Ovoid ring resonators for microlasers and ultrafast switching

Principal investigators

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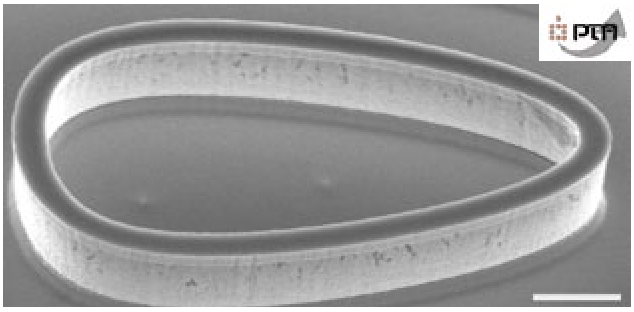
This project, which started in September 2014, aims at engineering the shape of optical ring microcavities so as to get a directional output emission beam, in view of an application to microlasers. Encouraging results have already been obtained for ovoid ring resonators containing quantum dots, which have been etched from a GaAs/AlGaAs semiconductor waveguide. Such extended microcavities display also important assets in the context of ultrafast cavity-switching experiments.

Description

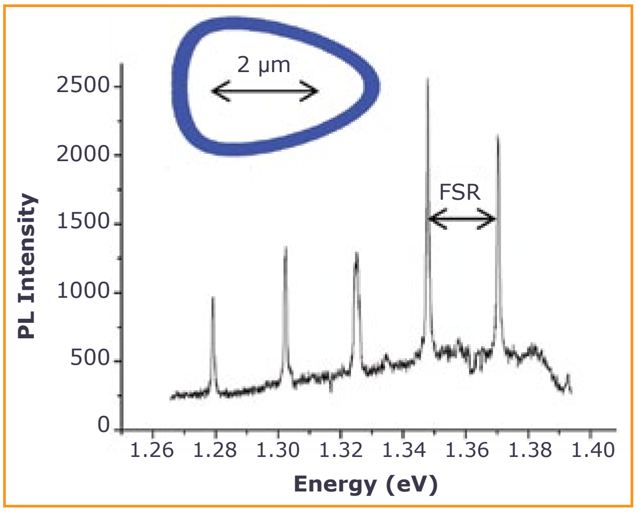
Ring resonators are widely used as couplers, filters and waveguide-coupled microlasers in integrated photonic circuits. Other applications (e.g. to optical sensing) have been until now hindered by the isotropic character of the emission of circular ring resonators. In this work, we study ovoid ring resonators, for which we expect to concentrate the radiation losses close to the ovoid's tip, and to tailor the radiation pattern. As shown in figure 1, such rings have been fabricated in the PTA nanofabrication facility by e-beam lithography and reactive ion-etching, starting from a GaAs/GaAlAs waveguide containing a layer of quantum dots in its core.

Microphotoluminescence experiments reveal a well-defined family of high Q whispering gallery modes. Preliminary experiments supported by electromagnetic modelling using the COMSOL software also show that the emission is concentrated in two main lobes, related to the escape of photons travelling clockwise or contra-clockwise inside the ring. We will explore in the future various methods potentially enabling emission into a single lobe, for instance by ensuring a one way circulation of light into the ring. Next to the recent observation of lasing under optical pumping, we will also aim at demonstrating lasing under electrical injection.

Such extended cavities are also interesting in the context of cavity switching experiments. We have already shown that the optical injection of free carriers induces a spectral shift of the WGMs on a picosecond time scale. This effect will be used to modify the spontaneous emission rate of embedded quantum dots in an ultrafast way, through an on/off switching of the Purcell effect.



Scanning electron micrograph of a typical ovoid ring resonator (scale bar : 1 µm)



Microphotoluminescence spectrum obtained for an ovoid ring resonator containing InAs quantum dots as active medium

Outcomes: T Sattler et al, in preparation for submission to Appl. Phys. Lett.
Collaboration: with the group of Willem L. VOS (University of Twente, The Netherlands) about the ultrafast switching of ring resonators.

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