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

Moderator: Nitin Samarth, Penn State University

4:40pm **PCSI-MoA2-33 UPGRADED: Spectroscopic Imaging Ellipsometry at Cryogenic Temperatures to Indicates a Structural Phase Change in a 2D Polar Metal***, Jakob Henz,* Muenster University, Germany*; Ursula Wurstbauer,* University of Muenster, Germany

realized by confinement heteroepitaxial growth (CHet). Hereby, metal atoms such as gallium, indium, silver or other metals are intercalated between graphene and silicon carbide substrate [1]. This results in large area, environmentally stable, 2D metals with a bonding gradient in z-direction ranging from covalent over metallic forces to a van der Waals interaction within only two to three atomic layers [2]. These materials feature interesting properties such as superconductivity at cryogenic temperatures [3] and large plasmonic response in the visible range [4].

To uncover the relation between light-matter interaction, temperature, emergent phases such as superconductivity and structural changes, 2D gallium is studied by temperature dependent spectroscopic ellipsometry and transport measurements down to 1 K.

Spectroscopic Imaging Ellipsometry (SIE) is a powerful optical measurement technique, combining the ability of an ellipsometer to determine layer thicknesses and optical properties of thin film samples to the monolayer limit with the lateral resolution of a microscope. The resolution enables the investigation of the homogeneity of the dielectric response on the micrometer scale in various systems such as TMDCs [5] and their heterostructures [6], or 2D polar metals [4].

In combination with a cryostat with free beam optical access, we explore the temperature-dependence of the local dielectric function of 2D polar gallium, a non-centrosymmetric bilayer metal, from room temperature down to 1 K. We show a change in the local dielectric response of the material from a homogenous behavior at room temperature to a heterogenous regime at low temperatures, characterized by two absorption peaks localized to distinct surface areas on the sample [7]. We interpret this change to indicate a structural phase transition in the material. No further transition coinciding with the emergence of the superconducting phase can be identified.

[1] N. Briggs et al., Nat. Mater.**19.6**, 637-643 (2020).

[2] M. A. Steves et al. Nano Letters **20**.11, 8312–8318 (2020).

[3] S. Rajabpour et al. Adv. Mater. 2104265 (2021).

[4] K. Nisi et al., Adv. Funct. Mater. **31**, 2005977 (2020).

[5] S. Funke et al., J. Phys.: Condens. Matter **28**, 385301 (2016).

[6] F. Sigger et al. Apl. Phys. Lett. **121**, 071102 (2022).

[7] J. Henz et al. in preparation (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***, Hua Lv, Tauqir Shinwari, Kacho I. A. Khan, Michael Hanke, Achim Trampert, Jens Herfort, Roman 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*; Kelsey Collins, Michael Newburger, Michael Page,* Air Force Research Laboratory*; Roland 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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