PhOREMOST
network of excellence
Promoting Nanophotonics in Europe

PhOREMOST
Emerging Nanophotonics Roadmap

Silvia M. Pietralunga

“Nanophotonics to Realise Molecular-Scale Technologies”
Roadmapping: one main activity in our network

Emerging Nanophotonics roadmap

Integration → Joint Research Projects → Education & Training

Dissemination
**Scientific and technical roadmap**

- Focus on selected *emerging (mid to long-term)* nanophotonic concepts, technologies and devices
- 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
How does it relate to MONA?

http://www.ist-mona.org/roadmaps

• MONA and PhOREMOST roadmapping activities were developed as a *coordinated effort*

• PhOREMOST’s emerging nanophotonics roadmap is *complementary* to MONA’s “Roadmap for Photonics and Nanotechnologies”
How is it structured?

- We have chosen selected topics, with high potential impact and outstanding scientific and technological challenges in three different areas:
  - Concepts
  - Technologies
  - Devices
Table of Contents: Concepts

- Random lasers
- Non-linear nano-optics
- Metamaterials in the visible
- Plasmonics
- Microcavities
- Optical trapping and sorting
Table of Contents: Technologies

- Infiltration Techniques
- Functionalisation
- Self-assembly
- Hybrid nanotechnologies
Table of Contents: Devices

- Photovoltaics
- Lighting and optical sources
- Sensing
- Light manipulation
- Nano-doped active materials
Example 1: Random lasers

• Motivations

– Obtain lasing in new random materials
  ➢ Cheap and easy large scale fabrication
  ➢ New optical properties
– Understand physics of random lasing
– Develop new applications in lighting, encryption, sensing...
Example 1: Random lasers

• Figures of merit
  – *Lasing efficiency, material stability, temperature sensitivity, …*

• Main challenges
  – *Theoretical model that includes interference:* understanding localized and extended modes in random systems
  – *Mode competition, stability:* how stable is the output, when is it chaotic, and role of mode competition
  – *Electrical pumping*
Example 1: Random lasers

<table>
<thead>
<tr>
<th></th>
<th>2 – 5 years</th>
<th>5 – 10 years</th>
<th>10 years and more</th>
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Red (No known solutions at this time), Yellow (Very hard but possible solutions), Green (feasible solutions under investigation), White (known solutions, first commercial products available)
Example 2: Sub-wavelength plasmon optics

• **Motivations**
  – Enhanced light-matter interaction at the nanoscale
  – Plasmon routing at the sub-micrometer scale for short distance interconnects
  – New hybrid materials
Example 2: Sub-wavelength plasmon optics

- **Figures of merit**
  - Molecular sensitivity in Surface Enhanced Raman Scattering (SERS)
  - Light guiding through submicrometer sections
  - SP-enhanced optical forces
  - ...

- **Main challenges**
  - Field confinement below the 20 nm level
  - Field Enhancement factor above 100
  - SP guiding through sections smaller than 100 nm
  - Controlling the dynamics of single molecules
  - Trapping objects as small as 100 nm
# Example 2: Sub-wavelength plasmon optics

## Timeline

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Example 3: nanoparticle-doped organics waveguide optical amplifiers

• Motivations
  – Optical gain on short distances for applications in integrated PLC
  – Organic PLC are attractive due to good performances and cost-effectiveness
  – Optical amplification at telecom wavelengths in organics is an issue, due to both absorption and luminescence quenching
Example 3: nanoparticle-doped organics waveguide optical amplifiers

- **Figures of merit**
  - Optical gain coefficient for the material
  - Waveguide propagation loss
  - Net optical gain for the implemented waveguide

- **Main challenges**
  - Increased gain of PMMA-based EDWA at $l = 1.50$ mm. To reach a gain parameter of about 4 db/cm
  - Realization of PMMA-based WDM for optical pumping
  - Realization of Chalcogenide doped single-mode waveguides
  - Realization of Plug and play devices
Example 3: nanoparticle-doped organics waveguide optical amplifiers

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Contacts

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www.phoremost.org
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Watch for it at http://www.phoremost.org/