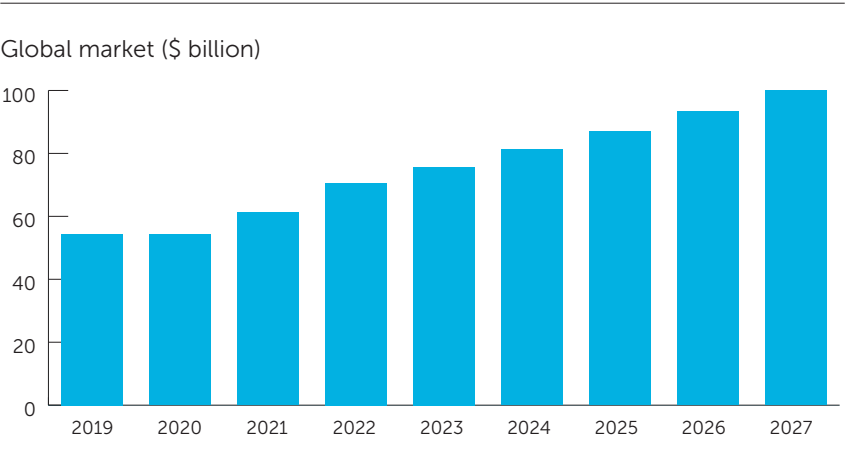
Table 5 – Sub-segments of the segment “Mobility: automotive, maritime, railway, aeronautics” and product typology
Source: Tematys/Photonics21, 2023

4.4 Industry 4.0: Processing and machine vision

World Market (2022)	\$70.6 billion
CAGR 2019–2022 (\$)	9%
European production (2022)	€25.2 billion
CAGR 2019–2022 (€)	8.8%
% of Global Market (\$)	38%
Main sub-segments	
In-line control and measurement	
Machine vision systems	
Processing: laser systems	
Processing: semiconductor and displays manufacturing	

Figure 32 – Forecast for the photonics global market: Segment Industry 4.0: Processing and machine vision
Source: Tematys/Photonics21, 2023

World market evolution



World market summary

The industrial photonics segment (mainly processing and machine vision) accounted for \$70.6 billion in 2022, with a CAGR of almost 9%. After a decline in 2019 and 2020, the segment experienced a significant increase in 2021 and 2022. The segment includes four main sub-segments:

- Machine vision systems were worth \$12.6 billion with a CAGR of 6%.
- Sensors used in manufacturing processes have a total market of \$11 billion, to which barcode scanners must be added at around \$2.9 billion.
- The third sub-segment is industrial laser systems: \$22 billion (including about \$4 billion for micromachining).
- All semiconductor (especially photolithography) and display manufacturing systems together accounted for \$19.4 billion. The growth (>11%/year) of this sub-segment explains the high CAGR of all industrial systems.

European production summary

In the global market for photonics systems, European production accounted for more than €25.2 billion in 2022, representing a global market share of 38%.

It accounted for 20% of total photonics production in Europe. Europe has a significant market share in photonics systems for manufacturing, in particular, industrial laser systems and semiconductor manufacturing (43%) and in machine vision (32%).

The main producers of industrial photonics systems in Europe are Germany, with a share of around 55% (Laser systems for materials processing, lasers for lithography) and the Netherlands (Photolithography), with a share of 20%. Italy, Switzerland and the United Kingdom follow. With Zeiss, ASML and Trumpf, Europe remains the only supplier for EUV photolithography. The positive trend will persist thanks to growth in the semiconductor and microwave sectors.

Germany is the leader in industrial sensing and imaging, thanks to key players (Sick, Basler, TKH Group/Allied Vision...). The United Kingdom, France, Italy, Switzerland, the Netherlands and Sweden follow. Many other countries are home to machine vision manufacturing. The competitive environment in this segment is still highly fragmented.

Sub-segments and main products

Photonics systems in this segment cover equipment used in industrial manufacturing. These include processing systems: laser systems for materials processing and systems for lithography, a key manufacturing process for semiconductors and flat panel displays. It also includes systems for in-line control and measurement, such as machine vision and online or final quality control, as well as shape, colour, size, and defect inspection. The main user industries for machine vision are the semiconductor, electronics and flat panel display industries. The main tasks of vision systems in industrial manufacturing are production monitoring, and Quality Assurance & Quality Control (QA/QC).

Sub segments	Product typology
In-line control and measurement	Process Spectroscopy and IR laser-based
	Optical Gas sensing
	Metrology for semiconductor
	In-line metrology (shape, colour, size, defects)
	Barcode Scanners
Machine vision	Cameras & visible-light imaging systems
	Coordinate Measurement Machines
	Non-conventional imaging systems (SWIR, MWIR, LWIR, THz)
Manufacturing & Processing	Laser systems for Macro-processing (cutting, welding, drilling, AM ...)
	Laser systems for Micro-processing
	Lithography systems for semiconductors and displays
	Laser annealing, etching, sputtering, and lift-off for displays
	LED/laser-based 3D printers

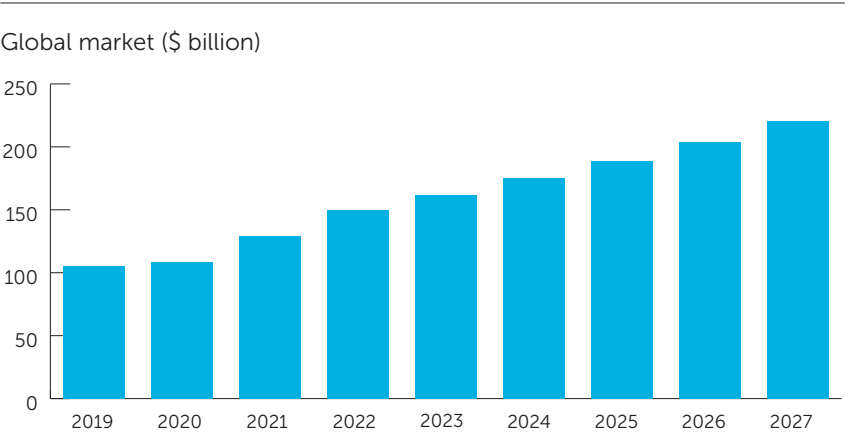
Table 6 – Sub-segments of the segment "Industry 4.0: Processing and machine vision" and product typology
Source: Tematys/Photonics21, 2023

4.5 Environment, lighting & energy

World Market (2022)	\$150 billion
CAGR 2019–2022 (\$)	12%
European production (2022)	€17 billion
CAGR 2019–2022 (€)	3%
% of Global Market (\$)	12%
Main sub-segments	
Measurement of pollution and GHG	
LED-based lighting modules & systems	
Photovoltaic modules	
Solar thermal energy (STE) systems	

Figure 33 – Forecast for the photonics global market: Segment Environment, lighting & energy
Source: Tematys/Photonics21, 2023

World market evolution



World market summary

- Photonic systems for the environment, lighting and energy are the second largest segment in terms of value at \$150 billion, after the consumer and professional segment. These systems are directly related to sustainable development as they can monitor the environment, produce ‘clean’ energy or save energy by using energy-saving sources (LEDs).
- ▶ Photovoltaic modules are the most important sub-segment, accounting for \$74 billion. With an overall growth of around 50% between 2019 and 2022, the growth is huge. Installed capacity has increased from 120GW in 2019 to around 240GW in 2022. After some growth due to supply constraints, the price of modules has fallen from \$0.4 per watt installed to around \$0.25.
 - ▶ The second sub-segment is lighting at around \$66 billion and a CAGR that has fallen to around 5%.
 - ▶ The last two sub-segments are thermal solar (≈\$4 billion) and environmental instruments (≈\$6 billion).

European production summary

In the global market for photonics systems for the environment, lighting and energy, European production accounted for EUR 17 billion, or 12% of the world market. This share has collapsed as a result of the strong growth of the photovoltaic sub-segment, in which Europe has practically no presence.

This segment accounts for 14% of total production in Europe. Europe has a significant market share in lighting (> 20%) and environmental monitoring (around 30%). On the other hand, the European market share for photovoltaic modules is less than 2%. For more than ten years, the industry has been facing severe price erosion driven by companies in China. Germany is the largest producer of lighting products, with a share of around 40%. Several other countries have a share of 5–10%, including Italy, France, the UK, Poland and the Netherlands.

The European lighting manufacturers have long held and continue to hold leading positions in the global lighting market. The technology shift to LED-based lamps has attracted new players to the lighting market, particularly in Asia. In China, the government is providing strong support for companies in this segment. European players will need to innovate both in terms of products and business models to maintain market share in the face of new entrants.

Sub-segments and main products

Sub segments	Product typology
Lighting ²²	OLED and LED Lighting (Inside and outside) – Car lighting is included in the Mobility segment (as well as lighting for other mobility means)
Energy	Photovoltaic modules (do not include panels)
	Thermal solar
Control and Measurement (urban & domestic level)	Photoelectric sensors for luminous flux
	NDIR devices and mobile NIR and MIR systems for gas and particle sensing
	IR thermography
	Ambient and proximity light sensor
	UV-C systems (mostly for surfaces)
	UV-C disinfection systems (mostly for water decontamination)

Table 7 – Sub-segments of the segment "Environment, lighting & energy" and product typology
Source: Tematys/Photonics21, 2023

²² Note that this sub-segment does not include all luminaires. A spotlight or a desk lamp are not included in this sub-segment at all. These are "solid-state" lighting subsystems such as LED modules, devices including LEDs, drivers and lenses for home lighting (bulbs), street lighting or professional lighting such as LED-based ceiling tiles or power modules for show or sports lighting.

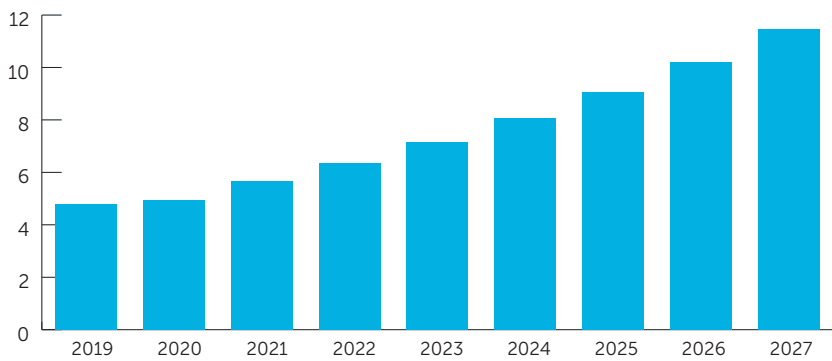
4.6 Agriculture and food

World Market (2022)	\$6.4 billion
CAGR 2019–2022 (\$)	14%
European production (2022)	€1 billion
CAGR 2019–2022 (€)	14%
% of Global Market (\$)	16%
Main sub-segments	
Imaging & Measurement	
Lighting in agricultural greenhouses	
UV disinfection	

Figure 34 – Forecast for the photonics global market: Segment Agriculture and food
Source: Tematys/Photonics21, 2023

World market evolution

Global market (\$ billion)



World market summary

Photonics for agriculture and food processing is still emerging, but it is clearly the fastest-growing segment. This segment accounts for around \$6.4 billion in 2022, with a CAGR of 14%.

Currently, lighting and UV disinfection are the dominant subsegments. Lighting advancements, especially with energy-efficient LEDs, facilitate controlled growth in greenhouses and novel farming practices like vertical and urban farming.

UV disinfection, the second largest subsegment, is crucial for various agricultural processes like irrigation and water treatment in breeding, dairy production, nurseries, and hydroponics. Beyond disinfection, UV technology, particularly UV-C, is emerging as a means to increase plant immunity and reduce reliance on chemicals for pest and disease control.

Other areas of growth in photonics for agro-food include imaging systems. These systems, which can be installed permanently or used in drones or robots, help in monitoring crop growth, animal welfare, and disease detection.

European production summary

A rapidly growing world population will dramatically increase the demand for food production. New practices, technologies and methods are therefore needed to achieve sustainable management of natural resources, manage climate change and ensure viable food production.

Europe has a key role to play in addressing these challenges due to its technological leadership in the agricultural sector and, in particular, at the forefront of high-tech precision farming. Relevant photonics devices and techniques include LiDAR, sensors, energy-efficient LEDs, spectroscopy, laser scanning, and multi- and hyperspectral imaging. The total production of Europe in this segment was about €1 billion in 2022.

In the market for agronomic and online sensors, which are mainly driven by tools for measuring sugars and proteins, the main players in Europe include FOSS, Zeiss, and Chauvin-Arnoux.

