DS 33: New Twists for Nanoquakes on a Chip - Emerging Applications of Surface Acoustic Waves in Condensed Matter Physics (Focussed Session): Session II

Surface acoustic waves (SAWs) with gigahertz frequencies and micrometre size wavelength can be elegantly generated using piezoelectric transducers fabricated with standard integrated circuit technology. Their small propagation velocity, tight surface confinement, as well as low susceptibility to decoherence and dissipation have been exploited over the past decades in numerous devices, in particular for electronic and optical signal processing. Today, the interaction of SAWs with electrical, optical, magnetic, and mechanical excitations in condensed matter is a highly active field of research. It is driven by the vision to harness the power of this technique in a broad spectrum of emerging applications including advanced sensors, the control of magnetization and collective excitations, as well as the coherent interactions between charge and spin excitations, photons, and phonons down to the fundamental level of single quanta. We propose a symposium that brings together experts for emerging and future applications of surface acoustic waves. For the proposed symposium we have identified potential speakers covering the large palette of fields which this versatile technique is successfully applied or currently evolving towards. These encompass nanoscale acousto-optic integrated circuits and plasmonics, the control of single quantum systems and collective excitations in hybrid systems. Because the proposed symposium covers a wide range of frontier research in which SAWs are employed with greatest success, it will serve as an ideal platform for scientific exchange. Thus, it aims to foster new interactions between the different scientific communities. Its most important goal is to introduce this exciting field of research to the many young Masters and PhD students, and postdocs attending the joint DPG-EPS Spring meeting and gives them the opportunity to present contributed talks at the symposium or associated sessions.

Organized by

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Time: Thursday 15:00–15:45 Location: H 2032

DS 33.1 Thu 15:00 H 2032

Acousto-electric transport in epitaxial graphene coated by a ZnO piezoelectric film — •Yi-ting Liou, Alberto Hernández-mínguez, Jens Herfort, João marcelo Lopes, Abbes Tahraoui, and Paulo Santos — Paul-Drude-Institut, Berlin, Germany

We report on the transport of charge carriers in epitaxial graphene on SiC induced by surface acoustic waves (SAWs). SAWs are elastic vibrations propagating along a surface, which can be generated by applying a radio-frequency power to interdigital transducers (IDTs) deposited on piezoelectric materials. In this contribution, we report acousto-electric currents in epitaxial graphene covered by MgO and ZnO. The ZnO film provides a strong piezoelectric potential, which facilitates the acoustic transport in graphene using GHz SAWs. The 15-nm thick MgO layer is used as gate dielectric and also protects the graphene during the ZnO sputtering process. Raman spectra after the deposition of MgO and ZnO show no defect generated in graphene. In addition, the field-effect mobility at room temperature is about 2970 $cm^2\ V^{-1}\ s^{-1}$, which indicates that the electrical properties of graphene were preserved. The acousto-electric current was found to be of the order of 10 to 60 nA [1], which is up to 75 times larger than in a previous work using a 200 nm-thick SiO_2 layer instead of MgO [2]. Prospective work will include the investigation of acousto-electric transport while gate voltages are applied to further control the electrical properties of graphene.

[1] J. Phys. D: Appl. Phys. 50, 464008 (2017)
[2] Appl. Phys. Lett. 108, 193502 (2016)

DS 33.2 Thu 15:15 H 2032

Acoustically-driven surface phonon-plasmon polaritons in graphene/h-BN and graphene/h-BN/graphene heterostructures on piezoelectric substrates — •Rajveer Fandan[1], Jorge Pedrós[1], Jürgen Schiefele[2], Alberto Boscá[1], Javier Martínez[1], and Fernando Calle[1] — [1]Instituto de Sistemas Optoelectrónicos y Microtecnología, Universidad Politécnica de Madrid, Spain — [2]Instituto de Ciencia de Materiales de Madrid, CSIC, Spain

Surface plasmon polaritons (SPPs) in graphene couple strongly to surface optical (SO) phonons in the substrate leading to hybridized surface phonon-plasmon polaritons (SPPPs). Moreover, unlike conventional SPPs in metals, graphene SPPPs can be tuned in situ through the modulation of the carrier density by electrostatic gating, covering the mid-IR to THz range. Here we demonstrate that surface acoustic wave (SAW) can be used to generate propagating SPPPs in graphene/h-BN and graphene/h-BN/graphene heterostructures on AlN substrates over a broad energy range. h-BN between the graphene and the AlN substrate not only significantly changes the SPPP dispersion but also enhances the lifetime as compared to the previously studied graphene/AlN system[1]. The SPP dispersion of graphene splits into multiple branches due to the coupling with the SO phonons of both h-BN and AlN. In addition, hyperbolic phonon branches appear in the case of multilayer h-BN. Moreover, the addition of a second graphene layer is shown to further disperse and strengthen the SPPPs, providing greater robustness and tunability for future SAW-based plasmonic devices. [1] Schiefele et al., Phys. Rev. Lett. 111, 237405 (2013)

DS 33.3 Thu 15:30 H 2032

Sub-decay time control of the optical emission of lead halide perovskite nanowires at room temperature — •Lisa Janker[1], Lakshminarayana Polavarapu[2], Yu Tong[2], Alexander S. Urban[2], Jochen Feldmann[2], and Hubert J. Krenner[1] — [1]Experimentalphysik 1, Universität Augsburg — [2]Photonics and Optics Group, LMU München

The outstanding, composition-tunable optical properties of hybrid halide perovskites sparked extensive research effort worldwide leading to optoelectronic applications for photovoltaics, light emission and detectors. While most breakthrough studies focused on thin films, very recently, perovskite nanocrystals, platelets and nanowires (NWs) have been synthesized enabling size-tuning of the optical properties.

Here we report on the dynamic modulation of optical emission of $CsPbI_3$ NWs by a piezoelectric surface acoustic wave (SAW). SAWs have found various applications to probe and manipulate nanosystems at radio frequencies, e.g. to determine the mobilities in III-V semiconductor NWs.

We compare PL-transients recorded from a bundle of NWs without and with a SAW interacting with the NWs. Our experimental data clearly demonstrates that the PL-decay is periodically modulated in time by the SAW. Most strikingly, the period of this modulation is precisely $\frac{1}{2}\ T_{SAW}$. The doubling of the modulation frequency points towards a field-induced displacement of the electron and hole forming an exciton. Such an electric field-driven nature of our approach promises deeper insight into excitonic properties of perovskite nanowires.