HL 10: Focus Session: Highlights of Materials Science and Applied Physics I (joint session DS/HL)

Jointly organized on the occasion of the 60th anniversary of the *physica status solidi* journals (*pss*, http://www.pss-journals.com), this Focus Session features several invited presentations, talks and posters from key contributors on core condensed matter and applied physics topics. Highlights comprise the latest results on diamond, nitride semiconductors, organic materials, two-dimensional and quantum systems, oxides, magnetic materials, solar cells, thermoelectrics and more.

physica status solidi was launched by Akademie-Verlag Berlin in July 1961 and is published by Wiley-VCH Berlin and Weinheim today, supported by Wiley colleagues in China and the US. While in its first three decades it served as an East-West forum for solid state physics, since 1990 it has evolved into a family of journals with international author- and readership in a globalized scientific world. Its professional editorial services include topical curation, peer review organization, technical editing, special issue and hybrid open access publication.

The Focus session celebrates the numerous close collaborations and the steady support which the journals receive from their Advisory Board members, authors, reviewers and guest editors, including many members of the DPG and the condensed matter physics community in Germany.

(More information on '60 years of *pss*' is available at http://bit.ly/60_years_pss)

Organizers: Stefan Hildebrandt (Editor-in-Chief, pss), Norbert Esser (TU Berlin, ISAS) and Stephan Reitzenstein (TU Berlin)

Time: Tuesday 13:30–16:15 Location: H3

Topical Talk HL 10.1 Tue 13:30 H3

Single crystal diamond grown by CVD: state of the art, current challenges and applications — •Jean-Charles Arnault[1], Samuel Saada[2], and Victor Ralchenko[3,4] — [1]NIMBE, UMR CEA-CNRS 3685, Université Paris-Saclay, F-91191 Gif sur Yvette, France — [2]CEA, LIST, DM2I, F-91191 Gif-sur-Yvette, France — [3]Prokhorov General Physics Institute of Russian Academy of Sciences, Vavilov str. 38, Moscow 119991, Russia — [4]Harbin Institute of Technology, Harbin 150080, P.R. China

Single crystal diamond is the material of choice for future power electronics. Its electrical and thermal properties outperform those of other wide band gap semiconductors like 4H-SiC, GaN or Ga2O3. In addition, diamond can host a wide range of color centers (NV, SiV, GeV,...) that bring optical and spin properties suitable for quantum applications. This explains the ultrafast development of quantum applications based on diamond materials within the last years. For both application fields, diamond films of excellent crystalline quality are required and an accurate tuning of dopants is needed. This talk will draw the state of art of single crystal diamond grown by CVD either starting with diamond substrate (homoepitaxy) or controlling diamond epitaxial nucleation on a foreign substrate (heteroepitaxy). Progresses on substrates, growth mechanisms and reduction of structural defects, doping, upscaling and applications will be reviewed. In light of last progresses, future challenges and the respective roles of homoepitaxial and heteroepitaxial materials in the applications roadmap will be discussed.

Topical Talk HL 10.2 Tue 14:00 H3

Tuning Semiconductor Mode-Locked Laser Frequency Combs by Gain and Cavity Design — Stefan Meinecke and •Kathy Lüdge — Institute of Theoretical Physics, Technische Univ. Berlin

Passively mode-locked semiconductor lasers produce sequences of short optical pulses at high repetition rates without the need for an external driving frequency. They find applications in optical data communication and metrology and are promising candidates for comb generation in all-optical integration schemes [1].

The gain material as well as the cavity design play a crucial role for their performance and can be designed easily via epitaxial growth. We explore the pulse performance optimization of a three-section tapered quantum-dot laser by means of a numerical model that assumes both the microscopic charge-carrier scattering processes as well as the light-propagation along the device. Motivated by an experimentally characterized device [2], we utilize pulse peak power, pulse width and long-term timing jitter to characterize the performance. The results predict optimal configurations for both the angle of the tapered gain section and the position of the saturable absorber section. These findings can be interpreted and understood in terms of the gain and absorption recovery processes within the active regions of the laser and thus explain why the nano-structured quantum-dot gain medium is especially suited for optimizing the pulse performance.

