# Work group 6 workshop

**Photonics21 Annual Meeting**

15th January 2010
Radisson Blu Royal Hotel Brussels

PHOTONICS21

# Agenda

| Time | Topic | |
|---|---|---|
| | JOINT SESSION WG1 and WG6<br>in room *T'Scerlaes* | |
| 13:00 - 13:10 | Welcome / WG1 review 2009 / agenda | Alfredo Viglienzoni, WG1 chair |
| 13:10 - 13:20 | WG6 review 2009 and link with WG1 | Angela Piegari |
| 13:20 - 13:40 | PIANO+ Call for Proposals:<br>Introduction / presentation and questions | Sebastian Krug / Mike Biddle |
| 13:40 -13:55 | Previous work: UK feasibility studies / approaches and players | Michael Robertson / Mike Wale |
| | SPLIT UP WG1 and WG6;<br>WG6 continuation in room *Amsterdam* | |
| 14:00 - 14:15 | Refocusing WG6 activities:<br>Emerging Photonics Materials and Technologies (content of new SRA) | Angela Piegari / Mike Wale |
| 14:15 - 15.15 | Proposals from members and discussion | WG6 members |
| 15:15 - 15.30 | Conclusions and actions for 2010 | Mike Wale |

# WG6 Activities 2009

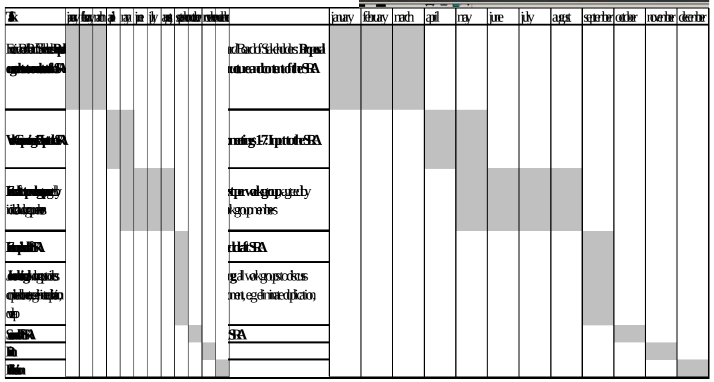
- Two workshops
  - <u>Florence</u>, February 11th 2009
    - Database of members activities and interests
    - Report on activities of other WGs
    - Table with WG6 selected technologies/priorities versus activities/applications of potential interest for other WGs
  - <u>Pisa</u>, May 28th 2009
    - Research Priorities for ICT workprogramme 2011-13
    - Common interests with application-oriented WGs



- Preparation of the new SRA

Bottom-up process (July-November 2009)

- Contribution to WG1-WG4 Chapters
- Additional Chapter (long-term research)



# WG6 Research Priorities for FP7

- Selected Research Priorities

❑**Photonic Integration**

❑**Advanced source technologies**

❑**Advanced functional materials for photonics**

- Criteria for prioritization

❑Position of European industry and research

❑Contribution to application-oriented WGs' strategic priorities

❑Leveraging effect (i.e. contribution to more than one WG)

# WG6 technologies for application-oriented WGs

**Work Group 1: Information and communication**

Innovative and cost-effective components R&D,
Higher functionality devices through the integration of electronics
*Photonic Integration*

**Work Group 2: Industrial production / Manufacturing and quality**

High power/high efficiency laser sources
High laser damage threshold components and coatings

**Work Group 3: Life sciences and health**

Lasers for medical therapy
Very low cost, miniaturised components and systems for medical applications

**Work Group 4: Lighting and Displays**

Organic photonics, nano-dots, nano-phosphors,
Multifunctional devices , product recyclability

# WG6–WG1 Photonic Integration in SRA Chapter 4.1

- Photonic Integration and Optical Interconnects

4.1.5 Technological challenges and research areas

The key drivers outlined earlier in this section provide the underlying key areas that need to be addressed by any research activities in optical communications. The following two key challenges are relevant in 2009 and it is expected the integration of optical functions will continue in the same way as seen in silicon. The initial development of transistors opened up new opportunities. Today we have integrated photonic devices with a few functions; in future we can expect to see much greater numbers of functions being built into a single device.

Generic photonic integration technologies

Photonic integration technologies are of key importance for realisation of the low-cost and high-performance components required in the network. For the new modulation formats required for 100 Gb/s transmission, for example, photonic integration is the only way to provide the required performance. But integration will lead to substantial cost reductions for lower bit rates as well. Mentioned by way of example the central offices in the access network, where substantial numbers of identical circuits can be integrated on a single chip.

