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Engineered Strain of APCVD Synthesized Graphene

The synthesis of graphene on both platinum and copper substrates is well established and is showing great promise towards large-area industrial scale production. However, growth of graphene on platinum substrates shows promise over copper because it can be reused for repeated growth, be grown at atmospheric pressure, be easily transferred to arbitrary substrates, and exhibits higher quality defect-free nanosheets. In addition, the control of strain in nanosheets is of great significance and has shown to open a band-gap in graphene [1], increase sensitivity in resonators [2], and increase photocurrent generation [3]. Despite vast research in the synthesis of 2D materials, there has been little to no discussion on the engineered strain of 2D materials during the thermal growth process. One reason, is due to the extreme temperatures needed for the decomposition of the nucleation gas, which makes incorporating instruments within the thermal chamber at high temperatures prohibitive.

In this work, we demonstrate a tensile test actuator (TTA), fabricated from stainless steel to conduct uniaxial tensile strain of platinum foil within the furnace. The platinum foil is doubly clamped and suspended, then placed within the thermal chamber, where it experiences thermal strain during the synthesis of graphene by atmospheric pressure chemical vapor deposition (APCVD). Growth is conducted within a three zone furnace utilizing mass flow controllers to control the nucleation gas methane (CH_4) and precursor gas hydrogen (H_2). Polycrystalline platinum foil from Sigma Aldrich with 99.9 wt% metal basis at 0.025mm thickness is used as the metal catalyst. The TTA and platinum foil are placed inside the furnace, along with a control sample, to allow for comparison between strained and unstrained conditions.

To investigate growth of graphene on uniaxial tensile strained platinum foils, characterization of the nanosheet structure is conducted utilizing Scanning Electron Microscopy (SEM) and Raman Spectroscopy. SEM of the platinum foil exposed to thermal strain shows evidence of thermal fatigue, consisting of striations along preferential grain directions. Comparison of strain between the control foil and strained foil are conducted by Raman Spectroscopy by observing a downshift in the 2D band, corresponding to increasing strain. Further growth experiments are showing unique morphologies and crystal structure on strained and unstrained substrates.

References

1. He, X.G., L.; Tang, N.; Duan, J.; Xu, F.; Wang, X.; Yang, X.; Ge, W.; Shen, B., *Shear strain induced modulation to the transport properties of graphene.* Appl. Phys. Lett., 2014. **105**.
2. Lee, S., et al., *Electrically integrated SU-8 clamped graphene drum resonators for strain engineering.* Applied Physics Letters, 2013. **102**(15): p. 153101.
3. Feng, J., et al., *Strain-engineered artificial atom as a broad-spectrum solar energy funnel.* Nature Photonics, 2012. **6**(12): p. 866-872.