Alliance 1: Photonics and semiconductors

Research axes and facilities

Generally speaking, research in photonics aims to improve the control of the generation, propagation, detection and conversion of light, at all intensities from intense beams to single photons, thanks to innovative materials which are often micro or nanostructured. Research on materials for optics (non-linear crystals, thin layers, multilayers, organic/inorganic hybrid structures) is a pre-required condition fulfilled in this project to support innovation in the field of laser sources, parametric generation, new states of light... One section of this field, nanophotonics, has been strongly developed by the Grenoble community during the last decades, especially with the creation more than twenty years ago, of a joint group between Institut NEEL and INAC dedicated to "Nanophysique et Semiconducteurs". By exploiting the confinement of electrons at the nanometer scale with quantum wells, quantum dots (QDs) or wires, and/or the confinement of photons at the wavelength scale with optical microcavities and photonic crystals, this group has evidenced numerous new basic physical phenomena, such as Bose-Einstein condensation of exciton-polaritons, polariton laser, detection and manipulation of a single spin in a QD, efficient monomode single photon sources, giant optical non-linearities. This know-how opens new opportunities to implement these original effects in various directions.

Actions within LANEF

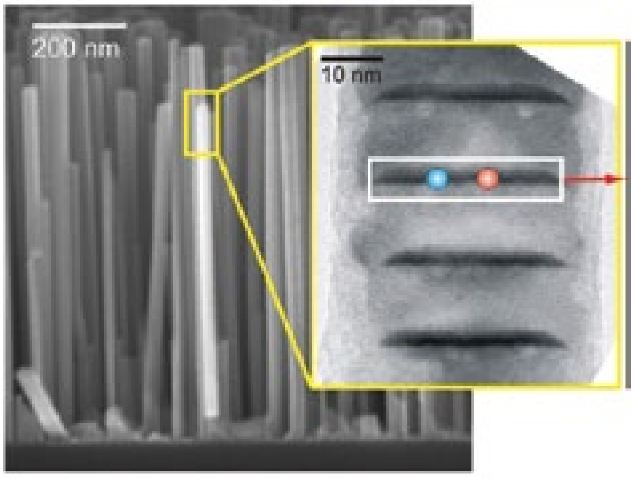
Quantum Optics. The "artificial atoms" realized with QDs and colloidal nanocrystallites allow a lot of new experiments in quantum optics. The coupling of these nanoobjects with photonic nanostructures (2D cavities, microdisks, photonic crystals, photonic wires, metallic nanoantennae for plasmonics) opens the field of cavity quantum electrodynamics (weak and strong light – matter coupling regimes). The production, manipulation and detection of these new quantum states of light (generation of single photons, pair or triplet of entangled photons, non-linear optics and optical quantum logic gates working at the scale of a single photon, quantum coherence on the macroscopic scale) will be systematically studied in order to develop revolutionary devices for communications, sensing and spectroscopy.

We also focus on developing the means of exploiting spin properties, with a single electron spin, single magnetic atom spin, and polarization of a single photon as ultimate limits.

Interconnected Molecular Beam Epitaxy chambers

Nano for energy. Nanotechnology provides a key to overcome current performance barriers for the production and the conversion of light. The goal of our initiative is to exploit the benefits of these nano-objects by enhancing understanding of conversion and storage phenomena at the nanoscale level: indeed nanoparticles and nanostructures can improve the collection and conversion of solar energy, while at the same time providing better thermal storage and transport.

The area of bandgap engineering, involving nanostructures such as quantum wells, strained or type II superlattices, quantum dots, and nanopillars, opens new paths for a wide variety of applications including energy generation and harvesting, laser and light emitting diode (LED) sources, infrared imaging. The consortium is also motivated to develop organic and hybrid photovoltaic systems by using a molecular engineering approach for the design and the synthesis of new molecules and polymers, new QDs in view of their use in stable, flexible, large area and low cost solar cells.



Quantum dots as a slice in a nanowire

Silicon photonics. Our aim here is to unveil new devices based on the unique properties of silicon down-sized to the nanometer scale, and to explore their potential applications compatible with conventional microfabrication and nanofabrication silicon technology. For example, light generation using Si or SiGe quantum dots, or silica doped with rare earth ions, embedded in silicon-on-insulator (SOI) photonic crystals can lead to ultra strong light confinement in high Q nanocavities and is a promising building block for future on-chip all optical light logic functions.

Key figures:
Permanent scientists from INAC, LNCMI, NEEL
50 PhD students and postdocs
Strong collaborations with Warsaw, Lausanne, ...
R&D and industry: LETI, LITEN, ...

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