Spectroscopic detection and characterization of multilayer graphene

Wafa. Alimi[1], A. Campos[2], L. Dewyspelaere[1], R. Parret[3], I. Boulet[3], I. Oserov[3], S. Clair[4], S. Bernardini[4], O. Chuzel[5], D. Talaga[6], S. Bonhommeau[6], T. Neisius[2], M. Cabie[2], C. Martin[1], G. Giacommetti[1], J.M. Layet[1], M. Minissale[1], C. Pardanaud[1]

[1]*Aix Marseille Univ, CNRS, PIIM, AMUTech, Marseille, France*
[2]*Aix Marseille Univ, CNRS, Centrale Marseille, FSCM, Marseille, France*
[3]*Aix Marseille Univ, CNRS, CINAM, AMUTech, Marseille, France*
[4]*Aix Marseille Univ, CNRS, IM2NP, Marseille, France*
[5]*Aix Marseille Univ, CNRS, Centrale Marseille, iSm2, AMUTech, Marseille, France*
[6]*University of Bordeaux, CNRS, Bordeaux INP, ISM, Talence, France*

e-mail: wafa.ALIMI@univ-amu.fr

Multilayer graphene is widely studied for its unique electronic properties, making it one of the most promising two-dimensional materials. These properties strongly depend on its band structure, affected by layer number and stacking order [1]. Raman spectroscopy, a rapid and non-destructive technique, allows precise analysis and control of these properties [2].
This study presents a statical investigation of graphene flakes obtained by mechanical exfoliation, examining the impact of thickness, layer number, staking types (hexagonal, rhombohedral, turbostatic and twisted), and sample preparation methods. A major finding is that rhombohedral staking, usually observed in few-layer graphene, can exist in thicker flakes (≈100 nm) over micrometer-scale regions, making them suitable for device applications. The type of polymer used during exfoliation significantly influences rhombohedral coverage: PDMS yields up to 84%, while acrylic-based polymer reaches 10-20% over 110 days of data confirmed these results through Raman spectroscopy. Tip-enhanced Raman also demonstrated strain effects from the polymer, possibly contributing to phase stabilization. Rhombohedral staking remains stable over several months and can even increase over time, suggesting it may be more stable than Bernal stacking under certain conditions. Acetone cleaning doesn't fully remove polymers but often preserves or enhances rhombohedral domains. This work highlights the critical role of exfoliation methods and facilities controlling stacking in thicker graphene. Furthermore, it provides an essential foundation for future research and potential applications based on rhombohedral graphite.

References

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