There are also many European SMEs and start-ups in this segment, including Avantes, AVL Motion, BoMill, Deka, Fritzmeier, Heliospectra, Lumichip, and Spectral Engines.

Sub-segments and main products

In this segment, we have only included systems that are fully dedicated to this market: vision and sensor systems and LED-based devices for lighting agricultural greenhouses.

It should be noted that general machine vision systems are included in the industrial segment. At the same time, a significant portion is used in the food industry.

In addition, optical measurement instruments such as reflectometers, particle measurement systems, FTIR systems, cytometers, etc., are also used in this segment.

Sub segments	Product typology
Imaging & Measurement	VIS Camera, RGB-NIR, Spectrometers, Cytometers, X-ray devices, THz devices
	Process Spectroscopy in the food industry
Photonics based treatment	UV-based devices online and on-field
	UV disinfection
Lighting	Horticulture illumination

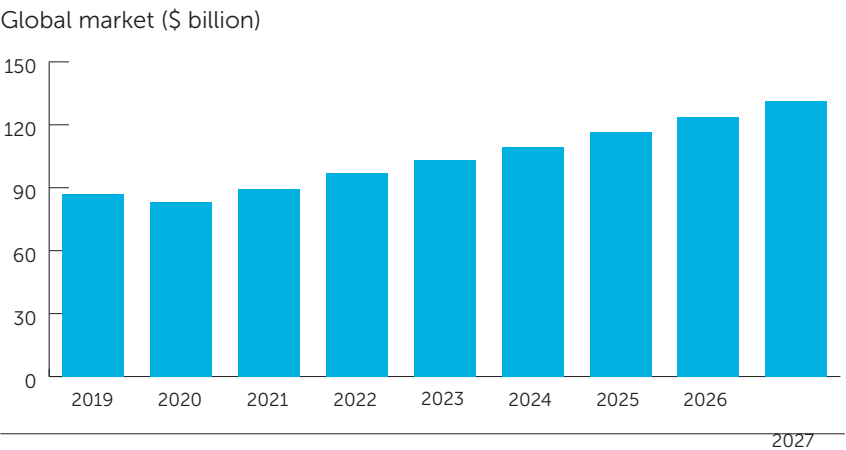
Table 8 – Sub-segments of the segment "Agriculture and food" and product typology
Source: Tematys/Photonics21, 2023

4.7 Healthcare and wellness

World Market (2022)	\$96.9 billion
CAGR 2019–2022 (\$)	4 %
European production (2022)	19.8 billion
CAGR 2019–2022 (€)	€6.5%
% of Global Market (\$)	21%
Main sub-segments	
Life science	
Medical Diagnosis	
Medical treatment	
Lens-based ophthalmic correction	

Figure 35 – Forecast for the photonics global market: Segment Healthcare and wellness
Source: Tematys/Photonics21, 2023

World market evolution



World market summary

The photonic devices and systems for the healthcare and wellness segment are worth a total of \$96.9 billion in 2022.

The largest sub-segment is eyeglasses and contact lenses, which account for a total of \$47.7 billion, growing at around 3% per year. Biophotonics devices and systems account for the remaining \$49.2 billion.

Diagnostic systems include:

- X-ray-based devices, such as radiography, mammography, and 3D tomography, cost \$19.3 billion.
- Other diagnostic equipment, which cost \$19.7 billion, includes endoscopes, OCT, and photo-acoustics.
- In vitro diagnostic and life science systems: DNA sequencers, cytometers, microscopes ...

The final sub-segment, laser-based treatment systems, was worth around \$6 billion.

European production summary

With a production volume of €19.8 billion in 2022, photonic devices and systems for healthcare and wellness account for 16% of European photonics production. This corresponds to a global market share of 21% (26% for instruments and devices and 14% for vision correction lenses).

Major products of the European industry include spectacles and contact lenses, endoscopes, microscopes and optical systems for medical diagnostics and biomedical instruments. The European industry is also well-represented in X-ray medical imaging, OCT and therapeutic laser systems. Its position is weaker in analytical equipment for biotechnology and pharmaceutical research and industry.

Germany accounts for almost 38% of European production, mainly due to a large share in the production of microscopes, endoscopes and medical imaging systems. France follows with a share of around 20%, followed by the United Kingdom (around 10%), Switzerland (around 5%) and Italy (around 5%). Many other countries host manufacturing in this sector (especially spectacles and contact lenses).

Sub-segments and main products

The Healthcare and Wellness segment includes therapeutic medical systems and in-vivo & in-vitro diagnostic systems. Life science comprises analytical systems used in research and development in the pharmaceutical and biotechnology industries. Major products include endoscopy systems and accessories, spectacle and contact lenses, therapeutic lasers and laser systems (including for cosmetic purposes), medical imaging systems (CR – computed radiography and DR – digital radiography), fluorescence diagnostic and analytical systems, diagnostic systems for ophthalmology, optical coherence tomography (OCT) systems, microscopes and surgical microscopes, capillary electrophoresis systems, DNA sequencers, cell sorters, plate and array readers.

It does not include non-photonic medical imaging systems such as MRI and ultrasound systems.

4 European photonics industry by application segment

Table 9 – Sub-segments of the segment
“Healthcare and wellness” and product typology
Source: Tematys/Photonics21, 2023

Sub segments	Product typology
Medical Diagnosis	X-rays-based (medical imaging) Mammography CT Scanner
	VIS-NIR based (dermatoscope, slit lamp, aberrometer ...)
	OCT
	Photoacoustic
	Other Laser-based (Raman, two photons, PDD)
	Surgery Microscopes
	Endoscopes
	Digital Pathology Scanners
Life science	Hematologic screeners
	Oximetry
	Sequencing
	Cytometry
	Biosensors
	Microscopy
Medical treatment	Laser based dermato, uro, ophtalmo, gyneco ... Aesthetic: laser-based Ophthalmic correction: laser-based Dental: laser-based Urology and gynaecology: laser-based Cardiovascular: laser-based Other (dermatology / veterinary laser-based)
	Photodynamic therapy
	UV based
Lens-based ophthalmic correction	Spectacle and contact lenses

4.8 Telecommunication and quantum information

World Market (2022)	\$48 billion
CAGR 2019–2022 (\$)	7.3 %
European production (2022)	€6.9 billion
CAGR 2019–2022 (€)	5.2%
% of Global Market (\$)	15%
Main sub-segments	
Wireline Telecom equipment	
Transmission equipment (fibres)	
Wireless optical communication	
Telecom instrumentation	
Quantum optics	

World market evolution

Global market (\$ billion)

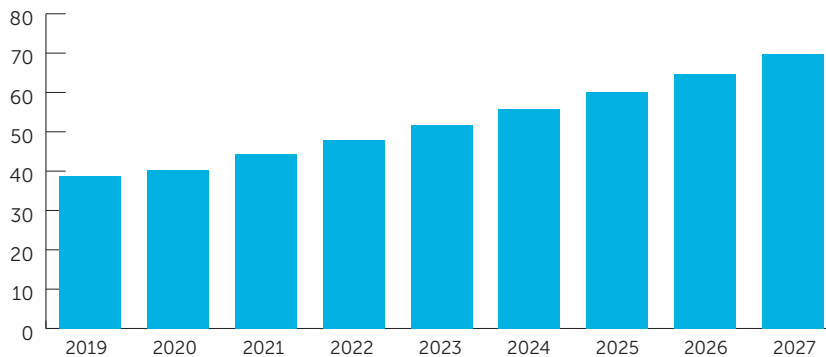


Figure 36 – Forecast for the photonics global market: Segment Telecommunication and quantum information
Source: Tematys/Photonics21, 2023

World market summary

Optical systems for telecommunications accounted for a total market of \$48 billion in 2022:

- Optical communication systems were worth \$22 billion, and optical cables were worth \$19.5 billion.
- The free-space optical telecommunications market is growing rapidly: \$2.7 billion. It includes FSO (Free Space Optics) and Li-Fi systems.
- The sub-segment of test and measurement equipment for telecommunications systems and networks accounted for \$3.4 billion.
- The quantum optics sub-segment is quite small and was worth around \$0.5 billion (including atomic clocks).

On the supply side, China was the largest supplier but lost market share following the trade war with the US. It now appears to have been overtaken by the US. Europe and Japan follow.

European production summary

In the global telecommunications market, European production accounted for €6.9 billion, a market share of 15%.

The optical telecommunications industry is highly concentrated. Today, a few manufacturers dominate the market: Nokia & Ericsson in Europe, Huawei & ZTE in China and Ciena & Infinera in the US. Other major players in Europe are ADVA Optical Networking and Infinera (formerly Coriant). The US manufacturer Coherent (formerly II–VI) also produces in Europe.

France is the leading country in terms of 35% of European production. The UK and Germany follow with a combined share of around 35%. Other major producing countries are Italy, Switzerland and the Netherlands.

Major players include: Nokia, Ericsson, ADVA Optical Networking, Infinera, Coherent, and Prysmian.

Sub-segments and main products

Optical telecommunications use light to transmit data over long distances (wide area networks) and short distances (local area networks). The long-haul segment includes metropolitan to worldwide data transmission. The technologies used are Wavelength Division Multiplexing (WDM/DWDM) and Synchronous Optical Network/Synchronous Digital Hierarchy (SDH/SONET). Ethernet is used in the metro segment. Data centres are increasingly using optical Ethernet. Their market share is growing, and they offer significant growth potential.

Systems and components include multiplexers/demultiplexers, switches, optical amplifiers, transceivers, lasers, LEDs, detectors, splitters, and connectors.

Please note that optical fibres are included in the components segment, but fibre optic cables are included in this segment.

Table 10 – Sub-segments of the segment “Telecommunication and quantum information” and product typology
Source: Tematys/Photonics21, 2023

Sub segments	Product typology
Wireline Telecom equipment	Switch, routers, OPP, Data Centre interconnects
	Optical Transceivers for Datacom
	Optical Transceivers for Telecom
Transmission equipment	Fibre cables, ETDA
Wireless optical communication	Free Space Optics (FSO), VLC, LIFI
Telecom instrumentation	Laser-based instrumentation
	DWDM tester, OTDR, Optical spectra analyser ...
Quantum Optics	Optical clocks, Quantum Key Distribution, Magneto-optical Traps

4.9 Defence and security

World Market (2022)	\$48 billion
CAGR 2019–2022 (\$)	7.5%
European production (2022)	€10.2 billion
CAGR 2019–2022 (€)	6%
% of Global Market (\$)	24%
Main sub-segments	
IR Imaging, night vision & measures	
Security & dual cameras for surveillance	
Displays for avionics (including HUD)	
Biometric systems	

World market evolution

Global market (\$ billion)

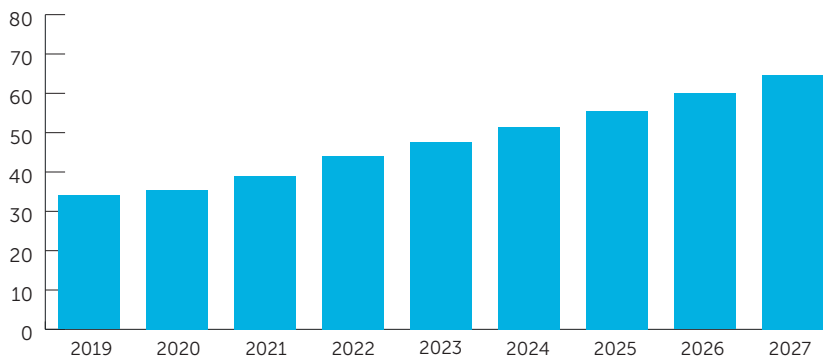


Figure 37 – Forecast for the photonics global market: Segment Defence and security
Source: Tematys/Photonics21, 2023

World market summary

The defence and security photonic systems segment is growing at around 7.5% per year, accounting for \$48 billion in 2022.

The main sub-segments are as follows:

- Infrared and night vision devices are mainly for defence and account for more than \$18 billion (including infrared seekers for missiles).
- Cameras for visible surveillance systems represent a market of around \$15 billion. In recent years, China has invested heavily in building a mass surveillance system, from which Chinese companies HikVision and Dahua have benefited. Outside China, European companies Axis and Bosch Security Systems have good market shares.
- X-ray-based security systems represent a \$5 billion market.
- Finally, the various biometric systems (AFIS: fingerprints, non-AFIS: iris, 2D or 3D facial recognition, etc.) have a market of around \$6.5 billion.
- Other smaller sub-segments are Displays, Range finders, Lidars

European production summary

In the global market for photonic systems for defence and security, European production accounts for €10.2 billion in 2022, a market share of 24%.

