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investigate novel tuning properties of polaritons at room temperature. Observed vibrational resonances in such cantilever and bridge microcavities open the way to opto-mechanical interactions of the strongly-coupled polaritons. The emerging feasibility of such MEMS-polaritonics suggests a number of technologies can be accessed.

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Efficient and broadband spontaneous emission control in fiber-like photonic nanowires — •Julien Claudon[1], Mathieu Munsch[1], Joël Bleuse[1], Nitin S. Malik[1], Emmanuel Dupuy[1], Yuntian Chen[2], Niels Gregersen[2], Jesper Mork[2], Ivan Maksymov[3], Jean-Paul Hugonin[3], Philippe Lalanne[3], and Jean-Michel Gérard[1] — [1]Joint group CEA-CNRS-UJF 'NanoPhysique et SemiConducteurs', CEA, INAC, SP2M, Grenoble, France — [2]DTU Fotonik, Department of Photonics Engineering, Technical University of Denmark, Kongens Lyngby, Denmark — [3]Laboratoire Charles Fabry de l'Institut d'Optique, CNRS, Université Paris-Sud, Palaiseau, France

Funneling a large fraction of the spontaneous emission (SE) of a quantum emitter into a single optical mode is a powerful strategy for improving the brightness of quantum light sources or developing an efficient spin-photon interface. In the solid state, preferential emission into a single localized mode has been first achieved taking advantage of the Purcell effect that arises in semiconductor optical microcavities. In the last years, the need to overcome the limited operation bandwidth inherent to a resonant approach has triggered intense research on SE control in waveguide structures. Among the investigated platforms, fiber-like photonic nanowires are particularly appealing, as shown by the recent development of a very bright single-photon source based on a wire with carefully engineered ends [1,2].

Here we focus on the mechanisms governing the SE dynamics of the embedded emitter and consider a photonic nanowire made of GaAs (refractive index n=3.5) and surrounded by air (n=1). It features a circular section (diameter d), and contains spectrally isolated single InAs quantum dots (QD) with a free space emission wavelength around 920 nm. The large refractive index contrast between the wire and the air cladding has two important consequences: i) The coupling to the 3D continuum of non-guided modes is strongly inhibited, thanks to a pronounced dielectric screening effect. Experimentally, the coupling to these modes can be probed by studying the luminescence decay of QDs embedded in 'small' wires (d = 120 nm), for which the coupling to the guided mode is vanishingly small. In that case, we measure a slow-down of the SE rate by a factor 16, a value which is comparable to the one obtained in state-of-the-art photonic crystal structures. ii) For larger structures (d = 220 nm), the fundamental guided mode is tightly confined in the wire. The emitter is well coupled to this mode, and the SE rate becomes comparable to the one measured on a QD embedded in bulk GaAs. These experimental results demonstrate the ability of these simple structures to funnel a large fraction (> 90%) of the SE into the guided mode [3].

For some applications (e.g. polarization encoded quantum key distribution, generation of indistinguishable photons), it is desirable to control the polarization of the emitted photon. This control can be efficiently implemented in a wire featuring an elliptical section with a moderate aspect ratio (~ 2). In that case, calculations show that the local density of optical modes is largely dominated by a single guided mode, with a linear polarization oriented along the major axis of the ellipse. Polarization-resolved measurements conducted on elliptical GaAs photonic nanowires embedding spectrally isolated InAs QDs fully confirm the predicted performances: the fraction of collected photons with the desired polarization can be as high as 95% [4].

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First-Principles Study of Light Emission from Si/Ge Quantum Well — •Yuji Suwa[1,2,3], Shin-ichi Saito[1,2,3], Katsuya Oda[1,2,3], Kazuki Tani[1,2,3], Makoto Takahashi[1,2,3], Etsuko Nomoto[3], Tadashi Okumura[3], Yong Lee[3], Misuzu Sagawa[1,2,3], Toshiki Sugawara[1,2,3], and Tatemi Ido[1,2,3] — [1]Photonics Electronics Technology Research Association (PETRA) — [2]Institute for Photonics-Electronics Convergence System Technology (PECST) — [3]Central Research Laboratory, Hitachi, Ltd., Kokubunji, Tokyo 185-8601, Japan

Efficient light sources made of silicon or germanium have large potential applications due to their affinity to silicon substrates. Incorporation of such light-sources into silicon devices enables a fusion of photonic devices and electronic devices. Because both of bulk silicon and bulk germanium are not good light emitters due to their indirect band-gap structures, enhancement of light emission is an important issue for such devices.

