CPP 38: 2D Materials 9 (joint session HL/CPP/DS)

Time: Thursday 11:15–12:15 Location: H36

CPP 38.1 Thu 11:15 H36

Generating extreme electric fields in 1 2D materials by dual ionic gating — •Benjamin Isaac Weintrub[1], Yu-Ling Hsieh[1,2], Jan N. Kirchhof[1], and Kirill I. Bolotin[1] — [1]Department of Physics, Freie Universität Berlin, Berlin, Germany — [2]Department of Mechanical Engineering, National Central University, Taoyuan City, Taiwan

We demonstrate a new type of dual gate transistor to induce record electric fields through two-dimensional materials (2DMs). At the heart of this device is a 2DM suspended between two volumes of ionic liquid (IL) with independently controlled potentials. The potential difference between the ILs falls across an ultrathin layer consisting of the 2DM and the electrical double layers above and below it, thereby producing an intense electric field across the 2DM. We determine the field strength via i) electrical transport measurements and ii) direct measurements of electrochemical potentials of the ILs using semiconducting 2DM, WSe2. The field strength across a bilayer WSe2 sample reaches ~2.5 V/nm, the largest static electric field through the bulk of any electronic device to date. Additionally, we create electric fields strong enough to close the bandgap of 3-layer and 4-layer WSe2 (~1.4 V/nm and ~0.9 V/nm respectively). Our approach grants access to previously-inaccessible phenomena occurring in ultrastrong electric fields.

CPP 38.2 Thu 11:30 H36

Tip-enhanced Raman spectroscopy combined with other Scanning Probe Microscopy Methods: Focus on 2D Materials — •Jana Kalbacova — HORIBA Jobin Yvon GmbH, Neuhofstr. 9, Bensheim 64625, Germany

New two dimensional materials are on the rise. After the wonder material graphene, new materials such as MoS2, MoSe2, WSe2 have an intrinsic bandgap and as such are opening new doors for semiconductor applications. Raman spectroscopy offers information on the chemical structure of materials but cannot provide information on the electronic properties such as surface potential or photocurrent of our sample. Co-localized measurements combining scanning probe microscopy (SPM) with Raman spectroscopy can already bring a wealth of information; however, further improvements can be obtained by a tip that will act as an antenna and amplify the Raman signal and thus breaking the diffraction limit in a method called Tip-enhanced Raman spectroscopy (TERS). Typically spatial resolution of 10 - 20 nm can be achieved. In this contribution, we investigate different 2D materials by a combination of TERS, tip-enhanced photoluminescence, Kelvin probe microscopy, and other SPM methods to show very locally for example doping variations or defects that would otherwise go unnoticed with other macro- and microscopic techniques.

CPP 38.3 Thu 11:45 H36

Defects in 2D WS_2 monolayers — Aswin Asaithambi[1], Roland Kozubek[1], Francesco Reale[2], Erik Pollmann[1], Marcel Zöllner[1], Cecilia Mattevi[2], Marika Schleberger[1], Axel Lorke[1], and •Günther Prinz[1] — [1]Fakultät für Physik und CENIDE, Universität Duisburg-Essen, Germany — [2]Department of Materials, Imperial College London, UK

In this presentation, we report about optical characterization and manipulation of defects in tungsten disulfide (WS_2) monolayers. WS_2 is one prominent member of the 2D transition metal dichalcogenides (TMDC). In these materials, defects and adsorbates can easily modify e.g., conductivity, optical properties, or even create single photon emitters. For this study we used high quality WS_2 CVD-grown monolayers to purposely introduce defects via irradiating them with Xe^{30+} ions with different fluences [1]. Low temperature photoluminescence (PL) spectra of these irradiated WS_2 monolayers show two defect related broad bands, beside the excitonic contribution. By exposing these flakes to laser light with powers up to 1.5mW, the intensity of these two PL bands can be reduced. By comparing the intensity of the excitonic contribution before and after this laser processing, we don't observe an increase in intensity, leading us to conclude, that the defects aren't getting healed. If the samples are heated to room temperature, the defect luminescence recovers. To interpret our observation, we suggest that the defects might be attributed to vacancy defects together with adsorbates at different defect sites.

[1] A. Asaithambi et al., Phys. Status Solidi RRL 2021, 15, 2000466

CPP 38.4 Thu 12:00 H36

Large perpendicular field in bilayer TMD via hybrid molecular gating — •Sviatoslav Kovalchuk[1], Abhijeet Kumar[1], Simon Pessel[1], Kyrylo Greben[1], Dominik Christiansen[2], Malte Selig[2], Andreas Knorr[2], and Kirill Bolotin[1] — [1]Department of Physics, Quantum Nanoelectronics of 2D Materials, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We consider structures in which bilayer TMDs are sandwiched between a layer of molecules and Si gate. We show that these structure allow increasing, by a factor of 2, maximum electric field achievable in this 2D material. This in turn, allows reaching electric field >0.2 V/nm. In MOS2 this is sufficient to bring interlayer excitons IX into resonance with either A or B intralayer excitons. We study coupling between these excitons, and give an outlook on the new technique to achieve large perpendicular electric fields detectable in optical measurements.