It represents about 8% of the total production in Europe. Europe has a significant market share in the sub-segment of infrared systems for defence. The main producing countries in Europe are France (>30%), Germany and the UK (together accounting for >40% of European production), followed by Italy and Sweden.

Thales is the leading European supplier of multi-domain Optronics. For land and naval applications, the leading European manufacturers are Thales, Safran, and Hensoldt. Their main competitors are in North America (Raytheon, Lockheed Martin and Teledyne FLIR) and Israel (mainly Elbit and Rafael).

Bosch Security Systems (GE) and Axis (SW) are major players in video surveillance cameras.

Sub-segments and main products

This segment includes optical and optronic systems for the defence, homeland security and civil protection markets. Systems include standard night vision cameras, sophisticated gated vision equipment, range-finding binoculars, and products such as periscopic sights and satellite systems. Displays are another important market segment for defence and security photonics, including avionics displays and head-up displays. Other products include range-finding and LIDAR systems, missile and ammunition guidance systems, and countermeasure systems.

Table 11 – Sub-segments of the segment “Defence and security” and product typology
Source: Tematys/Photonics21, 2023

Sub segments	Product typology
IR Imaging, night vision & measures	Periscopes, telemetry, tachymetry, laser vibrometry, countermeasures, CBRN measurements...
Displays	Avionics displays and head-up displays for defense & security applications
Security	X-ray security detection
	Cameras for security & video surveillance*
	Uncooled IR cameras for surveillance and firefighting
	Biometry: Automated Fingerprint Identification Systems (AFIS) and other non-AFIS devices (iris, 3D, veins ...)

***Note** on a small change in scope: in our previous study (2020), we included remote surveillance systems for security. In this report, we only include cameras, which is why the market size has decreased slightly.

4.10 Large instruments and space

World Market (2022)	\$4.5 billion
CAGR 2019–2022 (\$)	7%
European production (2022)	€1.5 billion
CAGR 2019–2022 (€)	10%
% of Global Market (\$)	34%
Main sub-segments	
Ground large instrument	
Optronics space payloads	

World market evolution

Global market (\$ billion)

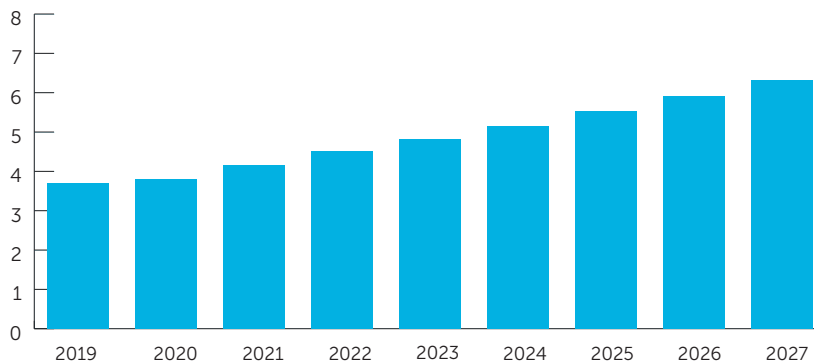


Figure 38 – Forecast for the photonics global market: Segment Large instruments and space
Source: Tematys/Photonics21, 2023

World market summary

The market for large instruments and space segments will be valued at approximately \$4.5 billion in 2022. This market can be challenging to comprehend due to its composition of multi-year programmes. Although budgets are typically disclosed, the portion allocated to optical instruments is seldom specified and can be overshadowed by the infrastructure expenses for large instruments like ELI or the overall cost of satellites in the space industry.

In the space sector, new options are emerging, such as low earth orbit constellations that offer a high revisit rate, complementary products to satellites like HAPS (High Altitude Platform), and the increasing use of the hyperspectral domain.

The main competitors in the commercial satellite market outside of Europe are Boeing, Lockheed Martin, Maxar, and Northrop Grumman. Furthermore, an increasing number of players from Russia, China, India, Japan, and other countries are gradually entering the space observation market.

European production summary

European production in this segment amounts to €1.5 billion in 2022, with a 34% market share.

European expertise, led by Thales Alenia Space and Airbus Group, is recognised in the field of optical satellite payloads, often combined with radar. This know-how covers a wide range of applications: intelligence, meteorology, altimetry, oceanography, climatology, carbon cycle studies, cartography and crisis management. Satellites with optical payloads help to improve our understanding of and protect the Earth.

In the institutional and military sectors, Thales Alenia Space, Airbus Group, and OHB are the main European players. At the same time, Boeing and Lockheed Martin are the main export competitors.

France, Germany, and the United Kingdom are the leading countries in European production, accounting for over 75% of it.

Large scientific instruments: France has a strong presence in the field of ultra-intense lasers with Thales and Amplitude, while Germany is also a player in this segment with the XFEL free-electron laser. It is worth noting that other countries have participated in this project.

4.11 Consumers and professionals

World Market (2022)	\$247.5 billion
CAGR 2019–2022 (\$)	4%
European production (2022)	€7.3 billion
CAGR 2019–2022 (€)	4%
% of Global Market (\$)	3%
Main sub-segments	
Homes and Offices	
Mobile phones and devices	
Professionals	
Entertainment & Leisure	

World market evolution

Global market (\$ billion)

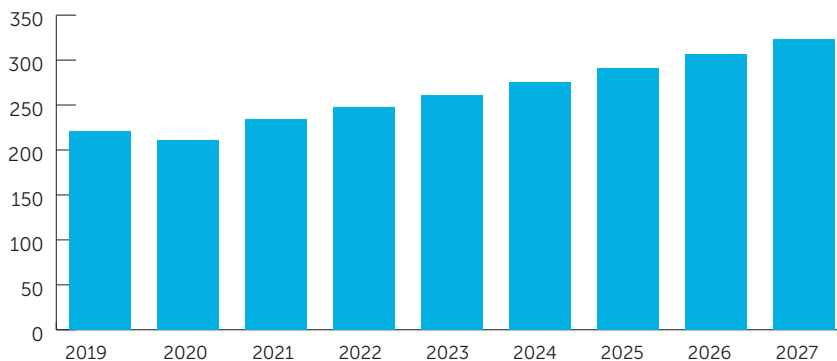


Figure 39 – Forecast for the photonics global market: Segment Consumers and professionals
Source: Tematys/Photonics21, 2023

World market summary

The market for photonic systems targeting both consumers and professionals is valued at \$247.5 billion in 2022, with an annual growth rate of 4%. However, this growth rate is lower than expected due to market saturation, particularly in the display and smartphone sectors.

The largest sub-segment is displays, valued at \$179 billion, of which \$121 billion is for TV and computer screens, and \$58 billion is for smartphone screens.

The smartphone camera module market is valued at \$28 billion, while other smartphone modules, including 3D sensors, are valued at \$6 billion. Computer peripherals, such as optical disk drives, optical mice, and laser printers, have a total value of approximately \$10 billion.

Finally, the leisure and entertainment sector, which comprises video projectors, AR/VR headsets, and LED video walls, has experienced significant growth and accounts for a total market value of \$18.8 billion.

European production summary

In the global market of photonic systems for consumers and professionals, European production accounts for €5.6 billion in 2022, which represents a market share of only 3%. Asia dominates this segment, while Europe's market share remains small. This is due to a combination of historical factors, such as the emergence of consumer products like flat panel displays in Japan and Korea, and economic factors, such as cheap labour and greater investment capacity in Asia, particularly in China.

Germany is the largest IT production location in Europe, with a share of over 20%. Its products include digital cameras, printing industry equipment, and optical printers. Italy follows, hosting producers of automated data acquisition equipment. The Netherlands host the European headquarters of a Japanese manufacturer of optical printers and copiers. AMS Osram in Austria and STMicroelectronics in France are also major players.

Hungary has a significant share in the European display production market, thanks to Samsung's production facility.

Sub-segments and main products

Major products in the optical and imaging industry include digital cameras, optical printers, copiers, scanners, barcode readers, and optical disk drives. Additionally, the industry produces image sensors and camera modules, which are primarily used in smartphones but also have other applications. The industry also encompasses a wide range of flat panel displays that utilise various technologies. The report covers multiple display technologies such as LCD, LED-backlit, LED, OLED, and e-Ink. However, it does not cover display-based products like monitors, notebooks, and TV sets. It also includes cinema projectors and cameras.

The table below provides details on the sub-segments and products.

Sub segments	Product typology
Homes and Offices	Scanners
	Optical disk drives
	Optical mouse
	Laser Printers and copiers
	3D printers
	Displays (FPD) for TV & laptop
	Fingerprint ID
Mobile phones and devices	Cameras module for smartphones
	Spectroscopic module for smartphones
	Displays for Smartphones
	3D modules for Smartphones
	Illumination sub modules (LED / VCSEL) for 3D sensing
Professionals	Zoom for professional camera
	Sport/passion optics (Telescopes, Binoculars, Rangefinders, and Riflescopes) for various Hobbies and sports (Shooting Sports, Golf, Water Sports, Wheel Sports, Snow Sports, Horse Racing)
	CCTV systems (design and manufacturing; the assemblers of purchase equipment are integrators)
Education	Photonic equipment for education
Entertainment & Leisure	Projection and Lighting
	Laser phosphor projector for office home theatre & digital cinema
	Laser-based projection TV & projector
	Laser Light show
	AR/VR Headsets
	Cinema projector
	Video Walls
	Urban Projection and urban large displays / Projection mapping

Table 12 – Sub-segments of the segment “Consumers and professionals” and product typology
Source: Tematys/Photonics21, 2023

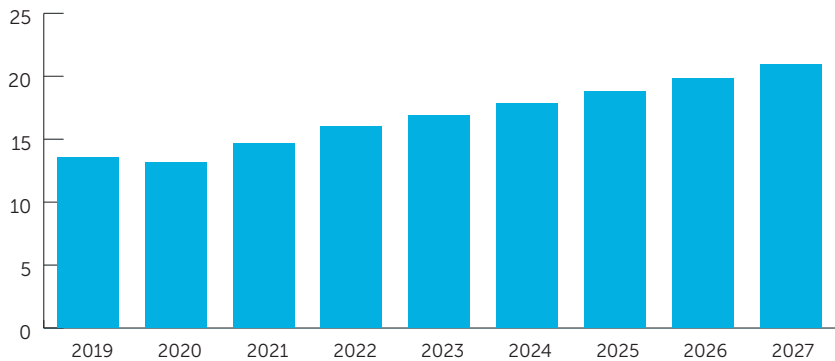
4.12 Instrumentation and optical measurements

World Market (2022)	\$16 billion
CAGR 2019–2022 (\$)	5.5%
European production (2022)	€5.6 billion
CAGR 2019–2022 (€)	7%
% of Global Market (\$)	37%
Main sub-segments	
Distance measurement	
Spectral measurement	
Distributed meas. (fibre sensors)	
Others	

Figure 40 – Forecast for the photonics global market: Segment Instrumentation and optical measurements
Source: Tematys/Photonics21, 2023

World market evolution

Global market (\$ billion)



World market summary

The optical instrumentation and measurement systems market is valued at \$16 billion in 2022, with an annual growth rate of 5.5%.

This market comprises:

- 3D measurement systems (stereo vision, photogrammetry, LIDAR, etc.): \$4.5 billion,
- Spectrometers and spectral cameras: \$6.5 billion,
- Fibre optic sensors: \$1.2 billion,
- Microscopes (other than those used for healthcare or life sciences): about \$1 billion,
- Optical instruments such as reflectometers, interferometers, ellipsometers, etc.
- Optical systems not elsewhere classified, such as custom optical benches.

European production summary

In the global market of optical instrumentation, European production accounted for €5.6 billion in 2022, representing a market share of 37%. This represents 4.5% of total production in Europe. Europe holds a significant market share in the field of microscopes, fibre optic sensors, spectrometers, and spectral cameras.

Germany and the UK together hold more than 60% of the share in European production due to their strong manufacturing base and history. Other major producing countries are France, Italy, the Netherlands, and Sweden. The main producing companies, with a revenue of over 100 million euros, include Zeiss, Leica Microsystems, Bruker Optik, Spectro Analytical Instruments, Analytik Jena AG, Horiba France, and Malvern Panalytical. These companies are mainly active in the standard product segment, such as microscopes and spectrometers.