[1] R. Guzmán et al., Opt. Lett. 42, 2318 (2017).
[2] S. Meinecke et al., Sci. Rep. 9, 1783 (2019).

Topical Talk HL 10.3 Tue 14:30 H3

Monolayer-thick GaN/AlN heterostructures for UVB & UVC ranges: technology, design and properties — Valentin Jmerik, Alexey Toropov, Valery Davydov, and •Sergey Ivanov — Ioffe Institute, Polytekhnicheskaya 26, Saint Petersburg, 194921, Russia

The development of monolayer (ML)-thick GaN/AlN multilayer heterostructures for deep ultraviolet (UV) optoelectronics is discussed. Analysis of plasma-assisted molecular beam epitaxy and metal-organic vapor phase epitaxy show that extreme interface sharpness and sub-ML accuracy in controlling the layer thickness are the main advantages of the former, while the lowest density of threading dislocations and wide possibilities for the implementation of various two-dimensional growth mechanisms are the attractive features of the latter. The structural properties of ML GaN/AlN heterostructures are evaluated comparatively by X-ray diffraction, scanning transmission electron microscopy and Raman spectroscopy. Studies of the optical properties of ML-thick GaN/AlN quantum wells (QWs) reveal that quenching of the Stark effect, suppression of polarization switching, as well as a true excitonic nature of the UV-emission in ultra-thin (1-2ML) QWs ensure a high internal quantum yield of 75% in such structures emitting at 235 nm. High optical quality of 100-nm-thick layers of ML-GaN/AlN digital alloys is confirmed by the optically pumped stimulated emissions in the range 262-290 nm with a minimum threshold of 700kW/cm2. The possibilities of using ML-GaN/AlN MQWs to fabricate powerful (Watt-range) electron-beam pumped UVC-emitters in the spectral range 240-260 nm are demonstrated.

15 minutes break

Topical Talk HL 10.4 Tue 15:15 H3

Optical and vibrational properties of layered 2D materials — •Janina Maultzsch — Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany

Atomically thin layered crystals have received great attention due to their fascinating physical properties. By deterministic stacking and twisting of these two-dimensional (2D) materials, an almost unlimited variety of material's combinations and resulting physical properties can be achieved. The properties can be further modified by chemical functionalization of the surface. In this talk I will present theoretical predictions on novel 2D antimony oxide structures which show tunable electronic properties depending on the oxygen content. Second, based on recent experiments on chemically functionalized MoS_2 layers, we present transitions from the 2H to the 1T' phase along with the characteristic phonon modes of the 1T' phase of MoS_2.

Topical Talk HL 10.5 Tue 15:45 H3

Organic/inorganic low dimensional material systems: Fundamental aspects and device applications — •Emil List-Kratochvil — Institut für Physik, Institut für Chemie & IRIS Adlershof, Humboldt-Universität zu Berlin, Zum Großen Windkanal 2, 12489 Berlin, Germany — Helmholtz-Zentrum für Materialien und Energie GmbH, HySPRINT Helmholtz Innovation Lab, Hahn-Meitner-Platz 1, 14109 Berlin, Germany

The ability to form heterostructures from different materials, yet from the same material class, has revolutionized electronic and optical technologies during the past decades. To explore novel electronic and optoelectronic functionalities based on heterostructures in a natural next step we have turned to systematically explore hybrid inorganic/organic materials systems (HIOS) in heterostructures combining materials from dissimilar material classes. Among different aspects in this HIOS research endeavour, it was found that an in-depth understanding and control over the energy level alignment in HIOS is the key to attain novel electronic and optoelectronic functionalities. In this contribution, we report on fundamental aspects of the self-assembled monolayer formation on different metal oxide and 2D semiconductors such as transition metal dichalcogenides, observations of switching processes and successful implementations in diode, light emitting diode, electrolyte gated field effect transistor and neuromorphic plasmonic device structures.