Q 67: Photonics IV

Time: Friday 14:00–15:45 Location: F 128

Q 67.1 Fr 14:00 F 128

Controlling the optical properties of single molecules by optical confinement in a tunable microresonator (exchanged with Q 55.36) — •Raphael Gutbrod, Alexey Chizhik, Anna Chizhik, Dmitry Khoptyar, Sebastian Bär, and Alfred J. Meixner — Institute of Physical and Theoretical Chemistry, University of Tübingen

Optical single-mode microresonators are structures which confine light to a small region in the range of half a wavelength. The broadband fluorescence emission and the decay lifetimes of single molecules are altered by the optical mode structure. In the tunable microresonator we present here, the resonator length can be changed reversibly with piezoelectric elements to a distinct position corresponding to a specific emission wavelength. The local mode structure of the electromagnetic field is changed at this position which results in a redistribution of the fluorescence and a modification of the lifetime for the same single molecule. The results obtained are in good agreement with the semiclassical model we developed for a better understanding of the coupling mechanisms between a single molecule and the cavity. The radiative coupling of the molecule to the electromagnetic field is also determined by the orientation of its transition dipole moment. Focusing a radially polarized doughnut mode laser beam (cylindrical vector beam) via a high NA into such a resonator leads to an inhomogeneous field distribution. By comparing the excitation pattern of a molecule with the calculated vector field distribution, we can determine the position or 3D-orientation of this molecule with high accuracy.

Q 67.2 Fr 14:15 F 128

Addressing single mode in GaAs/AlAs micropillar resonators — •Georgios Ctistis[1,3], Edwin van der Pol[1], Alex Hartsuiker[1], Maela Bazin[2], Julien Claudon[2], Jean-Michel Gérard[2], and Willem L. Vos[1,3] — [1]Center for Nanophotonics, FOM Institute for Atomic and Molecular Physics (AMOLF), Amsterdam, Netherlands — [2]CEA-CNRS Nanophysics and Semiconductors joint laboratory, Grenoble, France — [3]Complex Photonic Systems (COPS), MESA+ Institute for Nanotechnology, University of Twente, Netherlands

In this talk we present broadband white-light reflectivity experiments on micropillar resonators with diameters ranging between 1μm and 20μm. The micropillars consist of a GaAs λ-layer, sandwiched between two Bragg-stacks made of $\lambda/4$ GaAs/AlAs layers, and were fabricated by molecular-beam epitaxy. We are able to spectrally resolve distinct transverse modes in the reflectivity experiments and to address single modes by scanning the probe beam along the top facet of the micropillar. The positioning of the focused laser beam turns out to be crucial for pillar diameters exceeding the beam diameter, since at every position the coupling efficiency to different modes changes. By decreasing the pillar diameter, we are able to resolve single modes, since the spacing between the modes increases.

Q 67.3 Fr 14:30 F 128

Hybrid SOI nonlinear optical polymer racetrack resonator designs for electro-optical modulation — •Jan Hampe, Jan-Hendrik Wülbern, Stefan Prorok, Alexander Petrov, and Manfred Eich — TU Hamburg-Harburg, Eißendorfer Str. 38, 21073 Hamburg

Racetrack resonators based on the silicon-on-insulator (SOI) platform are proposed for modulation of an optical continuous wave (CW) signal by electrical signals.

The resonators are functionalized by a cladding of a second order nonlinear optical (NLO) polymer.

Two different concepts for the racetrack design employing different waveguide geometries for quasi-TE and quasi-TM polarization operation are presented.

The Pockel's coefficients of the in device poled NLO polymers are determined by the shift of the resonance wavelength with applied voltage and the modulation depth with low frequency signals.

In both resonator designs the electrical contact is established by fully etched segmented electrode sections to allow for an easy fabrication process.

Q 67.4 Fr 14:45 F 128

Fabry-Perot microcavities in ultra-small SOI waveguides — •Bülent A. Franke[1], Aws Al-Saadi[1], Shaimaa Mahdi[1], Sigurd Schrader[2], Viachaslau Ksianzou[2], Harald Richter[2], Stefan Meister[1], and Hans J. Eichler[1] — [1]Technische Universität Berlin, Institut für Optik und Atomare Physik, Berlin, Germany — [2]Technische Fachhochschule Wildau, Institut für Plasma- und Lasertechnik, Wildau, Germany

Microcavity filters in ultra-small Silicon on Insulator (SOI) waveguides are investigated. The microcavities are formed by one-dimensional photonic crystals (PhC) in Fabry-Perot structures, which are embedded in planar strip waveguides with 500nm width and 220nm height.