Despite their cost-saving potential, the application of photonic integrated solutions has been restricted to a modest number of niche markets. The main reason for the



4.1

Information and communication

4.1.1 Revitalising the European economy – Photonics21 information and communication strategy

Over the last five years the information age has changed the way many people live their lives. Young people are now on the third or fourth generation of mobile phone technol-
tant messaging platforms such as
and on to social networking sites
Plaxo are now used by many com-
touch with former colleagues and
ccess to many gigabytes of online
er equivalent to mainframe comput-
on their person in the form of USB

are starting to see great improve-
ough increased web access. These
nger-term benefits as the reliability



kits with powerful component libraries and a generic approach toward packaging. Chip dimensions should be standardised along with the positions of the optical and electrical input and output ports. Finally the Framework Programme should stimulate the formation of an ecosystem of users, designers, chip manufacturers, equipment manufacturers and software developers. Here it can build on the start that has been made in ePIXnet.

Optical interconnects

Photonics finds some of its most challenging applications in the access, metropolitan and core networks connecting equipment situated many kilometres apart. But photonics is also a key enabling technology in short-reach optical communications used to interconnect devices within equipment, for short-range, free-space optical communications and for very short-reach optical interfaces at high bit rates.

Optical fibre connections are also used in various data networks such as local area (LAN) and storage area (SAN) networks. They play an increasingly important role in computer networks – in data centres or 'server farms', for instance. The connections vary in length, from a few metres to around 10 kilometres.

As already observed in telecommunication networks, the transmitted data volumes are expected to increase at high growth rates. Data rates in the Tb/s range for a single connection appear realistic in five to ten years. Cost efficiency plays a significant role in this type of application, as does the drastic reduction of energy consumption. Optical technologies dissipate less heat and so need less cooling and ventilation equipment.

# WG6 SRA Chapter 4.6

- Cutting-edge materials and technologies

4.6

Cutting-edge materials and technologies

*Large-scale investments are required to develop technologies at the leading edge of current knowledge*

The European Commission has recently identified a number of 'key enabling technologies', a set of all-purpose technologies that will support industrial deployment. Photonics is included in this set, along with nanotechnology and advanced materials, in recognition of its ability to make a major contribution to European economic development, future competitiveness, quality of life and the environment. Within the field of photonics our aim is to identify key areas of research that have the potential to improve EU industrial performance and to have a beneficial effect on society in all of the above respects. Large-scale investments are required to develop technologies that are at the frontiers of current knowledge. Supporting long-term research activities will help preserve the balance between near-mid-term and far-edge research. In photonics there has always been a strong link between basic research and technology. Further strengthening this link is a priority for the photonics community throughout Europe.

The application-oriented sections of this document provide numerous examples that demonstrate the importance of innovative device technologies and advanced materials in providing the basis for wealth creation in Europe. Many vital fields of modern engineering, including semiconductors and photonics, were built on fundamental breakthroughs in the past decades. In the same way, it is clear that there will be a set of new technology developments, not described in the applications-oriented sections, that will provide the basis for disruptive innovation across a very wide field of applications.


- The European Commission has identified a set of five "Key Enabling Technologies" (September 30th, 2009): Photonics is included in this set
- Innovative technologies developed within WG6 will benefit to several WGs

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# WG6 SRA Chapter 4.6 content

- 4.6 Cutting-edge materials and technologies
  - ❑ 4.6.1 Emerging photonics materials
  - ❑ 4.6.2 New technologies and functional devices
    - Integration technologies and competitive manufacturing

## Emerging photonics materials

4.6.1

Progress in materials has always been central to photonics, with III-V semiconductors, heterostructures, ferroelectric crystals and optical fibres as important examples. The development of photonics over the past few decades has certainly been very impressive, due partly to leveraging the massive knowledge relating to silicon-based integrated circuit technology.

New photonics materials should enhance the performance of photonics and broaden its applications. This usually means improving functionality and reducing cost. In many applications one also has to address the physical size of the device (the 'footprint') and, of increasing importance, power dissipation. The following areas of materials research have been identified as being of particular significance. Many important developments will be based on synergies among various elements in this list, sometimes in combination with existing technology.