Sub-segments and main products

The sub-segment of Instrumentation and Optical Measurements comprises diverse systems for various applications. The main products in terms of market volume are fibre optic sensors, 3D measurements, spectrometers, and geometrical and distance measuring systems. These systems are used for geospatial and construction applications, oil and gas exploration, material and constituent measurement, particle characterisation, R&D, and many other applications.

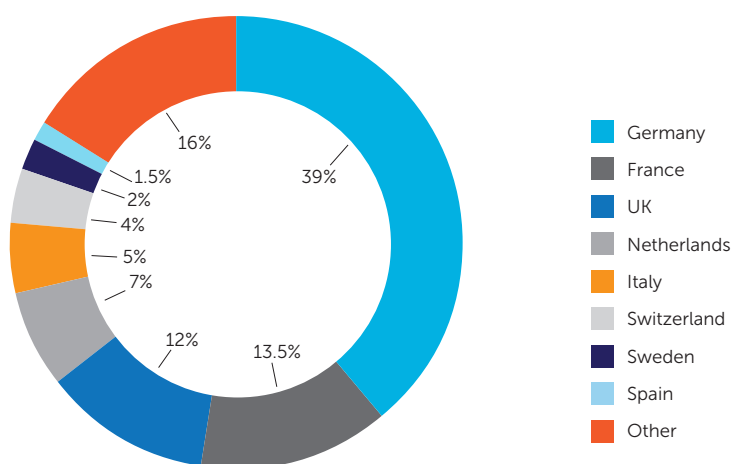
Sub segments	Product typology
Distance measurement	3D stereovision ...
	Airborne and drone LIDAR (corridor mapping, altimetry ...)
Spectral measurement	Colorimetry, RGB NIR imaging
	Hyperspectral imaging
	Optical Emission Spectroscopy
	Vibrational spectroscopy (FTIR + Raman + NIR + MIR)
	THz spectroscopy & imaging
	Visible and Near Visible Spectroscopy
Distributed Measurements	Narrowband laser used in measurements
	Fibre sensors (Bragg)
	Fibre sensors (Raman Scattering DTS)
	Fibre sensors (Rayleigh scattering DAS)
Other	Interferometric and others
	Microscopy (not life science)
	Optical instruments such as reflectometers, interferometers, ellipsometers, etc. and systems not elsewhere classified

Table 13 – Sub-segments of the segment “Instrumentation and optical measurements” and product typology
Source: Tematys/Photonics21, 2023

5 European photonics production by country

In 2022, the total production value of European Photonics was **€124.6 billion**, with a CAGR of 6.5% from 2019 to 2022. The breakdown by country is depicted in Figure 41. Germany has the largest production volume, accounting for 39% of the total, followed by France and the United Kingdom with 13.5% and 12% respectively. The Netherlands, Italy, Switzerland, Sweden, and Spain hold shares of 7%, 5%, 4%, 2%, and 1.5% respectively. The remaining European countries have a combined share of 16%. Approximately half of this 16% originates from EU Widening Countries (see the dedicated 'EU Widening Countries' section for further details).

Figure 41 – The European photonics industry – breakdown by country
Source: Tematys/Photonics21, 2023.



Note that aside from the overall market share, there is a “specialisation” in some segments of the countries, and they often have a greater share in their speciality.

In 2022, Germany produced €48.1 billion, accounting for 39% of European production. This share has remained stable since 2011. The German photonics industry is well-represented in rapidly growing segments such as photonics for industry, which includes laser materials processing, measurement, machine vision, and healthcare. Photonics for Industry is the largest segment in Germany and accounts for more than half of European production. In the fields of Environment, Energy, Lighting, Components, and Materials, the German Photonics industry holds a share of over 40%.

France accounted for 13.5% of all European output in 2022, with a production volume of €16.8 billion. The French Photonics industry has developed significantly in recent years, building on historical sectors such as Defence & Security and Telecommunications, where France’s share is over 30%. Photonics for Healthcare is also a significant segment in France, accounting for around 20% of European production.

With a 2022 production volume of € 14.8 billion, the United Kingdom accounted for 12% of all EU output. Components and Materials is the largest segment and accounts for about 15% of the European production. Photonics for Defence and Security is the second largest segment in the UK, producing >20% of the European production.

In 2022, the Netherlands produced €8.6 billion worth of photonics products, accounting for 7% of all European production. The largest segment of this production is Photonics for Industry, which represents over 20% of the European output. This includes producing lithography systems, where ASML is the world leader. ASML is responsible for over 50% of total photonics production in the Netherlands.

Italy produced €6.3 billion, accounting for around 5% of European production in the same year. Photonics for Defence & Security is the largest segment, followed by Photonics for Industry and Environment, energy, and lighting.

Switzerland accounted for approximately 4% of European production in 2022, with a production volume of €5.3 billion. The major segments of photonics production in Switzerland are Optical Components & Materials and Photonics for Industry.

Other significant contributors to European photonics production are Sweden, Spain, Finland, Belgium, Austria, and Denmark. Spain and Sweden accounted for production volumes of approximately €2 billion and €2.5 billion, respectively, in 2022. The photonics economic ecosystem in Finland has been evaluated at around €2.5 billion, including approximately €1.8 billion for manufacturing²³.

A note on the previously published 2019 EU photonics industry figures:

When compiling the statistics for 2022, we reviewed the 2019 figures and made slight modifications. We found that the valuation of the photonics industry in the UK had been slightly overestimated by around €1 billion due to the inclusion of some service-oriented companies in the listings. Additionally, the valuation of “other countries” had been slightly underestimated due to the omission of certain factories in our lists, particularly those belonging to foreign companies such as Samsung in Hungary and Hoya in some Eastern European countries. **Europe’s total for 2019 remains unchanged.**

The following subchapters focus on six countries and give details on the main segments and the main companies contributing to the production in each country.

²³ <https://www.photonics.fi>

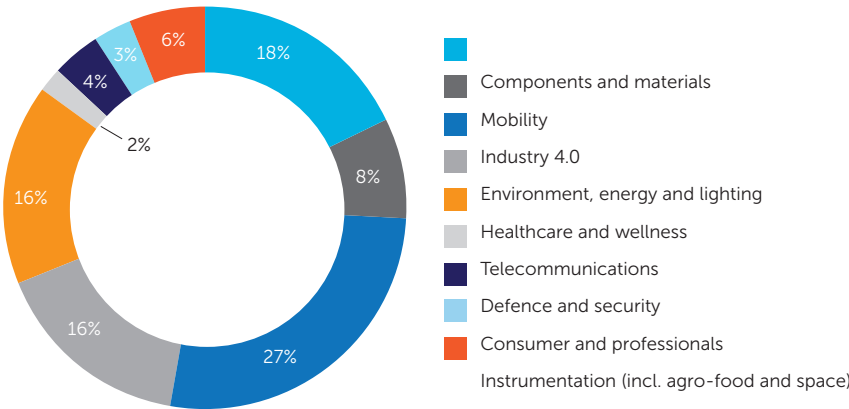
5.1 Germany



Area (km ²)	357,600
Population (2022)	83,237,000
GDP (2022)*	3,634
GDP CAGR*	1.6%
Currency	EUR
Photonics production	
Europe (€ billion)	124.6
Germany (€ billion)	48.1
Share / Europe	39%
Employees	188,000

Figure 42 – Photonics industry in Germany – Breakdown by segment
Source: Tematys/Photonics21, 2023.

Breakdown per segment



* In current US\$ billion (CAGR from 2019 to 2022) – Source: <https://documents.worldbank.org/en/publication/documents-reports/api>

Germany production summary

Germany is Europe's leading producer of photonics, with a production volume of €48.1 billion in 2022, accounting for 39% of all European production. This share has remained stable since 2010. The growth of photonics in Germany can be attributed to a long history of investment in research and innovation, a robust industrial base, and strong exports.

The major segments for photonics in Germany are:

- Photonics for Industry is the largest segment in Germany and accounts for more than half of European production. This includes machine vision and sensors, as well as laser systems for materials processing and microlithography. Key players in this segment include Trumpf, Zeiss, Sick, Ciba Vision, and Basler.
- Components and Materials are the second largest segment, accounting for about 40% of European production. The main companies producing optical glass are Schott and Heraeus. Optical components are made by companies such as Zeiss, Jenoptik, Qioptiq (part of Excelitas), Sill Optics, and Laser Components. Laser manufacturers include IPG, Coherent, Trumpf, and Toptica.
- The Environment, Lighting & Energy segment is the third largest, accounting for approximately 45% of European production. Major companies in this segment include Osram, Signify, IBC Solar, and Meyer Burger.
- Healthcare is a significant segment, accounting for almost 40% of European production. Products in this segment include endoscopes (e.g. Karl Storz), microscopes and surgical microscopes (e.g. Leica), spectacle lenses (e.g. Zeiss), medical lasers and systems (e.g. Lisa Laser), diagnostic systems for ophthalmology (e.g. Zeiss), and medical imaging systems (e.g. Siemens Healthcare).
- The Mobility segment, particularly car headlights, accounts for approximately 40% of European production.

Germany also produces digital cameras, printing systems, defence optronics and infrared and night vision equipment

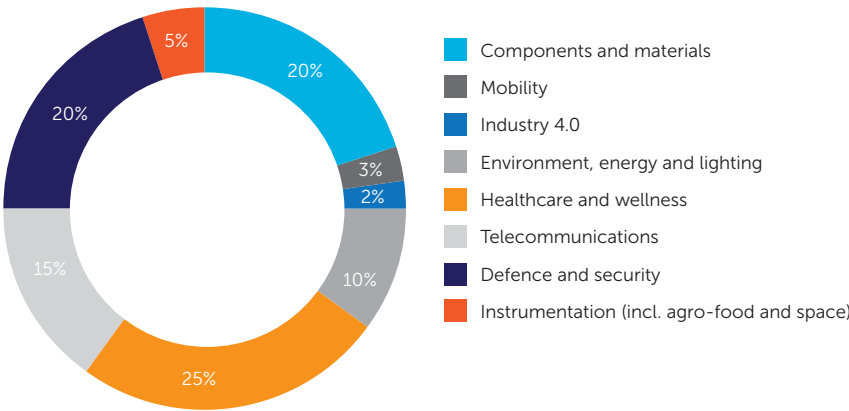
5.2 France



Area (km ²)	634,000
Population (2022)	67,872,000
GDP (2022)*	2,779
GDP CAGR*	0.6%
Currency	EUR
Photonics production	
Europe (€ billion)	124.6
France (€ billion)	16.8
Share / Europe	13.5%
Employees	60,000

Figure 43 – Photonics industry in France – Breakdown by segment
Source: Tematys/Photonics21, 2023.

Breakdown per segment



* In current US\$ billion (CAGR from 2019 to 2022) – Source: <https://documents.worldbank.org/en/publication/documents-reports/api>

France production summary

France accounts for 13.5% of European production, with a 2022 production volume of €16.8 billion, which is approximately 2% of the French industry. The French Photonics industry has developed well in the last three years, building on historical sectors such as defence and telecommunications. It is worth noting that the French photonics ecosystem, including engineering, distributors, and services, accounts for around €20 billion in 2022.

- ▶ The largest segment in France is Photonics for Healthcare. The leaders in this industry include GE Medical Systems for medical imaging, Essilor for spectacle lenses and contact lenses, Trixell for radiography and fluoroscopy, and Horiba ABX for haematology.
- ▶ Photonics for Defence and Security is the second largest segment in France, accounting for over 30% of European production. Additionally, France is the second largest producer of photonics for defence in the world, following the USA. Thales and Safran are the two leaders in this segment.
- ▶ The Components and Materials segment is the third largest, accounting for 16% of European production in 2022. The main companies producing components and materials are STMicroelectronics, Teledyne e2v, Soitec, and Saint-Gobain.
- ▶ Telecommunications is also an important segment, accounting for about one-third of European production in 2022. Nokia has substantial production operations in France due to the takeover of Alcatel-Lucent. The introduction of 5G technology is expected to increase sales in the near future.
- ▶ The Environmental, Lighting and Energy segment is also significant. France is home to the production of lighting components and modules by companies such as Signify, Schneider Electric, Hager, and Osram. In this same segment, ENVEA is one of the leaders in environmental measurement.

