X-ray diffraction as a tool to determine graphene flake quality

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To satisfy industry's demand for graphene, the production of graphene flakes by exfoliation of graphite is a promising approach due to its potential for high scalability as well as cost-effectiveness.
In contrast to 2D graphene sheets, these graphene flakes are a volume material, and characterization via the standard tools like Raman spectroscopy are not always representative. Therefore a characterization tool is needed to determine the resulting flakes' quality, e.g. layer number and lateral flake size, as well as the efficiency of the production method, e.g. the exfoliation degree. X-ray diffraction is such a method. For the structural analysis of graphite and non-graphitic carbons both ASTM standards as well as scientific models like that by Ruland and Smarsly [1] exist.
We investigated possible ways to determine the exfoliation efficiency and quality of graphene flakes. For that we looked at the applicability of the characterization methods established for graphite and other non-graphitic carbon materials to graphene. However due to the strong preference of orientation of the graphene layers a quantitative analysis is not trivial. Furthermore we propose possible approaches for minimizing the influence of the preference of orientation. This allows for comparison of the intensity of the 00ℓ reflexes, which are caused by inter-layer diffraction, and therefore correlate to the remaining graphite content after exfoliation treatment. Overcoming this XRD can be a powerful tool for assessing the graphene flake quality and developing a future global standard.

References

[1] W. Ruland, B. M. Smarsly, Journal of Applied Crystallography, 5 (2002) 624

Figures

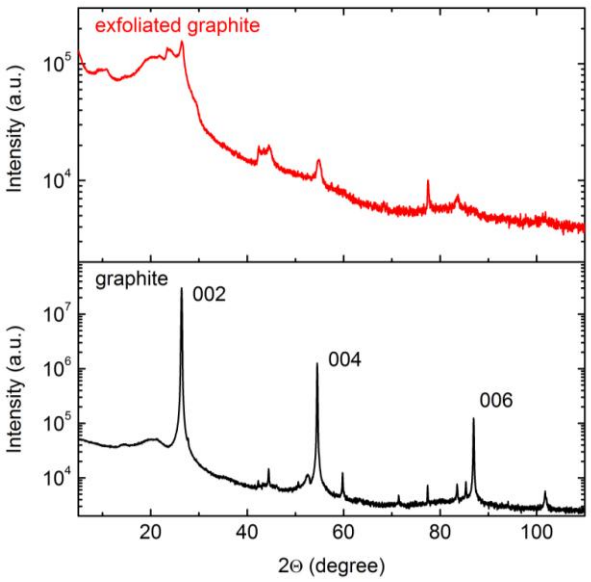

Figure 1: X-ray diffraction patterns of graphite (black) and graphene flakes prepared by exfoliation of graphite (red). The intense peaks in the graphite diffraction pattern are the 00ℓ reflexes which result from inter-layer diffraction. After exfoliation treatment their intensity decreased significantly due to loss of stacking order.