*New photonics materials enhance the performance of photonics and broaden its applications*

- Metamaterials (synthetic materials, mostly nanostructured). The issues here are partly theoretical, aiming to understand the electromagnetic properties and physics of the materials, but the accompanying technology development is equally important. Examples are photonic crystals, quantum dots including composite colloidal nanoparticles in a glass or polymer matrix or semiconductor media, and materials exhibiting negative permittivity or permeability or both. A major objective is to achieve lower losses than is the case for existing materials such as metals, since many important applications are currently hampered by the optical losses accompanying the special optical properties stated above. Theoretical understanding and experimental effort are both needed to overcome this crucial obstacle and allow photonics to follow in the footsteps of the electronics industry with respect to development and integration.
- Group IV photonics. This includes silicon (Si) and its combination with germanium (Ge) and tin (Sn) for applications such as modulators and light sources. The goal would be a low cost, CMOS-compatible material technology that could rival III-V materials in optical functionality and performance. Parallel research on heterogeneous integration of a variety of functional materials with silicon, again in a CMOS-compatible fashion, should also be pursued.
- Carbon nanotubes and graphene, which offer new vistas in photonics with their high absorption and mobility, complementing their use in non-photonic fields such as catalysis.
- Material engineering in oxides and chalcogenides. While these materials have been known for a long time, nanotechnology offers new possibilities to utilise phenomena such as phase changes to significantly alter optical characteristics in a way not achieved with other materials.

Fig. 4.6.2 A silicon wafer © IMEC



4.6.2

## New technologies and functional devices

While new materials, new structures and new phenomena offer endless possibilities for creating novel devices, concomitant development of new technologies is also needed. There is no doubt that micro- or nano-structuring will lead to more compact and more energy-efficient photonic devices. Micro-structured fibres have already proved their value for high-power fibre lasers and shown great promise for many other applications. Nano-structured materials such as semiconductors, metal nanoparticles and carbon nanotubes have also enhanced energy conversion in thin-film solar cells.

Great progress has also been made in the use of complementary materials within the same device to take advantage of specific properties of the materials. One example is the

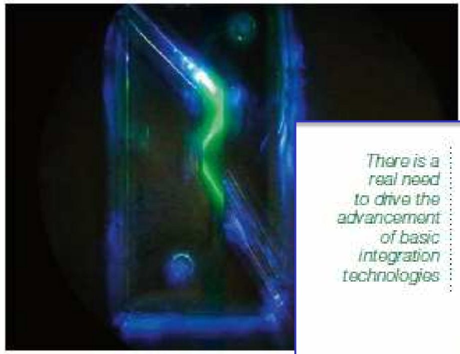

Fig. 4.6.3 Multiple internal reflectance device used as part of a 'lab-on-a-chip' © CSIC



### Integration technologies and competitive manufacturing

*There is a real need to drive the advancement of basic integration technologies*

Photonic integration is relevant for many of these proposed ideas and thus requires a more detailed description. Over and above the application-specific, shorter-term developments detailed in the application-oriented sections of this document, there is a real need to drive the advancement of basic integration technologies, develop radically new techniques to continue to expand the boundaries of performance, functionality and cost-effectiveness, and to develop new ways of working with these technologies to realise new systems and applications concepts. The following priorities have been identified:

# WG6 Next actions

- Refocusing WG6 activities in 2010
  - ❑ Technologies and materials:

    ***from SRA***

    - **Emerging photonic materials**, including
      - ✓ Metamaterials, artificial hybrid materials
      - ✓ Group IV photonics, heterogeneous integration of functional materials with silicon
      - ✓ Carbon nanotubes and graphene
      - ✓ Material engineering in oxides and chalcogenides
      - ✓ Nanoparticle integration e.g. in dielectric coating matrices
      - ✓ Polymer coatings for photonic devices

# WG6 Next actions

- Refocusing WG6 activities in 2010
  - ❑ Technologies and materials:

    ***from SRA***

    - **New technologies and devices**, including
      - ✓ Nanophotonic devices allowing the convergence of photonic and electronic technologies
      - ✓ Advanced sources
      - ✓ New functions integrated in optical fibres and fibre-based components
      - ✓ Plasmonics and nano-optics for highly integrated devices, as well as for sensors
      - ✓ Adaptive optics systems based on deformable mirrors with improved reliability, compactness and cost-effectiveness
      - ✓ Miniaturised X-ray optics and X-ray phase imaging
      - ✓ Photonic Integration (new systems and applications concept)……