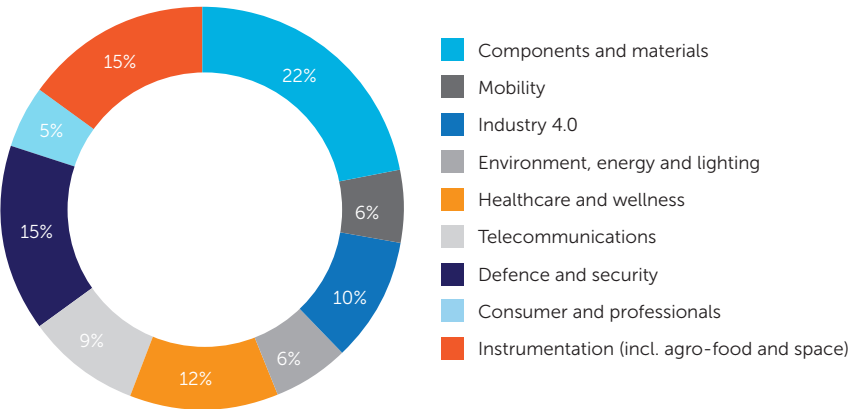
5.3 United Kingdom



Area (km ²)	242,700
Population (2022)	66,971,000
GDP (2022)*	3,089
GDP CAGR*	2.7%
Currency	GBP
Photonics production	
Europe (€ billion)	124.6
UK (€ billion)	14.8
Share / Europe	12%
Employees	58,000

Figure 44 – Photonics industry in United Kingdom – Breakdown by segment
Source: Tematys/Photonics21, 2023.

Breakdown per segment



* In current US\$ billion (CAGR from 2019 to 2022) – Source: <https://documents.worldbank.org/en/publication/documents-reports/api>

UK production summary

According to our evaluation, in 2022, the United Kingdom accounts for a share of 12% with a production volume of €14.8 billion (58,000 employees). It is important to note that this figure only pertains to the manufacturing of photonic products. When taking into account the entire economic ecosystem, including distributors, engineering, services, and fibre installation, we estimate a total of around €17.5 billion. This figure is consistent with the study conducted by UK PLG in 2023²⁴, which reported a value of £15.2 billion and 79,000 employees. The UK Photonics industry has experienced significant growth in recent years. After a sharp depreciation due to Brexit, the exchange rate between the Euro and the British pound has remained relatively stable between 2019 and 2022.

Major segments of Photonics production in the United Kingdom are the following:

- The largest segment, Components and Materials, accounted for approximately 15% of European production in 2022. This segment's products consist of optical glass and various components such as lenses, filters, and fibre.
- Photonics for Defence and Security is the second-largest segment in the UK, accounting for over 20% of European production. The primary companies producing in the UK are BAE Systems, Leonardo, Qioptiq, Qinetiq, Thales and Teledyne e2v.
- Instrumentation production in the UK accounts for approximately 25% of European production, with major players including Renishaw, Malvern Panalytical, and Keysight.
- The UK produces spectacle lenses, contact lenses, ophthalmic instruments, and medical lasers for healthcare photonics.
- In Telecommunications, Virgin Media O2 has activities in optical networks, and Lumentum produces optical networking components in the UK. Additionally, smaller companies have emerged in recent years that make components and modules.

²⁴ Source: UK Photonics 2023: The Hidden Economic Engine, Photonics Leadership Group (PLG), 2023.

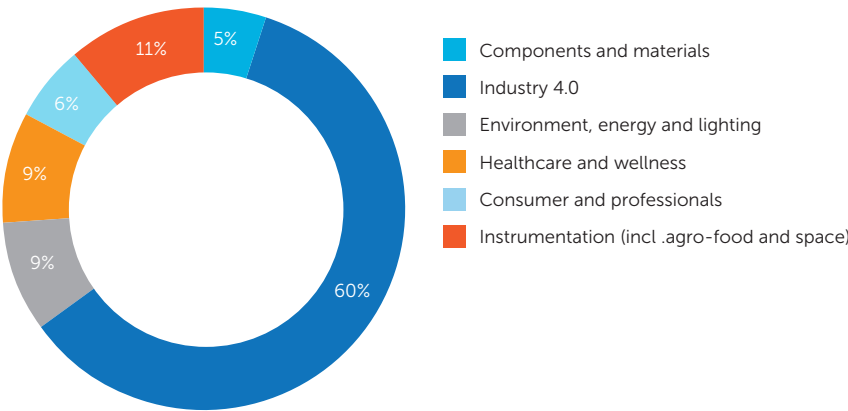
5.4 Netherlands



Area (km²)	34,200
Population (2022)	17,591,000
GDP (2022)*	1,010
GDP CAGR*	3.5%
Currency	EUR
Photonics production	
Europe (€ billion)	124.6
Netherlands (€ billion)	8.6
Share / Europe	7%
Employees	24,000

Figure 45 – Photonics industry in the Netherlands – Breakdown by segment
Source: Tematys/Photonics21, 2023.

Breakdown per segment



* In current US\$ billion (CAGR from 2019 to 2022) – Source: <https://documents.worldbank.org/en/publication/documents-reports/api>

Netherlands production summary

According to our evaluation, the Netherlands accounted for 7% of European production with a 2022 production volume of €8.6 billion. The production volume increased at an 11.5% CAGR between 2019 and 2022, mainly due to ASML's significant growth. Note that our calculations rely on an assessment by PhotonicsNL, which estimates that ASML should be included at 25% (National Agenda – July 2018). In 2022, ASML was responsible for over 55% of the total photonics production in the Netherlands.

The Netherlands hosts almost 300 companies directly or indirectly involved in photonics, including around 200 manufacturers. Major players in the photonics value chain include Signify (formerly Philips Lighting) in the lighting industry, Philips in medical photonics, and ASML in lithography machines. Additionally, NXP and Canon Production Printing have significant activities in the Netherlands. Additionally, the landscape includes numerous innovative start-ups and SMEs. The Netherlands also boasts a strong value chain for integrated photonics, encompassing design, fabrication, packaging, testing, and application development within the PhotonDelta ecosystem.

The major segments of photonics production in the Netherlands are as follows:

- ▶ Photonics for Industry, which accounted for over 20% of European production in 2022. ASML is the world leader in the production of lithography systems and laser materials processing systems. In addition, many SMEs are working on sensing for industry and machine vision.
- ▶ The second largest segment is Photonics For Healthcare, which includes Philips Medical and Canon Medical Systems, as well as many SMEs.
- ▶ Many companies are also active in the Agri-Food segment. However, photonics' share in the Netherlands' agri-food industry remains limited, accounting for only around 5% of total production. This is because photonics for agri-food specialists work within small enterprises.

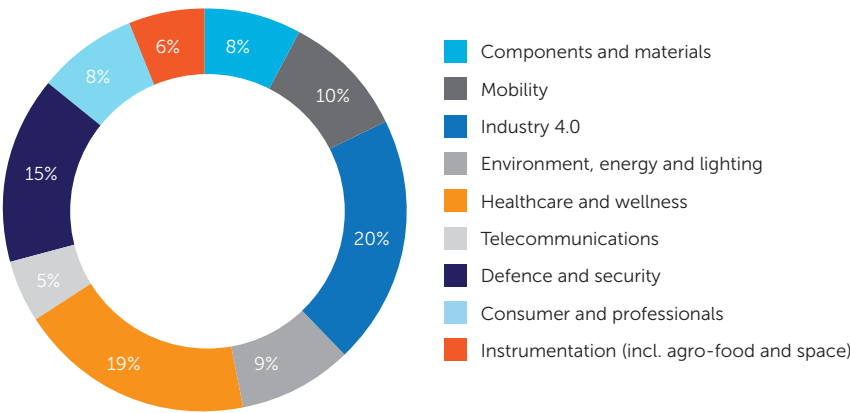
5.5 Italy



Area (km ²)	301,339
Population (2022)	59,030,000
GDP (2022)*	2,050
GDP CAGR*	0.6%
Currency	EUR
Photonics production	
Europe (€ billion)	124.6
Italy (€ billion)	6.3
Share / Europe	5%
Employees	16,000

Figure 46 – Photonics industry in Italy – Breakdown by segment
Source: Tematys/Photonics21, 2023.

Breakdown per segment



* In current US\$ billion (CAGR from 2019 to 2022) – Source: <https://documents.worldbank.org/en/publication/documents-reports/api>

Italy production summary

Italy accounted for about 5% of European production in 2022, with a production volume of €6.3 billion. Although Italy does not have a national association dedicated to photonics, there is a recent project to create such an organisation.

The major photonics production sectors in Italy are as follows:

- Photonics for Industry and optical measurement are produced by various companies such as El. En and Prima Industrie. Datalogic produces barcode scanners and related equipment for professionals in both industrial and retail sectors. As the third largest manufacturer in this industry, Datalogic is a leading provider of high-quality scanning solutions.
- Leonardo is a major player in the photonics industry, with a focus on defence and security, accounting for almost 10% of photonics production. The company combines the activities of former Selex ES and Galileo Avionica.
- Environment, Energy And Lighting: Italy is home to a significant lighting industry, which includes companies such as IGuzzini, 3F Filippi, and Signify Italy.
- In terms of mobility, Italy hosts car headlight production plants for several companies, including Forvia (formerly Hella) and Marelli Automotive Lighting.
- The Healthcare sector also has a presence in Italy, with Hoya and Essilor operating factories for the production of spectacle lenses and contact lenses. El. En manufactures laser-based medical systems. Additionally, numerous SMEs produce medical imaging equipment.

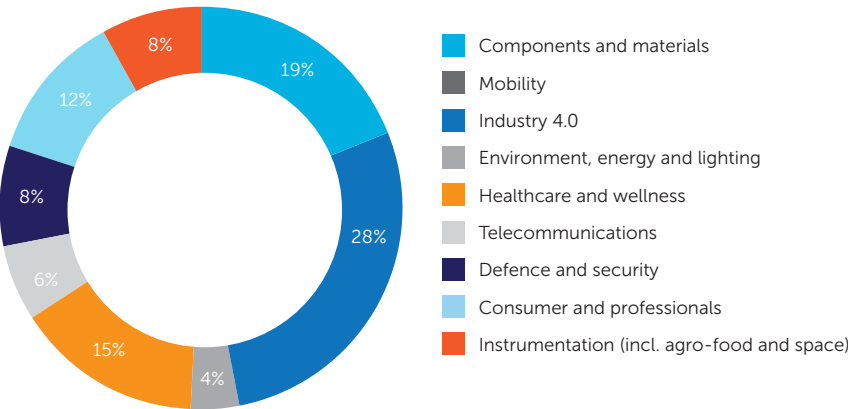
5.6 Switzerland



Area (km²)	41,284
Population (2022)	8,739,000
GDP (2022)*	818
GDP CAGR*	4.3%
Currency	CHF
Photonics production	
Europe (€ billion)	124.6
Switzerland (€ billion)	5.3
Share / Europe	4%
Employees	12,000

Figure 47 – Photonics industry in Switzerland
– Breakdown by segment
Source: Tematys/Photonics21, 2023.

Breakdown per segment



* In current US\$ billion (CAGR from 2019 to 2022) – Source: <https://documents.worldbank.org/en/publication/documents-reports/api>

Switzerland production summary

Switzerland accounted for approximately 4% of European production, with a production volume of €5.3 billion in 2022.

The major sectors of photonics production in Switzerland are as follows:

- ▶ Optical components and materials which represent around 8% of the European output. Manufacturers in Switzerland include Evatec, Spectros, and Fisba, as well as numerous SMEs such as Mikrop, SwissOptic, SUSS MicroOptics, ESPROS Photonics AG, and Exalos.
- ▶ Photonics is also a significant sector in the industry. Bystronic is the leading provider of laser systems for materials processing in Switzerland. Daetwyler Graphics produces laser engraving equipment for structuring rollers used in printing processes. Sensirion manufactures sensors for various industries.
- ▶ Consumers and Professionals: Logitech manufactures optical mice and webcams for video conferencing, recording, and gaming, but most of its production is located in China.
- ▶ Photonics plays a crucial role in Healthcare. Switzerland is home to major manufacturers such as Haag-Streit, Meridian Medical, and Hoya Lens Switzerland in the photonics industry.

Other sectors of photonics in Switzerland include Environment, Energy, Lighting, and Optical Communication. Huber+Suhner, Coherent, and Meyer Burger are also notable manufacturers in Switzerland. Additionally, Id Quantique is a leader in quantum communications.

5.7 EU-widening countries

Note: in this report and especially in this chapter, widening countries are EU countries with low participation rates in FP7 and H2020 projects.

In this part, we evaluate the revenues and employment of the Photonics Industry for the whole widening countries and focus on four countries (Czech Republic, Hungary, Lithuania, and Poland). We explain the strengths and weaknesses of the photonics industry in EU-widening countries, highlighting countries that have a particularly strong photonics industry and detailing the main photonics product types and end-user segments for these countries.

