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Advance Programme

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ROOM 7

scaling of the output average power of fiber laser systems.

CJ-8.2 FRI 11:30

Towards CEP-stable single-cycle pulses with microjoule-level energy at 8 MHz repetition rate

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A 20 cm long Kr-filled single-ring hollow core PCF, pumped by 36 fs pulses from a low-noise Yb fibre laser at 8 MHz, produces 7.3 fs pulses with microjoule-level energy.

ROOM 8

under continuous femtosecond laser irradiation. Over >400 hours, a stable octave-spanning supercontinuum plus second-harmonic generation allows for direct self-referencing of a frequency comb.

CK-8.2 FRI 11:15

Supermode-based second harmonic generation in a nonlinear interferometer

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We experimentally demonstrate supermode-based SHG through a specifically-designed integrated LiNbO3 nonlinear interferometer made of linear and nonlinear directional couplers with a fully-fibered pump paving the way for the demonstration of on-chip supermode-based entanglement.

CK-8.3 FRI 11:30

High-yield, wafer-scale fabrication of ultralow-loss, dispersion-engineered silicon nitride photonic circuits

•*J. Liu, G. Huang, R.N. Wang, J. He, A. Raja, J. Riemensberger, G. Lihachev, N. Engelsen, and T. Kippenberg*; *Swiss Federal Institute of Technology Lausanne (EPFL), Lausanne, Switzerland*

For widespread applications of nonlinear photonic integrated circuits, ultralow optical losses and high fabrication throughput are required. Here, we present a CMOS fabrication technique for photonic microresonators with mean quality

ROOM 9

PhoenixD (Photonics, Optics, and Engineering-Innovation Across Disciplines), 30167 Hannover, Germany

We report that, for both linear and circularly polarized femtosecond multi-color laser pulses, the infrared to terahertz conversion efficiency increases with the number of laser harmonics.

EE-5.2 FRI 11:15

Dispersion Management of Mid-Infrared Filamentation in Dense Gases

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In 3D+t numerical simulations, we propose an experiment, where a mixture of gases (nitrogen and water vapor) is used for the continuous transition from X- to O-shaped angle-wavelength spectrum of a femtosecond infrared filament.

EE-5.3 FRI 11:30

High-Energy Pulse Compression in the Mid-Wave Infrared

•*T. Nagy, L. von Grafenstein, D. Ueberschaer, and U. Griebner*; *Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Berlin, Germany*

We compress 45mJ, 2.4ps pulses of a 1kHz holmium laser emitting at 2.05μm wavelength to 90fs duration in a stretched hollow-core fiber. The pulses comprise >20mJ energy at >20W average power, setting a new milestone.

ROOM 10

harmonic generation in the THz regime. By exploiting 2D-patterned graphene patches and aligning the fundamental and third-harmonic frequencies with metasurface resonances, we achieve conversion efficiencies up to -19dB.

EH-5.2 FRI 11:15

Programmable Huygens' metasurfaces for active optical phase control

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We present tunable metasurfaces with incorporated phase change materials for optical phase control in transmission mode. The versatility of these metasurfaces is demonstrated by optically programming spatial light phase distributions with single meta–unit precision and retrieving high–resolution phase–encoded images.

EH-5.3 FRI 11:30

Nanomechanical Bistability in Photonic Metamaterial

•*D. Papas*[1], *J.-Y. Ou*[1], *E. Plum*[1], *and N.I. Zheludev*[1,2]; [1]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, Southampton, United Kingdom*; [2]*Centre for Disruptive Photonic Technologies, SPMS, TPI, Nanyang Technological University, Singapore, Singapore*

A nanowire array decorated with plasmonic resonators acts as optically bistable device. The optical properties of this metamaterial exhibit hysteresis and bistability when it is driven by a piezo actuator across its mechanical resonance frequency.

ROOM 11

free space millimeter radiation is a fast developing field that combines optoelectronics and RF domains. Here we present a quantum-cascade-laser based solution for THz laser emission and millimeter wave generation in a single device.

