PhOREMOST NoE

Nanophotonics to realise molecular-scale technologies

Scientific Roadmap for Nanophotonics

Integration — **Joint Research Projects** — **Education & Training**

Dissemination

What?

Scientific and *technical* roadmap

- Focus on selected *emerging (long-term)* nanophotonic concepts and technologies
- Identify main challenges and possible roadblocks
- Outcome should help to *steer and focus research* in nanophotonics for the scientific community at large and within PhOREMOST in particular

ToC Skeleton: Concepts

- Photonic crystals
- Random lasers
- Non-linear nano-optics
- Optical nanocavities & resonators
- Quantum confinement
- Metamaterials in the visible
- Plasmonics

ToC Skeleton: Technologies

- Infiltration techniques
- Functionalisation
- Self-assembly
  - Opals
  - Molecules – DNA
  - Nanoparticles - QDs+metal nanoparticles
- Patterning – Surface structuring
- Polymer and small molecule photonics
- Hybrid nanotechnologies
  - Si – III/V
  - Organics – Nanoparticles
- Near-field techniques

Example 1: Random Lasers

Application domains: research and devices

Motivation:
- Obtaining lasing in disordered structures
  - → Cheap and easy large scale fabrication
  - → New optical properties
- Understanding physics of random lasing
- Developing new applications (lighting, encryption, sensoring)

Figures of merit: lasing efficiency, material stability, temperature sensitivity, beta factor

Physics & applications of Random Lasers

Leading groups:

Fom-institute Amsterdam - good in modelling, new physical insight

Northwestern Univ. - has achieved new spectral properties

LENS Florence - new materials, applications

Univ. of Moscow - lasing in solid powders, …

Dependencies: electrical pumping of lasing materials, lasing of colloidal quantum dots (minor)

Conclusions recommendations: modelling or random lasing and physical understanding in good shape, materials have good stability, easy production. Electrical pumping to be addressed for lighting applications. Promising applications in security (encoding and sensoring).

Example 2: Magneto-Plasmonics

Application domains: research and devices

Motivation: Incorporate magnetic materials into plasmonics structures

→ Externally control plasmonic properties with a magnetic field

→ Develop active plasmonic devices

Understanding physics of magneto-plasmonic phenomena

Developing new applications (active optical devices, sensing, communications)

Figures of merit:

Dection efficiency is 3 times better than SPR sensor (changes of refractive index)

Expect 1 order of magnitude after optimization (2008). B.Sepúlveda et al. Optics Letters 31 (2006) 1085.

Physics & Applications of Magneto-Plasmonics

Leading groups: Prof. Armelles (IMM-CSIC),Prof. Safarov (Phys. Rev. Lett. **73** (1994) 3584.

Disadvantages: bigger losses due to the higher light absorption of the ferromagnetic metal compared to the pure noble metal, more complex to fabricate.

Future improvements: core/shell structures,…

Time by which applications are commercialized: Magneto-Plasmon Resonance Sensor under development, expected 2010.

Conclusions recommendations: Field in its infancy, wide range of opportunities and applications. Explore the integration of this concept with other nanophotonic areas, for example incorporation of magneto-plasmonic materials in Photonic Crystals. Optimize fabrication of core/shell ferromagnetic/noble metal nanostructures. Optimize patterning and surface structuring technologies.

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Technical Examples:

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