Investigation of the Heterogeneity and Temperature Dependence of Bilayer Gallium Intercalated at the Epitaxial Graphene/Silicon Carbide Interface with Cryogenic Spectroscopic Imaging Ellipsometry

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Metal intercalation at the interface of epitaxial graphene and silicon carbide (SiC) offers a powerful route for the stabilization of novel covalently bonded 2D phases. One method, confinement heteroepitaxial growth (CHet), results in large area, environmentally stable, mono- to fewlayer films [1]. Due to the bonding gradient along the out-of-plane direction ranging from covalent over metallic forces to a vdW interaction within only a few Angstroms, these systems have been dubbed 2D polar metals [2]. These materials systems feature a wide range of electronic and optical properties, from the tunable plasmonic resonances in binary In:Ga alloys [3] to a two phase system of semiconducting Ag monolayers [4].

Here, we focus primarily on 2D polar Ga, which stabilizes as metallic bi- and trilayer films. The material features interesting properties, including a thickness dependent plasmonic resonance [5], giant second-order susceptibilities approaching 10 nm V^{-1} [2] and a superconducting phase transition below 3 K [1].

To uncover the relation between light-matter interaction, temperature and structural changes, bilayer 2D gallium is studied by temperature dependent spectroscopic imaging ellipsometry.
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 dielectric response on the micrometer scale, allowing us to study the homogeneity of the terrace structure in 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 Ga, from room temperature down to 5 K. We show a change in the local dielectric response of the material from 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 [6]. We interpret this change to indicate a structural phase transition in the material.

References:
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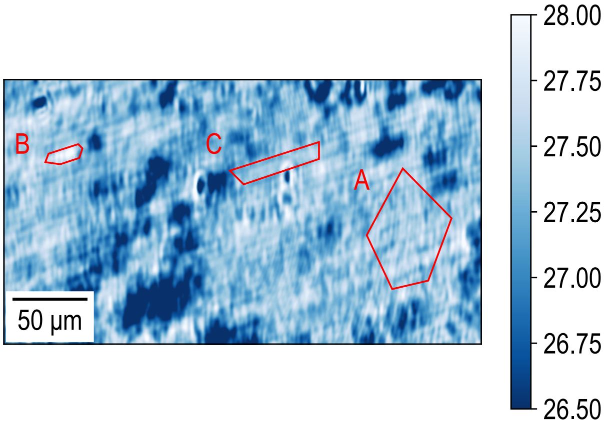

Fig. 1: Ellipsometric Ψ-map of bilayer 2D Ga at 575nm, at measured temperature 4K, showcasing terrace dependent optical behavior.