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Jakub Jagiello

Karolina Pietak, Artur Dobrowolski, Tymoteusz Ciuk

Lukasiewicz Research Network-Institute of Microelectronics and Photonics, Al. Lotnikow 32/46, 02-668 Warsaw, Poland

jakub.jagiello@imif.lukasiewicz.gov.pl

Enhancement of graphene-related and substrate-related Raman mode through dielectric layer deposition

Enhancement of the Raman signal intensity is currently among the most researched directions in developing Raman-based characterization techniques of all 2D materials as it elevates detection limits of their fine structural properties. The interest in Raman signal intensification is also triggered by the wide range of applications it can benefit, such as biochemistry and biosensing, polymer and materials science, catalysis, electrochemistry, the study of high-temperature processes, and the detection of hazardous gases [1]. In this work, we demonstrate a method for the enhancement of Raman active modes of hydrogen-intercalated [2] quasi-free-standing epitaxial chemical vapor deposition graphene and the underlying semi-insulating 6H–SiC(0001) substrate through constructive signal interference within atomic-layer-deposited amorphous Al_2O_3 passivation. We find that an optimum Al_2O_3 thickness of 85 nm for the graphene 2D mode and one of 82 nm for the SiC longitudinal optical A_1 mode at 964 cm^{-1} enable a 60% increase in their spectra intensities. We demonstrate the method's efficiency in Raman-based determination of the dielectric thickness and high-resolution topographic imaging of a graphene surface [1,3].

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References

[1] K. Pietak, J. Jagiello, A. Dobrowolski, R. Budzich, A. Wysmolek, T. Ciuk, Applied Physics Letters, 120 (2022), 063105.

[2] M. Szary, S. El-Ahmar T. Ciuk, Applied Surface Science, 541 (2020), 158668.

[3] A. Dobrowolski, J. Jagiełło, D. Czolak, T. Ciuk, Physica E: Low-dimensional Systems and Nanostructures, 134 (2021), 114853.

Figures

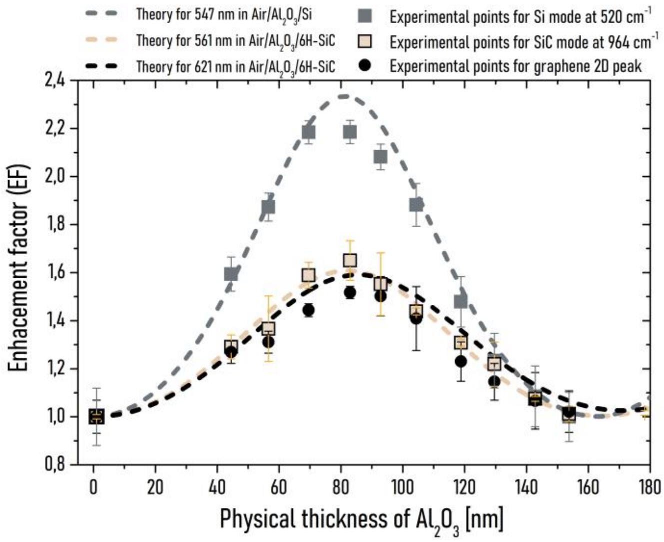

Figure 1: Theoretical (dashed lines) and experimental (square symbols) enhancement factor (EF) for the SiC LO A_1 mode at 964 cm^{-1} (marked in beige), the Si mode at 520 cm^{-1} (marked in gray), and the QFS graphene 2D mode at 2708 cm^{-1} (marked in black), all as a function of the Al_2O_3 physical thickness.