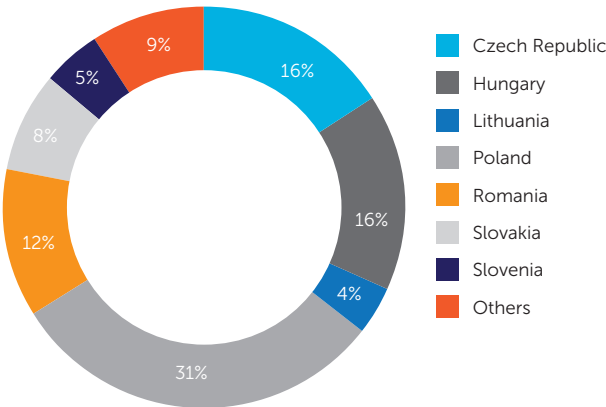
Introduction

There are 15 EU-widening countries: Bulgaria, Croatia, Cyprus, Czechia, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia.

In 2022, EU-widening countries accounted for €10 billion or 8% of European domestic production and approximately 45,000 employees. The revenue per employee is around €220,000, which is 20% lower than Europe’s average. The production is highly concentrated in four countries (Poland, Hungary, Czech Republic, and Romania), which together account for 75% of the total output.

Figure 48 – Photonics industry in EU-widening countries – Breakdown by country
Source: Tematys/Photonics21, 2023.

Photonics industry in EU widening countries



Local ecosystems vary depending on the country’s photonics expertise. In countries with strong mechanical and industrial skills (Poland, Czech Republic, Romania, Slovakia), the ecosystem is mainly built around the factories of foreign European (Signify, Prysmian, Marelli, Hella, Datalogic) or Asian (Samsung, Hoya, Olympus) manufacturers. These countries serve both as a rear base for the industrial policy of European groups (the latter replicating the model of the European automotive industry, which has relocated a significant proportion of its factories to these lower-wage countries) and as a bridgehead into European markets for Asian groups.

Ecosystems with a strong scientific culture in photonics (Lithuania in particular) are home to many small, niche companies based around a few major accounts (LightConversion, EKSPLA, Altechna, Brolis semiconductor, and ViaSolis) and, conversely, few foreign-flagged manufacturing plants.

Finally, two countries (Poland and Slovenia) are operating in a hybrid mode, with both foreign production plants (Signify, Corning, Essilor, Hella, Trumpf) and a strong endogenic ecosystem (Fotona, Opotek, PCO, OptoPol, and Vigo Photonics). In these two countries, however, the weight of factories remains predominant in terms of revenues and jobs compared with local companies.

A different breakdown for Europe as a whole can be observed by examining the applications addressed by companies based in these widening countries. Linked to factories, production is mainly oriented towards capital-intensive applications: displays (consumers and professionals), automotive headlights (mobility), LEDs and LED lighting fixtures (environment, lighting & energy), and to a lesser extent, telecoms, with a strong presence of fibre manufacturers (Corning, Prysmian).

These four applications account for 67% of total production in these 15 countries, whereas in Europe as a whole, they represent only 32%. Conversely, widening countries are less represented in the fields of components, lasers and Industry 4.0 (Lithuania being the exception).

EU widening countries – breakdown by segment

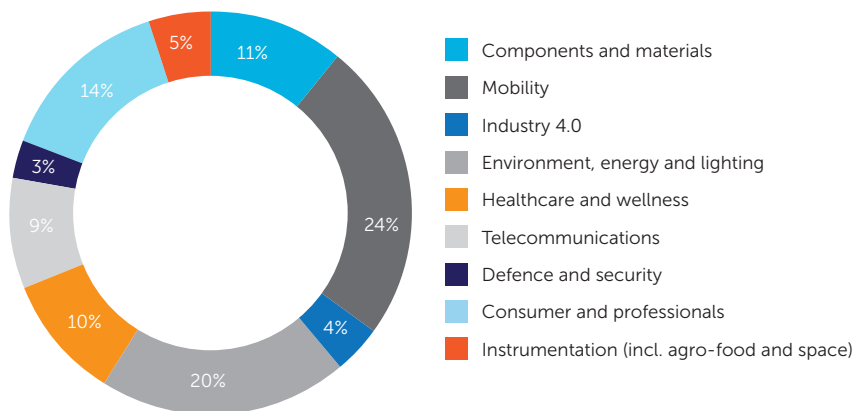


Figure 49 – Photonics industry in EU-widening countries – Breakdown by segment
Source: Tematys/Photonics21, 2023.

Poland

One of the EU economies that weathered the COVID-19 pandemic was Poland, which only experienced a -2% GDP recession (EU: -5.6%). Throughout 2020, Polish domestic demand contracted less (-1.5%) than in the rest of the EU (-3.5%) before experiencing a rapid recovery in 2021. GDP growth reached +6.9%, above the European average of 5.4%, and by 2021, Poland had regained and exceeded the GDP recorded in 2019 (€576 billion vs. €533 billion).

In 2022, on the eve of the Russian invasion of Ukraine, the Polish economy was enjoying positive momentum: 10.7% annual growth in Q1 2022, compared with an EU average of 5.7%. However, the outbreak of conflict in Ukraine fueled high inflation (estimated at 13.2% in 2022) and altered growth, which gradually fell to 0.6% in Q4 2022, below the European average (1.7%). Ultimately, however, Poland posted a full-year growth of 5.1%, above the European average (3.5%). Since joining the EU, Poland's growth has regularly been 1 to 3 points higher than the EU average.

Despite a serious slowdown in activity at the beginning of the year, Poland should still post a weak but positive growth of around 0.4% in 2023.

The Polish photonics industry (€3.2 billion) is in line with this general trend. Following the break-up of the Soviet Union, the Polish photonics industry emerged in the 1990s. This industry consists of a scientific cluster comprising more than a dozen departments at Warsaw University of Technology and the Military University of Technology, in addition to the universities in Wrocław, Gdańsk, Kraków, Lublin, and Toruń and more than 100 companies – 90% of them being SMEs. Most of the larger companies are subsidiaries of international groups like Signify, Corning or Thales. Among the country's strengths are photonic IC design, III–V semiconductors, OLED materials, infrared detectors & cameras and femtosecond lasers.

In recent years, a number of Polish photonics products have achieved international recognition and commercial success. The most outstanding examples of these products are as follows:

- Infrared detectors manufactured by VIGO PHOTONICS and developed at MUT, Warsaw, with annual growth over 20% in years 17–21;
- Top-quality GaN devices (diodes and SOA) manufactured by TopGaN, a leading manufacturer of bulk GaN.
- Optical coherence tomography for ophthalmological diagnostics manufactured by OPTOPOL, developed at the University of Toruń and sold to Canon in 2010.

In terms of prospects, Intel announced a \$4.6b investment in Wrocław in 2023 for the construction of a semiconductor assembly and test plant, which is due for completion in 2027. Intel's choice was determined by the country's cost-competitiveness and infrastructure, as well as the available talent in the physical sciences and engineering.

Czech Republic

Industry in the Czech Republic accounts for 30% of GDP, the highest ratio in the EU. Following Covid, the rebound remains moderate in 2021 (+3.6% vs. +5.4% for the EU), held back by supply difficulties in industry. The automotive sector was particularly hard hit by shortages of inputs for a sector that accounts for 9% of GDP and 25% of exports. In 2022, the war in Ukraine, the energy crisis and the resulting high inflation accentuated the difficulties, leading to a slowdown in growth (+2.4%), mainly driven by investment. After a stagnant first half of 2023, preliminary data for the 3rd quarter show GDP down by 0.3% quarter-on-quarter. Year-on-year, the decline reached 0.6% in Q3, after -0.5% and -0.6% in Q1 and Q2. The Czech economy is heading for a recession in 2023 (- 0.5% according to the latest forecast).

On a structural level, successive crises and their repercussions have interrupted the dynamic growth trend that prevailed until 2019 (+3% per annum on average since 2000). As a result, the Czech Republic is facing multiple challenges: the current economic growth model, based on a medium-value-added subcontracting manufacturing industry benefiting from competitive production costs, appears outdated. A qualitative move upmarket in production, based on innovation, investment and skills development, will make the economy more attractive and keep it competitive.

These overall figures for the Czech Republic are representative of its position in the photonics industry (€1.6 billion). The main plants in the automotive sector (Marelli, Hella) suffered in 2020 from the sharp decline in automobile manufacturing in Europe, followed by the inflationary shock generated by the energy crisis. However, with the investments linked to Extreme Light Infrastructure, the Czech Republic has the potential to renew the industry on a more local, higher value-added basis, along the lines of what has been achieved in Bordeaux with the Megajoule laser and the development of a local laser industry.

Hungary

Hungary is a high-income country with a medium-high level of industrialisation. The share of manufacturing is set to fall below 17% of GDP due to the expansion of services and construction. The country's industrial competitiveness is around the EU average. Hungary has specialised in industrial activities with a relatively high level of sophistication, the result of deep integration in international value chains through foreign direct investment. Thanks to the modernisation efforts of established companies and the addition of new highly productive production lines, Hungary ranks 18th in the EU in terms of labour productivity (gross value added per person employed) in manufacturing, ahead of the Czech Republic and Poland. Labour productivity is highest in the chemical, pharmaceutical and automotive industries.

Since 2017, economic and Foreign Direct investment policies have aimed to transform Hungary from a manufacturing hub to an advanced manufacturing and innovation centre. New forms of cash incentives and tax subsidies have been introduced to encourage business R&D activities and technology-intensive investment.

Nevertheless, the environment is closely linked to the development of factories and less so to the development of an endogenous photonic ecosystem. Among weaknesses, even if innovation expenditures have increased in recent years, the efficiency of the innovation system is still low, running at only 57% of the EU average. Business R&D capacities are mostly concentrated in foreign-owned companies, while government R&D spending stagnates. A general shortage of ICT specialists and engineers hinders the use of advanced technologies. The current education system is unprepared, and its financial means are inadequate to increase ICT literacy and provide a high-quality workforce.

Hungary's photonics industry (€1.6 billion) is still mainly driven by the large foreign factories of Samsung (displays), Hoya & Carl Zeiss Vision (vision

lenses). Semilab, on the other hand, grew out of the Hungarian Academy of Sciences and is Hungary's biggest local success story (1500 employees by 2022), focusing on highly dynamic semiconductor applications in the European environment.

Lithuania

On a macroeconomic level, after a significant post-COVID rebound in 2021 (marked by a 6% rise in GDP), growth in the Lithuanian economy gradually deteriorated in 2022, with GDP declining in the fourth quarter by 0.4% year-on-year. According to Eurostat, this was well below the 1.9% growth rate recorded in the eurozone over the same period.

Since 2022, the economic forecasts have been highly volatile and punctuated by continual downgrades as a result of the unstable and deteriorating context. While the main institutions expected annual growth of less than 1%, others predicted an economic recession in 2023, notably the IMF, SEB and Swedbank.

Given the country's size and local demand, photonics in Lithuania is primarily an export market. In 2020, China was Lithuania's leading export market, compared with less than 2% for Taiwan. Lithuania opened a Taiwanese representative office at the end of 2021, triggering political and economic retaliation from China. This had an immediate impact on the local industry, even though Taiwan offered to invest \$200 million to support Lithuania's high-tech sector, mainly semiconductors and lasers. Nevertheless, the industry, valued at about €400 million, is developing numerous innovations and high-quality products in fields such as laser fusion, tissue bioprinting, and ultrafast lasers for manufacturing and surface treatment. The Lithuanian local photonics industry should bounce back in the coming years, benefiting in particular from forthcoming reinvestment in the semiconductor sector.

6 Investment landscape

6.1 Global data analysis

An inventory of all reported investments in photonics companies has been carried out. The data covers the period from 2015 to 2022. The information was collected from several sources as outlined below and was homogenised and processed by TEMATYS:

- Crunchbase (www.crunchbase.com),
- EPIC database,
- TEMATYS database.

During that period, 1,449 photonic companies signed 2,692 deals and raised US\$ 50.703 million. (See tables in Table 14 and Table 15).

Number of deals	2015	2016	2017	2018	2019	2020	2021	2022
EU27	42	42	54	63	44	53	72	69
EU_Tot	75	73	89	100	85	88	103	114
USA	160	136	117	128	128	113	140	120
North America	182	157	140	142	149	135	156	135
Asia	54	72	89	99	75	53	62	88
Rest of the world	17	18	20	21	31	22	22	26
Total world	328	320	338	362	340	298	343	363

Table 14 – Table of the number of investment deals signed by photonics companies from 2015 to 2022

Source: Tematys/Photonics21, 2023.