CC-7.2 FRI 11:15

Demonstration of a Resonantly Amplified Terahertz Quantum Cascade Detector

•*P. Micheletti, J. Faist, T. Olariu, M. Beck, and G. Scalari*; *ETH Zurich, Zürich, Switzerland*

The photon-driven nature of the transport in terahertz quantum cascade laser can be exploited to detect light. Fast tunable detectors are demonstrated with responsivities higher then 17 V/W and working temperature up to 100 K.

CC-7.3 FRI 11:30

THz electroluminescence from non-polar ZnO quantum cascade structures

•*B. Hinkov*[1], *B. Meng*[2], *H.T. Hoang*[1], *N. Le Biavan*[3], *D. Lefebvre*[3], *D. Stark*[2], *M. Franckié*[2], *A. Torres-Pardo*[4], *J. Tamayo-Arriola*[5], *M.M. Bajo*[5], *A. Hierro*[5], *J. Faist*[2], *J.-M. Chauveau*[3], *and G. Strasser*[1]; [1]*TU Wien, Institute of Solid State Electronics, Vienna, Austria*; [2]*ETH Zürich, Institute for Quantum Electronics, Zurich, Switzerland*; [3]*CNRS-CRHEA and Universite Cote d'Azur, Valbonne, France*; [4]*Universidad Complutense de Madrid, Departamento de Ouimica Inorganica, Madrid, Spain*; [5]*Universidad Politecnica de Madrid, ISOM, Madrid, Spain*

Non-polar m-ZnO is a new material in THz-intersubband optoelectronics for overcoming previous LO-phonon-energy-based limitations as

ROOM 12

nonlinearities for future all-optical operation of larger reservoir computers.

JSIV-3.2 FRI 11:15

Noise-Resistant Optical Implementation of Analogue Neural Networks

•*D. Arguello Ron, M. Kamalian-Kopae, and S. Turitsyn*; *Aston University, Birmingham, United Kingdom*

Optical implementations of analogue artificial neural networks are susceptible to the inevitable fabrication and environment noise. Here we show how robustness of such networks can be enchanced by the noise injection during the training stage.

JSIV-3.3 FRI 11:30

Mutually coupled random lasers in complex photonic networks

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Random lasers are studied in networks where mutual coupling is demonstrated by detecting unique spectral signatures from compound cavities. Proposed experiments and simulations provide the basis for larger networks and use in complex computational tasks.

THz electroluminescence from non-polar ZnO quantum cascade structures

B. Hinkov[1,*], B. Meng[2], H. T. Hoang[1], N. L. Biavan[3], D. Lefebvre[3], D. Stark[2], M. Franckié[2], A. Torres-Pardo[4], J. Tamayo-Arriola[5], M. M. Bajo[5], A. Hierro[5], J. Faist[2], J.-M. Chauveau[3], and G. Strasser[1]

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Semiconductor material systems based on GaAs or InP are excellent candidates for optoelectronics in the mid-IR to terahertz spectral range. Consequently, they have readily been used for devices like THz quantum cascade lasers (QCLs) in recent years. But besides significant progress in recent years, THz-QCLs are still limited to operate well below room temperature only [1]. One main driving mechanism for such (temperature-) limitations, is based on the relatively low LO-phonon energy in the primary used GaAs material system of $E_{LO,GaAs}$ ~ 36 meV. This yields, especially at high temperatures approaching room-temperature ($E_{kT,\ room\ temp.}$ ~ 26 meV), a very strong thermally activated non-radiative scattering process, that is competing with the wanted optical transition. To overcome these material limitations, we follow a disruptive approach: we changed and investigated another material system that has a much larger LO-phonon energy: ZnO ($E_{LO,\ ZnO}$ ~ 72 meV), which is promising above room temperature lasing operation [2]. In the following, we present our results for realizing, i.e. designing and fabricating [3] MESA structures with light outcoupling gratings into MBE-grown ZnO/ZnMgO THz QCL structures. In addition, we present the first observation of THz intersubband electroluminescence from the ZnO material system [4].