Recently we showed that a silicon quantum-well can be a good light-emitter if the thickness is thin enough (less than several nanometers) as a result of theoretical and experimental studies [1-4]. This can be explained by direct transitions due to a valley-projection. When a Si(001) quantum-well is fabricated, two of six electron valleys of bulk silicon at X-points are projected onto Γ-point in a two-dimensional k-space. Then, direct transition occurs because hole valleys exist at Γ even in a quantum well. Such a light emission is enhanced when the thickness of the quantum-well is very thin. At that time, the energy level of the projected electron valleys at Γ is lower than that of remaining four valleys due to a quantum-confinement effect and anisotropy of the effective masses of electrons.

Germanium has two important differences with silicon. One is that it has four electron valleys at L-point, and the other is that there is an additional electron valley at Γ-point whose energy level is slightly higher than that of L. Consequently, there are two possible approaches to enhance light-emission from germanium. One is to use L-valleys through a valley projection like a silicon, and the other is to use Γ-valley. As a result of first-principles calculations of germanium quantum-wells, we found that using Γ-valley is more effective because of its large optical matrix element.

In order to use Γ-valley, we have to achieve an effective electron injection into it, which is usually difficult due to higher energy level compared to L-valley. We studied methods of applying tensile strains to modify conduction band and n-type doping to fill out L-valleys [5]. We found that both methods are effective and important. To have a positive optical gain necessary for realizing germanium laser, calculated results show that the above two methods should be used fully. Direction of the tensile strain can be an important key factor.

In parallel with theoretical calculations, we are doing experiments to realize silicon/germanium quantum-well laser. We are fabricating both single quantum-well structures and multi-quantum-well 'fin' structures. We will also show experimental results of these light-emitting quantum-wells at the conference.

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Optical sensing of individual nanoparticles in silicon-based two-dimensional hollow photonic crystal cavities — •Nicolas Descharmes, Ulagalandha Perumal Dharanipathy, Zhaolu Diao, Mario Tonin, and Romuald Houdré — Laboratoire d'Optoélectronique Quantique, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Suisse

Optical detection and manipulation of individual nanoparticles rely on the ability to confine strong electromagnetic (EM) fields in volumes smaller than a cubic wavelength and to simultaneously ensure overlap of the field with the particles. Such levels of confinement are difficult to achieve with classical light focusing methods but are within reach of state-of-the-art photonic nanostructures. Semiconductor-based photonic bandgap cavities have demonstrated large field confinement abilities. Their applicability to particle sensing and manipulation is nonetheless limited by the tendency of the field to concentrate in the semiconductor rather than in the sensing medium. Two-dimensional hollow photonic crystal (HPhC) cavities however fulfill both these requirements though they surprisingly received less attention than their one-dimensional counterparts or plasmonic approaches.

A variety of HPhC cavities can be fabricated offering estimated overlaps comprised between twenty and eighty percents while featuring quality factors up to several tens of thousands in silicon. This type of structures constitutes therefore an ideal platform for the study of nanoparticle and EM field interaction investigation. One very interesting aspect of this interaction, in contrast to classical light focusing methods, lies in the resonant nature of the field interacting with the particle.

In this work, design and fabrication of two types of HPhC cavities of different quality factors and estimated overlaps is reported. Cavity design is performed using a combination of Plane Wave Expansion (PWE) and 3D Finite Element Analysis (3D FEM) tools. Fabrication relies on state-of-the-art electron beam lithography and reactive ion etching of silicon. The obtained cavities are subsequently integrated in an ultrathin microfluidic circuit, whose thickness is chosen to compare with standard glass microscope coverslips. The centimeter size optofluidic structure obtained is finally immersed in aqueous medium and operated to demonstrate single particle detection on a chip. Detection events, materialized by a shift of the resonance frequency of the cavity, are generated in a consistent manner by attracting colloidal polystyrene beads near the cavity region, assisted with standard optical tweezers. Resonance frequency tracking of the cavity mode is realized through continuous scans of the excitation wavelength while recording cavity-scattered light. We show that this approach allows reversible and repeatable in-situ monitoring of the impact of a particle on the cavity mode.

In a second part of this work, existence of retroaction of the cavity field on the particle will be presented. It consists in a positive feedback mechanism where the particle contributes, through the shift mechanism demonstrated above, to the building up of the resonant cavity field, while the later attracts the particle towards the larger field regions through gradient force. The retroaction results in an alteration of the Brownian motion properties of the particle under investigation. Power and wavelength-dependent study of the Brownian motion will be presented.

Future prospects include the use of microfluidic integrated hollow photonic crystal cavities for the investigation and manipulation of biological microorganisms such as bacteria, viruses and DNA strands in one hand and of optical gain materials like colloidal nanocrystals and quantum dots on the other hand.