Impact of Helium Ion Irradiation on Micro- and Nano-Scale Properties in monolayer MoS_2

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Research on 2D materials is advancing, influencing physics, chemistry, and applications [1]. The atomically thin nature makes them highly sensitive to extrinsic factors, offering vast tuning opportunities—from deformation to chemical doping and deliberate introduction of defects. To understand the impact of defects on material properties as well as the effect of the substrate, it is essential to create defects in a controlled manner and utilize micro- and nano-scale spectroscopic and microscopy techniques [2].
In this work, we investigate the electrical, optical, and vibrational properties of MoS_2 with induced defects via helium-ion irradiation. Defects, at defined ion doses, were introduced on three different types of samples: suspended monolayers, monolayers prepared by large-area exfoliation on gold, and directly exfoliated monolayers on SiO_2. The effects of defects and the role of the substrate were studied using surface probe techniques such as AFM, Kelvin probe force microscopy, and conductive AFM. Additionally, spectroscopy techniques like micro-Raman and PL spectroscopy were used, along with a combination of both in the form of tip-enhanced Raman spectroscopy and photoluminescence. Suspended samples were also analysed with high-resolution transmission electron microscopy (HR-TEM). These methods revealed the micro- and nano-scale influences of defects on optical, structural, and electronic properties of MoS_2.
The obtained results highlight the importance of fully understanding the impact of defects on 2D materials and their applications involving defects engineering.

References

[1] Wang, Xin, et al., Advanced Materials, 35.50, (2023): 2206576.
[2] Fekri, Zahra, et al., Advanced Electronic Materials, 10.9, (2024): 2400037

Figures

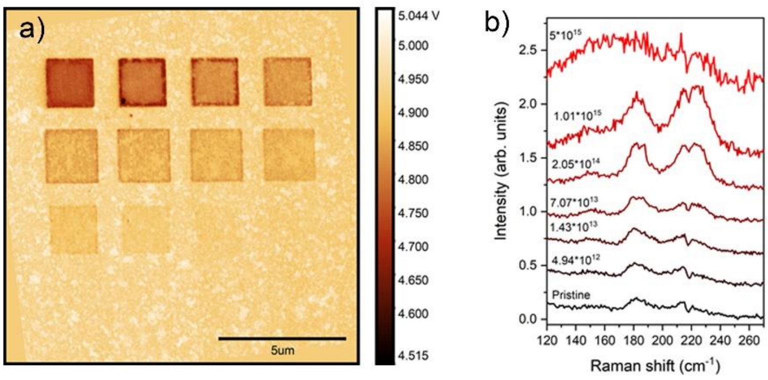

Figure 1: The effects of helium-ion irradiation on monolayer MoS_2 exfoliated on gold: a) variation of the work function with the dose (from pristine to $5{\cdot}10^{15}$ ions/cm^2); b) Raman spectra obtained with the 633 nm laser.