ZnO has a wurtzite lattice structure as main crystallographic conformation. To avoid internal fields, it is therefore highly beneficial to use one of its non-polar orientations, like the m-plane ($01\bar{1}0$) direction, which significantly simplifies the quantum design of the highly complex heterostructures of QCLs. While various (dry- & wet-) etchants do exist for the commonly used ZnO orientations like c-plane (0001), we had to develop a novel optimized etching scheme for m-plane ZnO. This etching includes smooth vertical sidewalls and low defect densities. Figure 1(a) shows the most important steps of our newly-developed and recently published [3] ICP-RIE etching scheme including: 1. Masking with SiN, 2. Dry-etching in $CH_4/H_2/Ar$ (30/3/3 sccm, RF = 250 W, ICP = 200 W, 20 mTorr, 20°C → > 30 nm/min, selectivity: ZnO:SiN/10:1) and 3. Wet (smoothing) etch in diluted $HCl:H_2O$/1:16. By additionally applying H_2O_2 for 5 min. at 95°C, we could also reduce surface leakage currents by more than 2 orders of magnitude [3]. Based on the previously described fabrication scheme, we realized MESA devices which include chirped 2nd-order topside outcoupling gratings (see Fig. 1(b), inset) from a newly designed THz QCL structure [4]. Its active region consists of a 4-QW $ZnO/Zn_{0.88}Mg_{0.12}O$ design with 100 periods. We then show in Figure 1(b) that we obtain the first observation of THz intersubband electroluminescence in ZnO from these structures [4]. Here, we present the bias dependent results measured at 110 K (Fig. 1(b)). We show a peak signal at ~8.5 THz, a spectral range that is not accessible by regular GaAs-based devices, due to the reststrahlen band between and 8 and 9 THz.

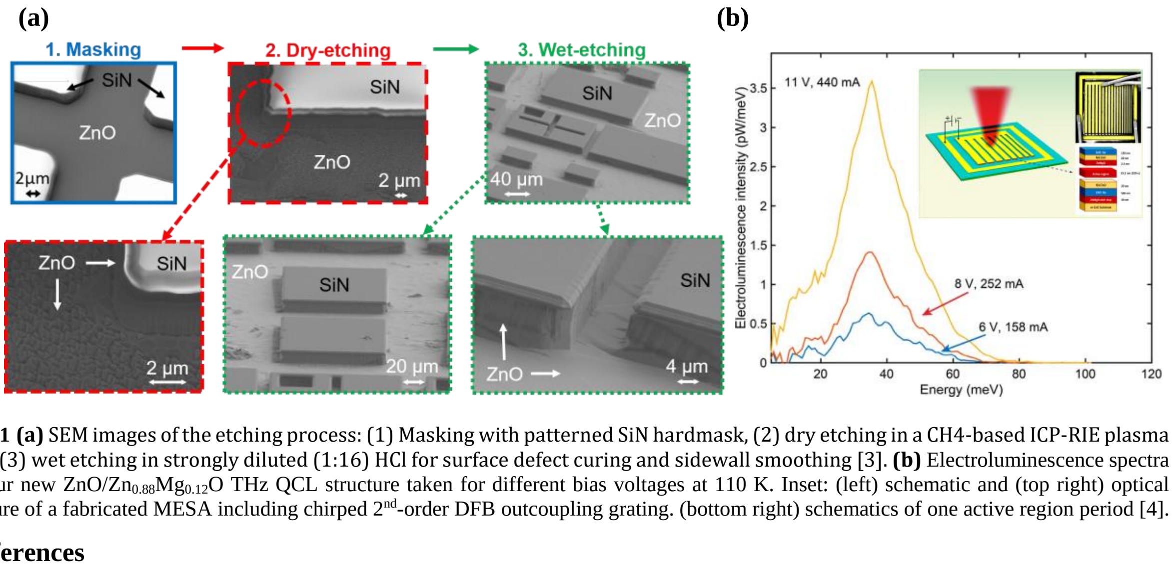

Fig. 1 (a) SEM images of the etching process: (1) Masking with patterned SiN hardmask, (2) dry etching in a CH4-based ICP-RIE plasma and (3) wet etching in strongly diluted (1:16) HCl for surface defect curing and sidewall smoothing [3]. **(b)** Electroluminescence spectra of our new $ZnO/Zn_{0.88}Mg_{0.12}O$ THz QCL structure taken for different bias voltages at 110 K. Inset: (left) schematic and (top right) optical picture of a fabricated MESA including chirped 2nd-order DFB outcoupling grating. (bottom right) schematics of one active region period [4].

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