IPO, loans and public subsidy are not taken into account; EU_Tot covers the European Union (EU27) and all other European countries, and North America covers the USA, Canada and Mexico (source Crunchbase, TEMATYS).

Amount raised (\$ million)	2015	2016	2017	2018	2019	2020	2021	2022
EU27	161	204	286	302	190	435	1,365	615
EU_Tot	260	437	515	518	425	586	1,858	956
USA	1,605	3,672	2,453	1,732	2,725	2,989	6,798	4,647
North America	1,758	4,233	3,020	1,850	2,902	3,403	7,136	4 991
Asia	330	658	1,131	2,463	1,162	1,240	3,211	3,435
Rest of the world	109	217	178	196	385	238	670	235
Total world	2,457	5,544	4,845	5,027	4,874	5,466	12,875	9,616

Table 15 – Table of funds raised as capital investment by photonics companies from 2015 to 2022

Source: Tematys/Photonics21, 2023.

IPO, loans and public subsidy are not taken into account; EU_Tot covers the European Union (EU27) and all other European countries, and North America covers the USA, Canada and Mexico (source Crunchbase, TEMATYS).

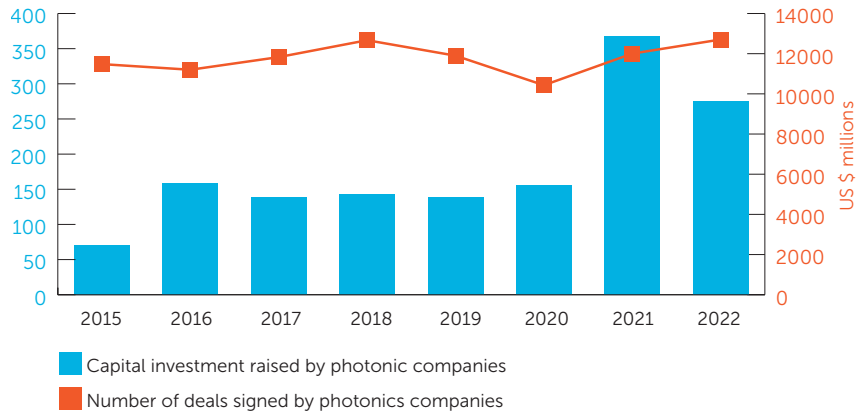
The number of deals per year was steady during the period between 298 and 363. The lowest value (298) corresponds to the COVID-19 period. This fall was around 10% compared to an average of 337 deals per year. The recovery was also rather quick since, as of 2021, the number of deals returned to 343. The average deal growth from 2015 to 2022 was 1.5%, which was low compared with the average growth of the photonic industry of around 7%.

6 Investment landscape

Figure 50 – Deals signed and amount raised as capital investment by photonics companies (2015 to 2022)
Source: Tematys/Photonics21, 2023.

IPO, loans and public subsidy are not taken into account; EU_Tot covers the European Union (EU27) and all other European countries, and North America covers the USA, Canada and Mexico (source Crunchbase, TEMATYS).

Deals signed and amount raised as capital investments by photonics companies (2015 to 2022)

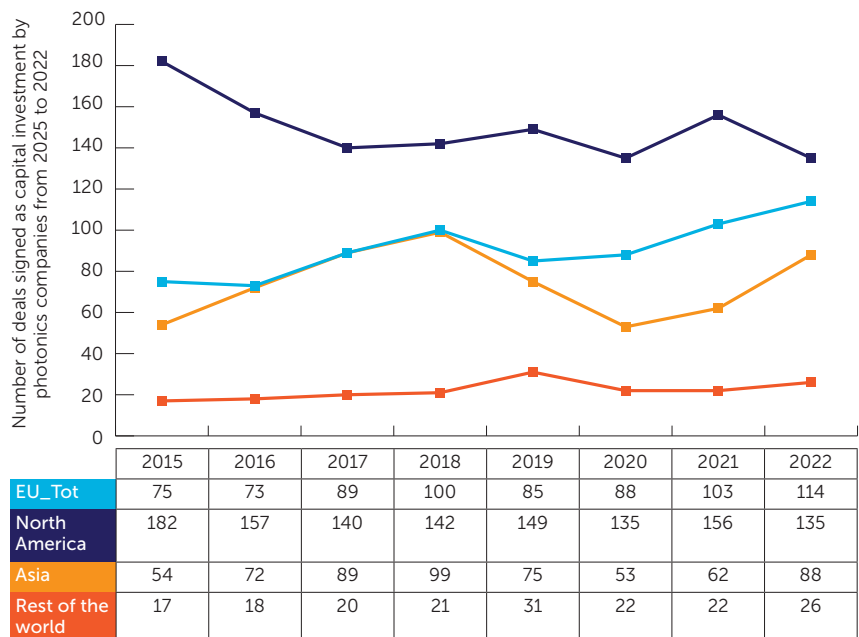


If the number of deals did not vary, the amounts dramatically increased in 2021 and 2022 after a steady figure of around \$150 million from 2016 to 2020. The average deal size during 2016–2020 was around \$15 million, but as of 2021, several companies, such as Chipone Technology, PsiQuantum, AEye, Fourth Partner Energy, Luminar, etc., managed to raise much higher amounts.

6.2 Analysis per geographical area

Figure 51 – Number of deals signed as capital investment by photonics companies from 2015 to 2022
Source: Tematys/Photonics21, 2023.

IPO, loans and public subsidy are not taken into account; EU_Tot covers the European Union (EU27) and all other European countries, and North America covers the USA, Canada and Mexico (source Crunchbase, TEMATYS).



On average, for the period 2015–2022, 44% of the deals are signed in North America, while Europe and Asia respectively account for 27% and 23% on average. However, the number of deals has decreased for North America from 182 to a plateau of 145 deals per year. On the contrary, the number of deals has increased for Europe from 75 to 114, with a slight drop in 2019 and 2020. In Asia, the same trend can be observed from 2015 to 2018, but the COVID-19 drop was much more significant in 2020, where the number of deals was 53, almost the same as in 2015 (54). The number of deals from the rest of the world increased slightly from 17 to 26 in 2022, with a peak up to 31 in 2019.

Fundraising in photonics companies. Breakdown by geography 2019–2022 (\$ millions)

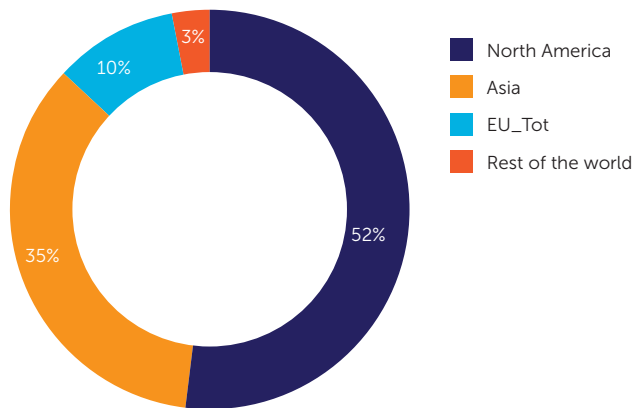


Figure 52 – Amounts raised as capital investment by photonics companies from 2019 to 2022

Source: Tematys/Photonics21, 2023.

IPO, loans and public subsidies are not taken into account; EU_Tot covers all European countries

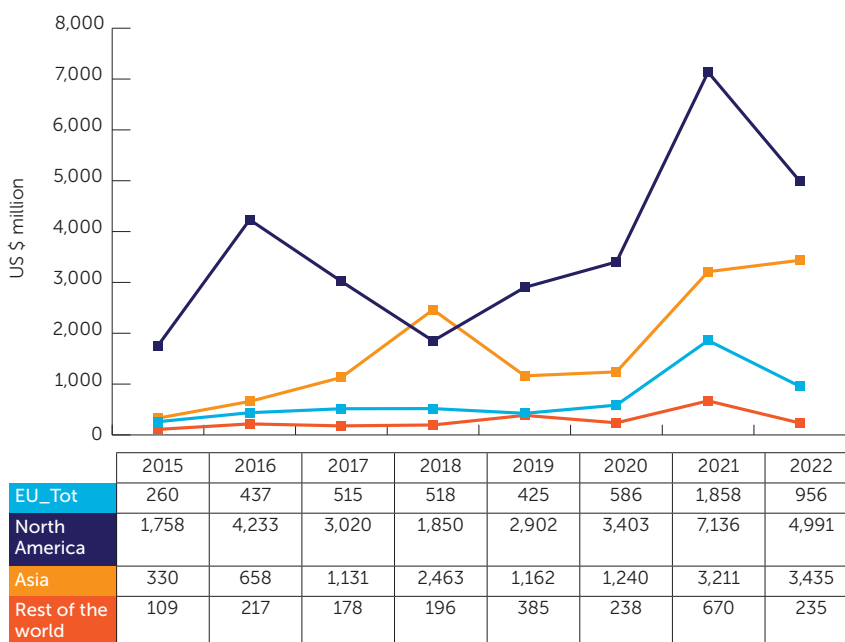


Figure 53 – Amounts raised as capital investment by photonics companies from 2015 to 2022, breakdown per geographical area

Source: Tematys/Photonics21, 2023.

IPO, loans and public subsidy are not taken into account; EU_Tot covers the European Union (EU27) and all other European countries, and North America covers the USA, Canada and Mexico (source Crunchbase, TEMATYS).

The amount raised provides a different perspective compared to analysing deal numbers. On average, North American photonic companies raised 52% of the total amount for the period 2019–2022 (almost 50% for the US alone), which is five times higher than European companies. While Asian amounts were similar to Europe in 2015, they have since increased dramatically to be 3.5 times larger than the amounts raised in Europe in 2022.

For North America (2016, 2021) and Asia (2018), huge differences can occur from one year to another due to large deals (more than US\$ 150 million) signed, which significantly alter the figures but may not be fully representative of the trend.

For every geographical area, a huge increase is observed for 2021. However, only Asia maintained the trend, as all the others showed a decrease in 2022.

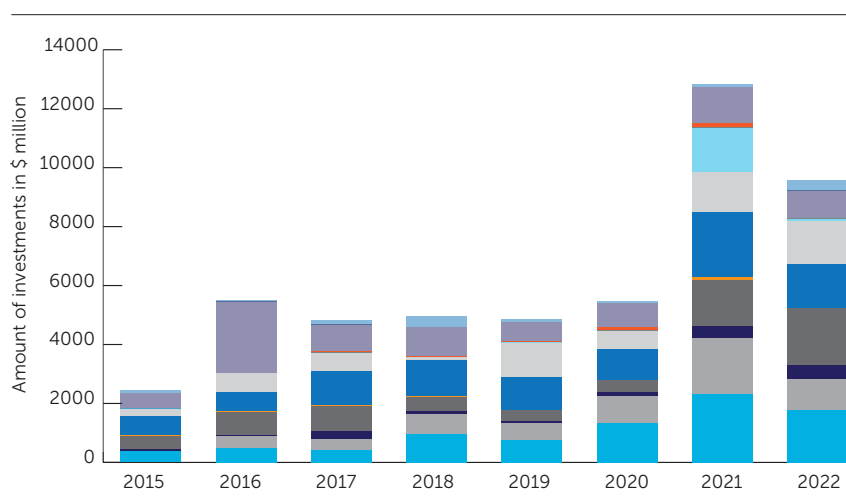
6.3 Breakdown by application segment

As per the segment breakdown (Figure 54), the “Environment and Energy” segment was able to raise the largest amounts in 2022, just ahead of the Core Components segment. These are followed by “Healthcare and Wellness” and “Telecom and Quantum”, which are very close together. The third group is “Mobility” and “Consumer”, followed by “Industry” and “Instrumentation”. The three application segments which raised the least are “Agriculture”, “large instruments”, and “Defence”.

In terms of evolution from 2015 to 2022, three kinds of profiles can be observed. “Consumer”, “Healthcare”, “Instrumentation”, and “Defence” show a peak in 2017 and 2018, another one in 2021 and a significant drop in 2022. The segments “Energy”, “Telecom and Quantum”, and “Industry” show a similar start but still grow in 2022. For the segments “Core components” and “Mobility”, no obvious peak can be observed in 2017–2018, but they are subjected to the 2022 drop.

Figure 54 – Investment statistics from 2015 to 2022 – breakdown per segment (\$ million).

Source: Tematys/Photonics21, 2023.



