DS 7: Optical Analysis of Thin Films II (Reflection, Ellipsometry, Raman, IR-DUV Spectroscopy, ...

Time: Monday 15:00–16:15 Location: H32

DS 7.1 Mon 15:00 H32

Topology Related Phenomena in Anisotropic Organic Microcavities — •Ota Kunt, Markas Sudzius, Hartmut Fröb, and Karl Leo — Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP), Dresden, Germany

We investigate planar microcavities consisting of two dielectric Bragg reflectors and an optically anisotropic uniaxial cavity layer with its optical axis tilted with respect to the growth direction of the structure. The optical properties of these devices are thoroughly investigated by angular and polarization resolved spectroscopic measurements and simulated using transfer matrix technique, which is extended to account for the optical anisotropy. Both experiment and simulations show polarization splitting of the cavity modes due to anisotropy. The modes are in general elliptically polarized, non-orthogonal and differ in both energy and spectral broadening. Points in the photon in-plane momentum space are found where the modes coalesce in both energy and energy broadening, are circularly polarized and are cores of polarization vortices. These points represent non-Hermitian degeneracies or exceptional points of a non-Hermitian system. We investigate in detail the analogy between the system's optical response and that of a biaxial absorbing crystal and investigate the influence of organic gain material in the cavity.

DS 7.2 Mon 15:15 H32

Structural Color Sensors: Tracking the Thermal History of Materials — •Henning Galinski[1], Volker Schnabel[1], Max Döbeli[2], and Ralph Spolenak[1] — [1]Laboratory for Nanometallurgy, Department of Materials, ETH Zurich Vladimir-Prelog-Weg 1-5/10, 8093 Zurich, Switzerland — [2]Ion Beam Physics, ETH Zurich, Otto-Stern-Weg 5, 8093 Zurich, Switzerland

The engineering of non-destructive, low footprint optical sensors has attracted significant interest in research in recent years. Such devices can enable real-time and spatiotemporal tracking of materials properties even in secluded applications, such as offshore wind turbines, or extreme environments, as found in thermal solar collectors. Here, we demonstrate a novel thermal sensor based on structural color that provides direct optical feedback of materials properties such as hardness, wear and resistivity [1]. The sensor can be used at high temperatures (1000 °C) and allows the continuous detection of changes in refractive index larger than 1%. The monitoring concept relies on a lossy Gires-Tournois interferometer configuration using thermally induced detuning of a highly absorbing state in the optical spectrum as sensor feedback. The displacement of the absorbing state is directly proportional to thermally induced changes in hardness and resistivity in the material. Using the specific case of TiAlN coatings we show that such detuning is due to a symmetry-breaking structural phase transition, which is accompanied by the formation of saturated structural colors.

[1] V. Schnabel, R. Spolenak, M. Döbeli, H. Galinski, Advanced Optical Materials 2018, 6, 1800656.

DS 7.3 Mon 15:30 H32

The influence of deposition conditions on the continuous broad sub-bandgap-absorption of the High Entropy Oxide: MgCoNiCuZn-O — •Lars Wenning and Emeline Michel — I. Institute of Physics (IA), RWTH Aachen University, Germany

Introducing entropy as a competing factor to synthesize and engineer new materials has been shown to be a promising way to discover new materials like high entropy alloys, which exhibit astonishing mechanical properties, e.g. combining high fracture toughness and high yield strength. Advancing the idea of entropy stabilized alloys to High Entropy Oxides is expected to lead to novel materials for industrial applications and scientific research. Some high entropy oxides have already shown astounding properties like colossal dielectric constant or room temperature superionic conductivity. This work investigates the extraordinary optical behavior of MgCoNiCuZn-oxide thin films and the influence of processing conditions during the reactive sputter deposition. To this end the films are characterized employing a variety of techniques including X-ray diffraction as well as optical characterization using ellipsometric spectroscopy and FT-IR spectroscopy.

DS 7.4 Mon 15:45 H32

Optical properties along the pseudo-binary line between Bi2Se3 and Sb2Se3 — •Ludovica Guarneri, Stefan Maier, and Matthias Wuttig — I.Physikalisches Institut (IA), RWTH Aachen University, D-52056 Aachen, Germany

A unique bonding mechanism, coined metavalent bonding (MVB), has recently been introduced. It is characterized by set of unique properties including large optical dielectric constants, high Born effective charges and soft optical modes. It has been identified in a class of inorganic materials including Phase Change Materials, Thermoelectrics and Topological Insulators. In addition, a unique bond breaking mechanism has been found, where MVB materials are characterized by a high probability of multiple events, i.e. several fragments being dislodged by a single laser pulse in atom probe tomography. Such a behavior is not found in materials which utilize ordinary covalent, metallic or ionic bonding. Bi2Se3 and Sb2Se3 show respectively high and low probability of multiple events, which indicates that Bi2Se3 employs MVB, while Sb2Se3 does not. We have thus studied the pseudo-binary line Bi2Se3:Sb2Se3 to investigate how MVB breaks down. To this end, we measure the optical properties using FT-IR spectroscopy between 30 meV and 0.80 eV. In this range, the dielectric function is governed by the electronic polarizability of the valence electrons, allowing to probe chemical bonding. In a narrow stoichiometry range on the Bi-rich side, a significant increase in the dielectric constant upon crystallization is observed. This finding is evidence for the formation of MVB, which confirms that MVB is a distinctive bonding mechanism.

DS 7.5 Mon 16:00 H32

Tailoring the optical properties of atomically-thin tungsten disulfide via ion irradiation — •Linan Ma[1], Yang Tan[1], Mahdi Ghorbani-Asl[2], Shengqiang Zhou[2], Arkady V Krasheninnikov[2], and Feng Chen[1] — [1]School of Physics, Shandong University, Jinan, China — [2]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam and Materials Research, Dresden, Germany

Two-dimensional transition metal dichalcogenides exhibit excellent optoelectronic properties. However, the large band gaps in many semiconducting transition metal dichalcogenides make optical absorption in the near-infrared wavelength Regime impossible, which prevents applications of these materials in optical communications. In this work, we demonstrate that Ar ion irradiation is a powerful post-synthesis technique to tailor the optical properties of the semiconducting tungsten disulfide by creating S-vacancies and thus controlling material stoichiometry. First-principles calculations reveal that the S-vacancies give rise to deep states in the band gap, which determine the near-infrared optical absorption of the tungsten disulfide monolayer. As the density of the S-vacancies increases, the enhanced the near-infrared linear and saturable absorption of tungsten disulfide is observed, which is explained by the results of first-principles calculations. We further demonstrate that by using the irradiated tungsten disulfide as a saturable absorber in a waveguide system, the passively Q-switched laser operations can be optimized, thus opening new avenues for tailoring the optical response of transition metal dichalcogenides by defect-engineering through ion irradiation.