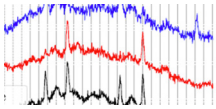

Whispering gallery modes in microdiscs

Light can be confined within micro- or nanostructures, resulting in both resonance and energy localization. In cylindrical dielectric microstructures, resonant modes propagate along the circles bounding the cylinder: these are called whispering gallery modes. The energy is then localized in a ring, with an intense evanescent extension near the micro-cylinder. These highly resonant modes are used for microlasers, photonic devices and biosensing. However, manufacturing such high-quality resonators on a chip requires a complex, time-consuming and costly cleanroom lithographic process, which is a limitation for industrial use. Members of the Acoustics and Optics for Nanoscience and Quantum team have developed a versatile, fast and inexpensive photolithography process for fabricating such resonant cavities, paving the way for laser applications.

We manufacture microdisks by photolithography on a layer of negative photoresist, deposited on a thin layer of gold. Using a standard optical microscope and a UV laser, we crosslink the resin to obtain dielectric disks whose size (between 2 and 10 μm in diameter) depends on the shape and intensity of the laser, the thickness of the resin layer and the exposure time. The manufacturing process is therefore scalable and controllable in terms of the position and size of the microdisks. Colloidal CdSe/CdS core/shell quantum dots, offering high photostability, are then deposited on the sample. Their ligands are chosen to bind selectively and homogeneously to the microdisk. Under UV illumination, these quantum boxes efficiently excite whispering gallery modes whose energy is concentrated on a ring at the boundary of the microdisk. The spectrum of light scattered by the microdisk reveals resonant gallery modes with a quality factor of at least 6000.

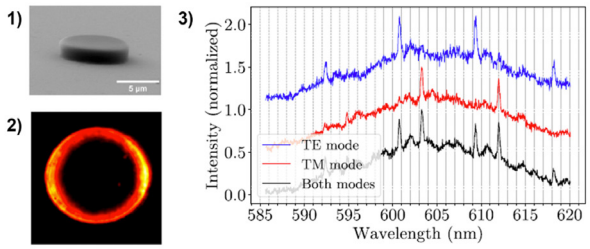

Figure
(1) SEM image of a micro-resonator.
(2) Fluorescence image of the resonant gallery modes inside the microdisk.
(3) Spectra of the gallery modes (black) and its modes in TE (red) and TM (blue) polarization.

Our protocol has enabled us to fabricate a dielectric microdisk whose surface is selectively coated with fluorescent quantum dots in order to excite resonant whispering gallery modes. This paves the way for on-chip, low-threshold microlasers.

Reference

Photolithographed Whispering Gallery Mode Microdisk Cavities Coupled to Semiconductor Quantum Dots
Charlie Kersuzan, Sergei Celaj, Willy Daney de Marcillac, Thomas Pons*, Agnès Maître*
ACS Photonics, 11(4), 1715-1723 (2024)
https://hal.science/ALLINSP/hal-04862425v1

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