Impact of Sulfur Annealing on Graphene for Growth of Transition Metal Dichalcogenides (TMDCs)

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Two-dimensional (2D) heterostructures composed of graphene and Transition Metal Dichalcogenides (TMDCs) have garnered significant attention owing to their unique physics and potential applications in diverse devices. TMDCs, including MoS_2, WS_2, $MoSe_2$, and WSe_2, are favoured for electronic and optoelectronic applications due to their band gap range and strong light-matter interaction. The absence of dangling bonds in both TMDCs and graphene allows seamless integration in heterostructures, paving the way for superior devices compared to single-material configurations. While stacking individual layers using mechanical exfoliation has been prevalent, recent advancements in chemical vapor deposition (CVD), electrodeposition, and atomic layer deposition offer promise for large-area growth and scalability [1][2]. However, high-temperature exposure during or post-growth is necessary, potentially altering the properties of graphene. We investigate the impact of sulfur annealing on the electrical and structural properties of graphene for TMDCs growth. Systematic annealing at temperatures ranging from 300-800°C under various conditions was conducted. Our findings reveal that vacuum annealing induces etching in graphene, exacerbated by the presence of sulfur species, leading to significant degradation in electrical properties (**Fig.1**). Notably, coating graphene with self-assembly monolayers mitigates this degradation, enabling the deposition of high-quality TMDCs on graphene. Electrodeposition of MoS_2 and WS_2 on graphene followed by sulfur annealing post-processing demonstrates the efficacy of this strategy. This study sheds light on the critical role of sulfur annealing in influencing graphene quality and paves the way for the growth of TMDCs on graphene for high-performance electronic applications.

References

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[2] Ran Guan et al., CrystEngComm, 2021, 23, 146 DOI: 10.1039/d0ce01354d

Figures

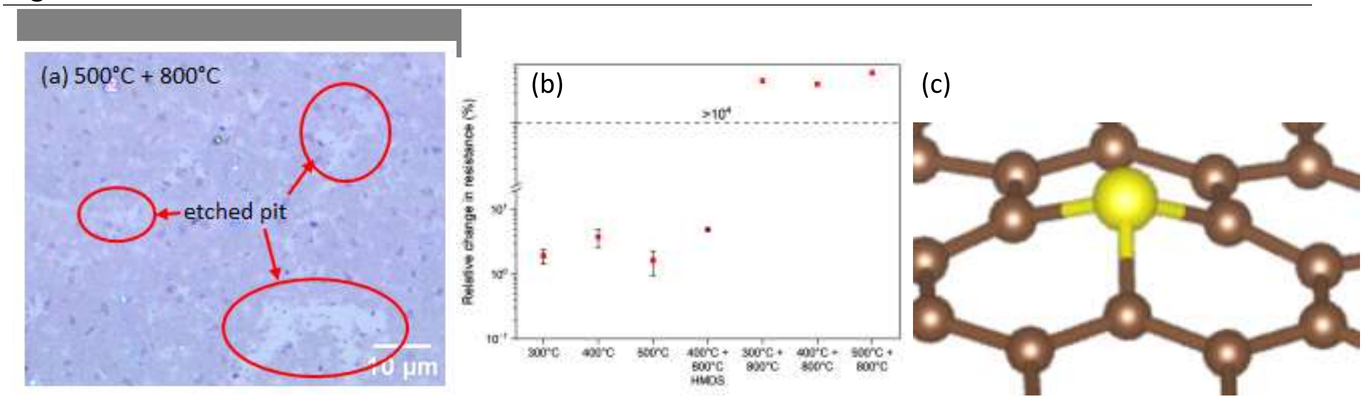

Figure 1: Influence of Sulfur Annealing on Graphene. (a) etch pits appears after graphene annealed 500°C under sulfur followed by 800°C in vacuum (b)The resistance demonstrates a notable elevation with higher annealing temperatures (c) DFT simulation on adsorption of sulfur on graphene surface.