Wire Cavity Photonic Crystal Hybrid III-V Laser on Silicon Wire

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Abstract

We report laser emission from hybrid III-V nanocavities on silicon on insulator waveguide. The cavity is optically pumped by the surface laser emission is coupled into the SOI wire and collected at its output.

For the high Q/V factor they offer, small volume cavities based on a periodic line of holes in a waveguide (wire cavities) are being extensively studied both theoretically and experimentally[1]. Even though a lot of attention has been devoted to passive structures and incorporating an active element has not been explored yet, though it is an exciting possibility as the strong light confinement promises ultra-small lasers with low laser thresholds. Making them CMOS compatible would open up myriads of applications. For this, the most efficient way would be to combine III-V active elements and low-loss passive silicon photonic circuitry drawing benefit from the technological advancement in both material systems. In this work, we report laser emission obtained at 1.55μm from InP-based wire cavity heterogeneously integrated to silicon on insultalator wavguides.

The sample is depicted in Fig. 1a, the lower level is composed of narrow Si waveguides (~500nm wide and ~220nm high) where the light propagates passively, and the top layer is the active InP-based wire cavity. Silicon waveguides are fabricated in a CMOS fab using 193nm DUV lithography on SOI. The InP heterostucture is grown by MOCVD and the wire cavity obtained through electron beam lithography followed by plasma etching. Details on the fabrication may be found in [2]. The samples are optically surface-pumped by a pulsed 800nm diode laser at repetition rate of 300kHz with a 2% duty cycle. The emission is detected simultaneously, from the surface of the wire cavity and at the output of the SOI wire. The results of the measurements are shown Fig. 1b. As the design of the cavity is optimised for guided mode emission and we measured a guided emission that is a factor of three higher than the vertical emission.

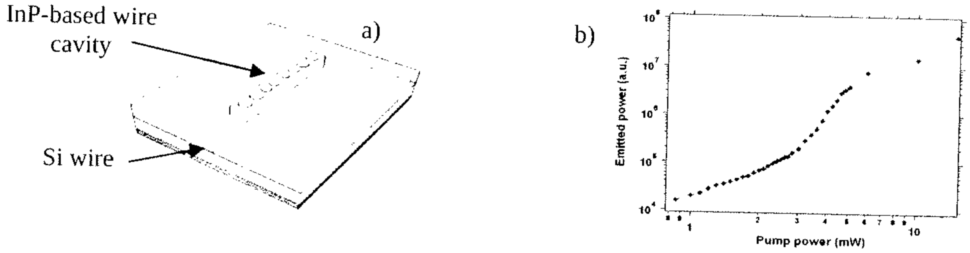

Fig.1 a) Schematics of the studied sample. b) Emitted power versus pump power.

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References

[1] J.S. Foresi et al., Nature **390**, pp. 143-145 (1997).

[2] T. J. Karle et al, J. Appl. Phys, **107**, 063103 (2010)

Room: Maiman

TOM 1

10:00 Student presentation

Three-dimensional particle manipulation in stereoscopic optical tweezers using complex non-diffracting elliptical beams

C. Alpmann[1], R. Bowman[2], M. Woerdemann[1], M. Padgett[2], C. Denz[1]; [1] Westfälische Wilhelms Universität Münster, Institut für Angewandte Physik (DE), [2]University of Glasgow, Department of Physics and Astronomy (UK).

We demonstrate the generation of high quality Mathieu beams of various orders. The transversal field distributions of these non-diffracting beams enable us to create complex 3D particle structures in stereoscopic optical tweezers, which gives three-dimensional observation. [3469]

10:15 Student presentation

Microscope-based orientation and sorting of biological objects with optical tweezers and forward scattered light

B. Landenberger[1,2], A, Rohrbach[1]; [1]Lab for Bio- and Nano-Photonics, University of Freiburg (DE), [2]Centre for Biological Signalling Studies (bioss), University of Freiburg (DE).

An inverted microscope-based setup is presented that allows manipulation with optical forces, multi-dimensional tracking, multi-spectral observation, and analysis of biological objects ranging in size from single suspension cells to small embryos, consisting of thousands of cells. [3315]

10:30 Student presentation

Microfluidic systems combined with optical micromanipulations and spectroscopy for live-cell analysis and sorting

Z. Pilát, A. Jonáš, O. Samek, J. Ježek, M. Šerý, P. Zemánek; Institute of Scientific Instruments of the ASCR, v.v.i., Academy of Sciences of the Czech Republic (CZ).

We have investigated a combination of optical trapping with microspectroscopic techniques and microfluidic chips for advanced biotechnological applications. [3486]

Room: Michelson

TOM 2

10:00

Low divergence Terahertz photonic-wire laser

M.I. Amanti, Gi. Scalari, F. Castellano, M. Beck , J. Faist; ETH Zurich, Institute for Quantum Electronics (CH).

Edge emitting, terahertz quantum cascade photonic-wire lasers, based on a third order Bragg grating are presented. Devices with a power consumption as low as 300 mW, with a single frequency output power of more than 1.5 mW in a single narrow spot are demonstrated. [3639]

10:15 Student presentation

A new material system for terahertz quantum cascade lasers: InGaAs/GaASb

C. Deutsch[1], A. Benz[1], K. Unterrainer[1], P. Klang[2], H. Detz[2], M. Nobile[2], A.M. Andrews[2], W. Schrenk[2], G. Strasser[2]; [1]Vienna University of Technology, Photonics Institute (AT); [2]Vienna University of Technology, Center for Micro- and Nanostructures and Institute for Solid-State Electronics (AT).

