Raman Spectroscopy of Epitaxial Graphene: Thermomechanical Properties and Enhanced Light-Matter Interaction

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Abstract

Raman spectroscopy provides a powerful, non-destructive probe of graphene, offering rich information on its structural, electronic, and vibrational properties, including strain, doping, and electron-phonon interactions.[1] Here, we employ resonance Raman spectroscopy to investigate epitaxial graphene on SiC(0001) achieved by intercalation of H, In, and Sn into the zeroth layer of graphene (ZLG), as well as the monolayer graphene (MLG) system.

Intercalation enables controlled tuning of the graphene-substrate interaction, ranging from quasi-free-standing graphene (QFMLG) to the formation of distinct 2D interfaces (Fig. 1a) [2,3]. Raman studies reveal clear signatures of strain and charge doping, depending on the intercalant and interface configuration. While, QFMLG on hydrogenated interface behaves nearly free-standing, the 2D metallic interfaces enable tuning of graphene's electronic and mechanical properties. Exemplarily, the thermomechanical behaviour of graphene show strong dependence on the interfacial coupling tunable by intercalant species. Particularly, we demonstrate the formation of a 2D metallic triangular Sn(1×1) interface. Combined with a plasmonic Sn nanoantenna (Sn-NA) and tip-enhanced Raman spectroscopy, this leads to over two orders of magnitude enhancement of the graphene Raman response via gap-mode plasmonic effects, accompanied by modified selection rules and electron-phonon coupling (Fig. 1b) [4]. These results demonstrate Raman spectroscopy as a versatile tool for characterizing intercalated graphene and elucidating graphene-interface interactions, with implications for tunable optoelectronic applications.

References

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Figures

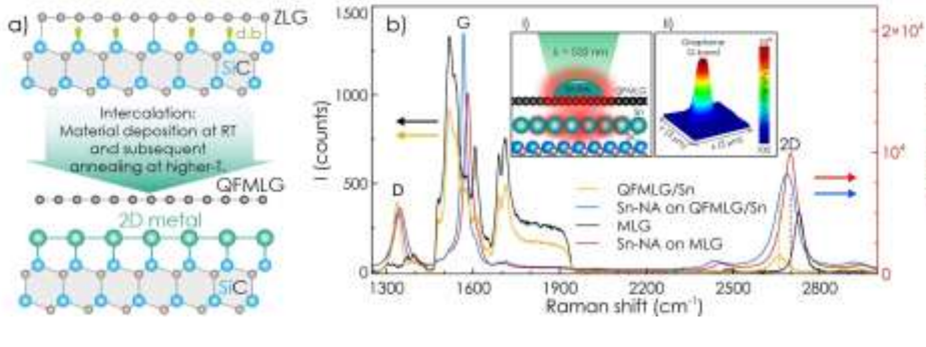

Figure 1: a) Schematic view of intercalation process. b) SERS spectra of MLG, QFMLG/Sn using a single $\sim$200 nm Sn-NA (right axis) compared to conventional Raman spectra of the same systems (left axis). Insets: i) schematic of the SERS configuration for Sn-NA on QFMLG/Sn (not to scale); ii) SERS map showing enhanced G-band localized at the Sn-NA.