PCSI
Room Keahou I - Session PCSI-MoA2
2D Materials and Graphene I

Moderator: Nitin Samarth, Penn State University

4:20pm **PCSI-MoA2-29 Dielectric Tensor and Coupled Excitations in Layered (Magnetic) Semiconductors***, **Ursula Wurstbauer**,* University of Muenster, Germany **INVITED**

Two-dimensional materials exhibit unique properties due to their atomically thin structure and weak van der Waals (vdW) coupling between layers resulting in layer dependent properties. As in the case of the layered magnetic semiconductor CrSBr, individual layers are ferromagnetically ordered below the Neel temperature (T_N≈132K), while adjacent layers are coupled antiferromagnetically. Due to the highly anisotropic electronic bands in CrSBr, electronic and excitonic states at the fundamental band-gap behave quasi-one-dimensional [1]. Moreover, the resulting excitonic transitions are highly sensitive to the collective spin order. Below the critical temperature, an external magnetic field applied along the magnetic hard directions drives the system from the antiferromagnetic into a ferromagnetically ordered state causing a quadratic red-shift of the exciton energies theoretically explained by spin-allowed charge transfer changing the composition and nature of excitons [2]. By resonant inelastic light scattering (RILS) experiments in resonance with those excitons, we reveal and study strong coupling between charge, lattice and spin degrees of freedom.

Moreover, thin CrSBr film host self-hybridized polaritons [3]. To develop a better understanding of the extraordinary light-matter interaction in CrSBr, we access the materials dielectric tensor in the paramagnetic phase by spectroscopic imaging ellipsometry that is hard to access by alternative approaches such as reflectance measurements due to the strong anisotropy. In agreement with theory, we extract highly anisotropic dielectric functions along the crystallographic main axes with strong excitonic resonances particularly in the plane [4].

We gratefully acknowledge the fruitful collaboration with Florian Dirnberger, Julian Klein, Zdeněk Sofer, Marie-Christin Heißenbüttel, Thorsten Deilmann and Michael Rohlfing.

[1] J. Klein et al. ACS Nano, 17, 6, 5316–5328 (2023).

[2] M.-C. Heißenbüttel et al. arXiv:2403.20174.

[3] F. Dirnberger et al. Nature 620, 533–537 (2023).

[4] P.M. Piel, S. Schaper et al (2024).

5:00pm **PCSI-MoA2-37 Above Room Temperature Ferromagnetism in Epitaxially Grown Films of the 2D Magnets Fe_5GeTe_2 and Fe_3GaTe_2***, H. Lv, T. Shinwari, K. I. A. Khan, M. Hanke, A. Trampert, J. Herfort, R. Engel-Herbert, **Joao Marcelo J. Lopes**,* Paul-Drude-Institute for Solid State Electronics, 10117 Berlin, Germany

2D magnetic materials and van der Waals (vdW) heterostructures are promising building blocks for the realization of novel devices with integrated electronic, optical, and magnetic functionalities [1]. However, most of the studies on these materials have so far been performed using bulk crystals and flakes, both not suitable for integration in device processing. Hence, it is crucial to develop their scalable growth in order to realize highly uniform films and heterostructures with well-defined interfaces. It also requires that each material component of the heterostructure remains functional, which ideally includes magnetic order above room temperature for the 2D magnets. Among different candidates, the 2D ferromagnetic metals Fe_5GeTe_2 (FGeT) and Fe_3GaTe_2 (FGaT) show a great potential due to their relatively high Curie temperature and perpendicular magnetic anisotropy [2,3]. In this contribution, we will report on scalable growth of FGeT and FGaT films on epigraphene/SiC(0001) via molecular beam epitaxy. Structural characterization using different methods reveals the formation of continuous and crystalline FGeT and FGaT films (e.g., Fig 1a). Moreover, magneto-transport and magnetometry measurements reveal ferromagnetic order persisting above 350 K with an out-of-plane anisotropy (see Fig. 1b,c). We will discuss in detail the correlation between structure and magnetism, showing the effects of thickness, Fe composition, and the formation of metastable phases on the magneto-transport properties of the materials. These results represent an important advance beyond non-scalable bulk crystals and flakes, thus marking a crucial step towards future applications.

[1] J. F. Sierra *et al.*, Nat Nanotech. **16**, 856 (2021).

[2] S.N. Kajale *et al.,* Nat Commun. **15**, 1485 (2024).

[3] H. Lv et al., Small **19**, 2302387 (2023); IEEE Trans. Magnetics **60**, 4100505 (2024).

5:05pm **PCSI-MoA2-38 Electrical Side-Gate Control of Magnetic Anisotropy in a Composite Multiferroic***, **Katherine Johnson**,* Ohio State University*; K. Collins, M. Newburger, M. Page,* Air Force Research Laboratory*; R. Kawakami,* Ohio State University

Composite multiferroics consisting of a ferroelectric material interfaced with a ferromagnetic material can function above room temperature and exhibit improved magnetoelectric (ME) coupling compared to single-phase multiferroic materials, making them desirable for applications in energy-efficient electronic devices. This work studies the coupling between molecular beam epitaxy grown ferromagnets in a multiferroic heterostructure. The electrical control of magnetoresistance and magnetic anisotropy of single-crystalline $Fe_{0.75}Co_{0.25}$ on PMN-PT(001) is investigated using a side-gate geometry. Angle-dependent magnetoresistance scans reveal that the origin of this effect is strain-mediated magnetoelectric coupling. This electrical control of magnetic properties could serve as a building block for future magnetoelectronic and magnonic devices.

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