The photonic crystal microcavities are fabricated in a CMOS environment using 248nm DUV lithography. Several types of PhC micorcavities were optically characterized by a measurement setup using an external cavity laser (ECL) (tunable from 1520nm to 1630nm) and a nano-positioning system with an active differential intensity alignment system for the coupling of light.

Results of a number of different cavity filters, for instances multicavity, first and higher order cavities will be presented. Furthermore the measured transmission characteristics will be compared with simulations.

Q 67.5 Fr 15:00 F 128

Frequency Stable Fiber Ring Laser based on Whispering Gallery Modes — •Benjamin Sprenger, Harald G. L. Schwefel, and Lijun Wang — MPI für die Physik des Lichts, Günther-Scharowsky-Str. 1 / Bau 24, D-91058 Erlangen, Deutschland

We use high quality (Q) factor whispering gallery mode resonances in microspheres to stabilize a fiber loop laser. Microspheres are created by melting the tips of standard 1550 nm fibers, and can have Q factors up to 10^8. We evanescently couple into the high Q modes of such a sphere using a tapered fiber, and out using a fiber polished at a sharp angle. By including this frequency selective element into a fiber loop laser we manage to stabilize the laser to single-mode emission. The linewidth is determined to be 170 kHz, limited by the resolution of a heterodyne beat measurement with a grating stabilized diode laser. This corresponds to a Q factor of 10^9, and is five orders of magnitude larger than in the unstabilized regime. Additionally, we observe a redshift with increasing pump intensity due to the thermo-refractive index inside the microsphere. Further experiments will focus on a more rigid coupling design to prevent the slight drift of the emission, as well as investigation of the linewidth and quantum behavior.

Q 67.6 Fr 15:15 F 128

Directional emission from Terahertz whispering gallery mode resonators — •Harald G. L. Schwefel[1], Sascha Preu[1], Sebastian T. Bauerschmidt[1], Stefan Malzer[1], Gottfried H. Döhler[1], Hong Lu[2], Arthur C. Gossard[2], and Lijun Wang[1] — [1]MPI für die Physik des Lichts, Erlangen — [2]Materials Department, Univ. of California, Santa Barbara, USA

High quality (Q) whispering gallery mode (WGM) resonators are known to feature extremely narrow frequency selectivity. Their azimuthal symmetry dictates however non-directional spatial emission. Theoretical studies predict that an inclusion of a finite scatterer inside the WGM resonator leads to directional emission [1]. In the THz domain, with millimeter wavelength, the accuracy requirements for fabricating such resonators are chiefly relaxed. Resonators in the optical domain, for comparison, require (sub-) nanometer accuracy. We report strong directional emission with a minimal loss in the Q factor from a 10 mm poly-ethylene disk including a 1 mm scatterer. For characterizing the resonator properties and emission pattern we use continuous-wave, room temperature operating Terahertz n-i-pn-i-p superlattice photomixer sources, pumped by two frequency off-set diode lasers operating at the telecommunication wavelength. The THz radiation is coupled into the resonators through the evanescent field of a thin dielectric waveguide and collected in the far-field with a Golay cell. Qualitative agreement of experiment and theoretical expectation will be reported.

[1] J. Wiersig and M. Hentschel, *Phys. Rev. A* **73**, 031802 (2006).

Q 67.7 Fr 15:30 F 128

Optical bistability and all-optical switching in bottle microresonators at very low powers via the Kerr effect —

•Michael Pöllinger and Arno Rauschenbeutel — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz

We present experimental results on nonlinear, low-power photonics applications of a silica whispering-gallery-mode microresonator. In contrast to microspheres and microtoroidal resonators, where the light is typically guided in a narrow ring along the equator of the structure, the prolate shape of our bottle microresonator gives rise to an advantageous mode structure with two independent coupling points accessible for two nanofiber-couplers. This makes our resonator a real four-port device. Moreover, at a wavelength of 852 nm, the resonator yields an ultra-high intrinsic quality factor Q exceeding 10^8 and a mode volume around $V = 1300\ \mu\text{m}^3$. The resulting Q^2/V-ratio is among the highest realized for optical microresonators. The shift of resonance frequency in units of the linewidth scales with this ratio. Therefore, despite the small nonlinear refractive index of silica we observe optical bistability and all-optical switching at thresholds of some 100 μW via the Kerr effect and of some tens of μW for the slower thermo-optical effect. Finally, the possibility of enhancing the Kerr nonlinearity by coating the resonator with thin polymer-films is discussed.

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