6.4 EU27 – US – ASIA Benchmarking

The tables below compare the investment statistics in the EU27, the US and Asia. These tables show a breakdown per deal size, respectively, the number of deals, the amount raised, and the average size of deals between 2019 and 2022.

Deal size / Geo – number	EU27	USA	Asia
<5 M\$	163	237	113
5 M\$ or more, below 10 M\$	24	61	32
10 M\$ or more, below 50 M\$	43	135	101
50 M\$ or more, below 100 M\$	6	30	12
100 M\$ or more	2	38	20
Total	238	501	278

Table 16 – Number of deals between 2019 and 2022, breakdown by deal size and geographical area
Source: Crunchbase, TEMATYS.

Deal size / Geo – \$ million	EU27	USA	Asia
<5 M\$	230.1	391.4	234.3
5 M\$ or more, below 10 M\$	171.9	472.1	280.1
10 M\$ or more, below 50 M\$	874.1	3,302.1	2,519.9
50 M\$ or more, below 100 M\$	445.4	2,042.6	955.6
100 M\$ or more	883.1	10,950.1	7,215.6
Total	2,604.6	17,158.3	11,205.5

Table 17 – Amount raised between 2019 and 2022, breakdown by deal size and geographical area
Source: Crunchbase, TEMATYS.

Deal size / Geo – average \$ million	EU27	USA	Asia
<5 M\$	1.4	1.7	2.1
5 M\$ or more, below 10 M\$	7.2	7.7	8.8
10 M\$ or more, below 50 M\$	20.3	24.5	24.9
50 M\$ or more, below 100 M\$	74.2	68.1	79.6
100 M\$ or more	441.5	288.2	360.8
All deal sizes / Geo – Average \$ million	10.9	34.2	40.3

Table 18 – Average deal size between 2019 and 2022, breakdown by deal size and geographical area
Source: Crunchbase, TEMATYS.

Between 2019 and 2022, 501 US-based photonics companies raised money, compared to 238 in the European Union and 278 in Asia. While European photonic companies could raise US\$ 2.6 billion, American companies could raise US\$ 17 billion, 6.5 times more. Meanwhile, Asian photonic companies could raise US\$ 11 billion, over four times more than their European counterparts.

Another significant difference lies in the average amount per deal. In the European Union, it is approximately US\$ 10.9 million, a third of the average deal size in the USA (US\$ 34 million) and a quarter of the average deal size in Asia (US\$ 40 million).

In all geographical areas, as the deal size category increases (from fewer than US\$ 5 million to between 5 and US\$ 10 million), the number of deals

drops. Then, in the range of US\$ 10–50 million, the number of deals rose significantly, only to fall again in the range of US\$ 50–100 million. Then, in the USA and Asia, the number of deals increase again for the highest deal sizes. There were 38 deals signed in the US in the US\$ 100 million or more category compared to 30 in the lower range. In Asia, the corresponding deals were 20 over 12. However, in the European Union, this decreased from 6 (US\$ 50–100 million) to 2 (100 M\$ or more).

When considering smaller deals (<\$5 million), the figures are comparable with 237 for the USA, 163 for the European Union and 113 for Asia, even if the average deal size is lower in the European Union (US\$ 1.4 million) than elsewhere (USA: US\$ 1.7 million and Asia: US\$ 2.1 million).

However, the major differences occur in large deal sizes. The larger the deal size, the more pronounced the differences between the European Union, the USA, and Asia will become. For example, combining the categories between US\$ 5 and US\$ 50 million, 67 European companies (24 + 43) signed deals. In contrast, in the USA, there were 196 (61 + 135), three times more. In the category of US\$ 50 to US\$ 100 million, there were five times more in the USA (30) than in Europe (6) and twice as many in Asia (12). In the category of over US\$ 100 million, only two deals were signed in the European Union, yet 38 were signed in the USA, and 20 were signed in Asia.

How photonics is understood and considered by European investors is a great challenge for the photonics industry. Huge sums of money could be raised by quantum or energy fusion companies, speaking only of hardware technologies. These companies promise results that are still hypothetical, even if their success would be great breakthroughs. However, European photonic companies that develop critical technologies, also for quantum and fusion, that are available and make money today do not find investors, especially in the industrialisation phase. The second issue is the consequence of the scarcity of European investors interested in photonic technologies. European companies often have to find foreign investors to finance their growth.

7 Main data sources

European and global data

- 2023, French photonics assessment for 2022, Tematys.
- 2023, Trend Report Photonics 2023/2024, Spectaris (2023).
- 2020, European Photonics Industry and market study. Report published by Photonics21.

North America

- For the USA: Optics and Photonics: The Impact on a Global Economy, OPTICA, 2022.
- For Canada: Canadian Photonic Industry Consortium (CPIC).
- SPIE publishes the “2022 Optics and Photonics – Industry report”.

United Kingdom

The Photonics Leadership Group (PLG – <https://photonicsuk.org>) published UK Photonics 2023: The Hidden Economic Engine.

Japan

The Optoelectronics Industry and Technology Development Association (OITDA) of Japan publishes an annual report based on a production survey.

Korea

The Korea Association for Photonics Industry Development (KAPID) publishes an annual report.

Taiwan

The Photonics Industry & Technology Development Association (PIDA) of Taiwan publishes an annual production survey.

Others

Australian and New Zealand Optical Society (<https://optics.org.au>) published a report: “Photonics in Australia and New Zealand – Lighting Economic Growth – An Industry Review 2020”. This report will be updated soon.

8 Appendix 1: Details about the methodology

1 – Listing the European photonics companies

The objective was to construct a list of European companies in the field of Photonics that was as exhaustive as possible. The sources for this first list were broadly based: companies were identified from databases belonging to Tematys and Photonics21, as well as lists of companies from clusters, national platforms, and photonics events. The list was augmented with keyword searches in databases like D&B (Dun & Bradstreet).

2 – Using annual reports, databases and interviews to evaluate the revenues of photonics companies

Data on revenues and employment for companies engaged in photonics manufacturing was obtained from annual reports and the D&B database based on matching the company name, city, and country.

The reference sales figures are those for 2022 unless this was not available. To multiply the number of companies listed, in some cases, the revenue for 2021 has been used. Turnover prior to 2022 has been corrected with the turnover growth index.

For companies that do not report revenue, the following assumptions were made: companies that do not report are mostly small companies. 100% of their turnover is photonics and is less than €10 M. The distribution of their turnover is identical to the distribution of the turnover of companies with a turnover of less than €10 M that have filled in their turnover.

3 – Evaluating the proportion of photonics-related activity for diversified companies

For diversified companies producing both photonics and non-photonics products, the reported total revenue and employment figures were then adjusted for the proportion of photonics-related activity.

An average revenue per employee ratio for the photonics industry was calculated based on the same data. This ratio was then used for companies for which revenues or number of employees were not available.

4 – Analysing big companies in details

For this study, more than 50 major companies were analysed – both through the publication of their latest annual report and through interviews with some of them to assess the size and dynamics of photonics in their group. To achieve this, the following list of European and international groups was used:

- Photonics components: AMS AG, Berliner Glas, Coherent, Corning, II–VI, Jenoptik, ST Microelectronics, Saint-Gobain, Schott
- Optical fibres: ASN, Leoni, Nexans, Prysmian
- Photonics for Industry: ASML, Bystronic, IPG Photonics, Sick, Trumpf
- Photonics for Automotive: Hella, Marelli Automotive Lighting, Valeo, Veoneer
- Lighting: Osram, Signify, Zumtobel
- Healthcare: GE Healthcare, Karl Storz, Philips, Siemens
- Ophthalmology: Essilor, Hoya

- Telecommunications: ADVA Optical Networking, Ericsson, Nokia
- Defence & Security: Airbus, BAE Systems, Diehl, Leonardo, Rheinmetal, Robert Bosch, Safran, Thales
- Instrumentation and diversified companies: Carl Zeiss, Horiba

This focus was an important part of the work as these large companies have activities not only throughout Europe but across the world, so we have to estimate their photonics revenues in each segment and each country.

5 – Online Survey

In order to complete the collected data (on R&D investment, exports, expected growth, etc.), an online survey was carried out.

This comprehensive method above, which combines multifaceted approaches, produces a reliable assessment of the European photonics industry size and other characteristics and is appropriate to industries for which no single applicable SIC code exists.

9 Appendix 2: Segmentation of photonics applications

Categories	Sub-categories	Products typology
0. Photonics – Core components and materials		
	Materials, Thin Films and Generic Components	Optical glass, filters, prisms, coatings, lenses, electrochromic glass
	Sources	LEDs, laser chip, laser module
	Image sensors (CCD, CMOS, InGaAs...), detectors	Image sensors (CCD, CMOS, InGaAs...), detectors
	Production equipment	MBE, MOCVD, 2PP, Laser writing
	Assembly equipment	Pick & place
1. Mobility: automotive, maritime, railway, aeronautics		
	Imaging & sensors	LIDAR, Cameras, speed and distance optical sensors
	Lighting	Automotive lighting and others
	Projectors, HUD & AR/VR	Screens and displays for Aerospace, Automotive, Motorcycle
2. Industry 4.0		
	In-line control and measurement	Process Spectroscopy, Gas sensing
		In-line measurement (shape, colour, size, defects.)
	Machine vision	Cameras & visible-light imaging systems
		Barcode Scanners
		Non-conventional imaging systems
	Material processing, laser cleaning	Laser sources for cutting, welding, and cleaning.
		Lithography tools (for semiconductors)
		LED and laser-based 3D printers
3. Environment and energy (including lighting/building)		
	Lighting	Lighting
	Energy	PV Material, cells & panels
		Thermal solar
	Control and Measurement (urban & domestic level)	Presence sensors, aerosol measurement, luminous flux, Measurement of BTEX, VOC, CO2 ...
4. Agriculture and Food		
	Imaging & Measurement	VIS Camera, RGB-NIR, Spectrometers, Cytometers, X-rays, THz
	Photonics based treatment	UV-based online, on field

Categories	Sub-categories	Products typology
5. Health and Wellness		
	Medical Diagnosis	X-rays based (Computed Tomography)
		VIS-NIR based (dermatoscope, slit lamp, aberrometer ...)
		Laser-based (OCT, Photoacoustic, Raman, two photons)
		Surgery Microscopes
		Endoscopes
		Digital Pathology Scanners
	Life science	In-vitro Diagnostics and imaging
	Medical treatment	Laser based (dermato, uro, ophtalmo, ...)
		LED and fibre-based (PDT)
		UV based
		Lens-based ophthalmic correction (eyeglasses and contact lenses)
6. Telecommunication and quantum information		
	Telecom equipment	Telecom Devices (QC, Tx/Rx, TOSA...)
	Fibres	Fibres
	FSO (space et ground)	FSO
	LiFi	LiFi
	Telecom instrumentation	DWDM tester, optical spectra analyser ...
	Quantum Optics	OPU, Magneto-optical Trap
7. Defence & security		
	Imaging, measurements, countermeasures	Periscope, night vision, telemetry, tachymetry, laser vibrometry, countermeasures, CBRN measurements...
	Weapons	Laser weapons, THz & Microwave weapons
	CCTV and security lighting	Camera for security & video-surveillance
8. Large instruments and space		
	Ground (ELI, ELT...)	Components and Systems
	Space	Components and Systems
9. Professionals and consumers		
	Home	Scanners
		Optical disk drives

9 Appendix 2: segmentation of photonics applications

Categories	Sub-categories	Products typology
		Optical mouse
		Laser Printers and copiers
		3D printers
		Displays for TV, Laptop
		Fingerprint ID
	Mobile phone and device	Smartphone device Spectro & cameras for smartphones
		Displays for Smartphones
	Professional	Video camera, professional camera
		Binoculars
		Telescopic sights
		CCTV systems (design and manufacturing; the assemblers of purchase equipment are integrators)
	Education	Photonic equipment for education
	Entertainment & Leisure	Lasers and Lighting
		Urban Projection and large urban displays
10. Instrumentation and Optical Measurements		
	Distance	3D stereovision, LIDAR, ...
	Spectral measurements	FTIR, Raman, Spectros, Colorimetry, RGB NIR imaging, Hyperspectral imaging
	Distributed measurements	Fibre sensors (Bragg, DTS, Raman, Brillouin)
	Other	Other sensors
11. Services		
	Services specifically dedicated to the photonic industry and community	Optical design
		Marketing, finance, Communication, Human resources, business development
		Industrialisation consulting
12. Distributors & Resellers		
	Distribution	All brand distribution
		Local selling offices of foreign companies
13. Software		
		Optical design and simulation software
		Other simulation software