We demonstrate terahertz quantum cascade laser devices based on the Aluminum free InGaAs/GaAsSb material system. Disk devices in a double-metal waveguide configuration show spectral emission between 3.6 and 4.1 THz and reach operating temperatures up to 105 K. [3543]

10:30

Performance of a compact, continuous-wave terahertz source based on a quantum-cascade laser

H. Richter[1], M. Greiner-Bär[1], S.G. Pavlov[1], A.D. Semenov[1], M. Wienold[2], L. Schrottke[2], M. Giehler[2], R. Hey[2], H.T. Grahn[2], H.-W. Hübers[3]; [1]German Aerospace Center (DLR), Institute of Planetary Research (DE); [2]Paul-Drude-Institut für Festkörperelektronik (DE); [3]Institut für Optik und Atomare Physik, Technische Universität Berlin (DE).

We report on the development of a compact, easy-to-use terahertz radiation source, which combines a quantum-cascade laser (QCL) with a compact, low-input-power Stirling cooler. [3377]

Room: Foucault

TOM 3

10:00 Student presentation

Wire cavity photonic crystal hybrid III-V laser on silicon wire

Y. Halioua[1,2], F. Raineri[1,3], A. Bazin[1], T.J. Karle[1], P. Monnier[1], I. Sagnes[1], G. Roelkens[2], R. Raj[1]; [1]Laboratoire de Photonique et de Nanostructures, (CNRS-UPR20) (FR), [2]Photonics Research Group, IMEC/Ghent University (BE), [3]Université Paris Diderot (FR).

We report laser emission from hybrid III-V nanocavities on silicon on insulator waveguide. The cavity is optically pumped by the surface laser emission is coupled into the SOI wire and collected at its output. [3625]

10:15

High frequency GaAs nano-optomechanical disk resonator

L. Ding[1], C. Baker[1], P. Senellart[2], A. Lemaitre[2], S. Ducci[1], G. Leo[1], I. Favero[1]; [1]Laboratoire Matériaux et Phénomènes Quantiques, Université Paris-Diderot, CNRS (FR), [2]Laboratoire Photonique et Nanostructures, LPN/CNRS (FR).

We present a high quality optical/mechanical GaAs disk resonator for cavity nano-optomechanics experiments. We measure giant optomechanical coupling rate (up to 10GHz/nm) and high frequency (up to GHz) mechanical modes, both resulting from the resonator nanoscale dimensions. Motional sensitivity of 10-17 m/√Hz is obtained. [3397]

10:30

Ultra-sharp edge filtering in nanotethered photonic wire evidenced by delay measurement

A. Talneau[1], I. Sagnes[1] , R. Gabet[2], Y. Jaouen[2], H. Benisty[3]; [1]CNRS-Laboratoire de Photonique et de Nanostructures (FR), [2]TELECOM Paris Tech, [3]IOGS Laboratoire Charles Fabry, CNRS (FR).

Within a suspended InP photonic wire, the periodically spaced nanotethers holding the wire can behave as coupled resonators on a partially reflecting waveguide, creating an ultra-sharp filter edge. This complex resonant mechanism is investigated theoretically and evidenced experimentally using optical low coherence reflectometry. [3535]

Room: Newton

TOM 4

9:45 Student presentation

Complete wavefront reconstruction at infrared wavelength using speckle phase retrieval

V.A. Gonzalez, T.J. Abregana, P.F. Almoro; National Institute of Physics, University of the Philippines (PH).

Reconstruction of an object wave front at infrared wavelength (1024 nm) using a speckle based phase retrieval technique is demonstrated experimentally. Correlation of the reconstructions with those obtained using digital holography confirm the effectiveness of our technique. [3531]

10:00 Student presentation

Observation of the differences between scalar and rigorous calculation at CGHs in Twyman-Green interferometers for lens testing

W. Iff[1], S. Glaubrecht, N. Lindlein, J. Schwider; University of Erlangen, Chair of Optics, Institute of Optics, Information and Photonics (DE).

We investigate how differences between the scalar thin element approximation (TEA) and the rigorous calculation at computer generated holograms (CGHs) in Twyman-Green interferometers in null test configuration affect phase and intensity in the detector plane. The TEA and rigorous ray optics (RROM) are employed for the simulations. [3484]

10:15

On-line 4D microscopy of non-periodic changing surfaces using high speed white light interference microscopy

P.C. Montgomery, F. Anstotz, J. Montagna; Institut d'Electronique du Solide et des Systemes, Laboratoire Commun UdS-CNRS, UMR 7163 (FR).

A 4D (3D+t) real time interference microscopy system has been developed based on a high speed camera coupled with a FPGA processor. Real time 3D measurement at up to 25i/s allows the characterisation of changing microscopic surfaces. [3471]

10:30 Student presentation

3D reconstruction in digital holographic microscopy

F. Joud[1], F. Verpillat[1], M. Atlan[2], M. Gross[1]; [1]Laboratoire Kastler Brossel, UMR 8552 CNRS ENS (FR), [2]Institut Langevin, ESPCI, 10 Rue Vauquelin (FR).

We describe an original method able to perform the holographic reconstruction in Digital Holographic Microscopy (DHM) without distortion of the 3D image in the longitudinal z direction. This method is well suited to reconstruct the 3D image the wave-field diffracted by an object. The reconstruction parameters can be calculated from the holographic data, without calibration of the setup. Reconstruction of the 3D wavefield diffracted by a 200 nm gold particles under TIR illumination is presented as an example. [3460]

10:45 - 11:15 coffee break (exhibition hall)