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High quality graphene TEM supports for high-resolution transmission electron microscopy

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Background incl. aims

Transmission electron microscopy (TEM) plays a critical role in the investigation of the atomic structure, morphology and chemical composition of nanomaterials. The field has significantly evolved during the last decade through the implementation of improved aberration correctors, novel detectors, more stable stages/holders and the implementation of many new low dose techniques. However, further progress in spatial resolution, contrast and potentially beam damage can still be achieved from improvements in sample preparation, particularly from the optimization of the TEM sample support.

The ideal sample support would be as thin and clean as possible in order to avoid interference with the sample signal, resulting in a background noise and a reduction of the contrast in the final (S)TEM image. Conventional grids consist of a fine metal mesh covered with an amorphous carbon layer (~20 nm), usually perforated with holes. For thin samples, this 20 nm is too thick to provide contrast, therefore a continuous support layer of 2 nm – 5 nm amorphous carbon is often used.

Graphene-based TEM grids have recently appeared as a promising alternative to the regular carbon coated TEM grids. Graphene, a monolayer of tightly bound carbon atoms, possesses exceptional properties. The monoatomic thickness of graphene minimizes the background signal, significantly improving signal to noise ratio which is crucial for high resolution imaging. Additionally, graphene’s excellent electrical and thermal conductivity makes it an ideal candidate for dissipating excess heat and charge from the sample, mitigating electron beam induced damage.

However, to fully capitalize on the advantages of these new TEM grids, the graphene substrates need to be of exceptional quality. Therefore, we identify the current state of the art of the available graphene TEM substrates and discuss the existing problems with these grids and how these can be overcome.

Methods

Utilizing TEM and STEM, we evaluate key quality metrics of the currently available graphene TEM grids and discuss their relative importance. Based on these parameters, we compare the commercial grids with in-house made grids and discern their advantage in several advanced experiments.

Results

Unfortunately, depending on the transfer method and subsequent cleaning method, the graphene quality strongly fluctuates. Graphene grids are often plagued by cracks, folds, metal nanoparticles and polymer residues. Such impurities add background noise, introduce undesired obstructions in TEM images and degrade the conductive properties of the graphene. On the contrary, our in-house graphene grids alleviate some off these drawbacks, enabling previously unattainable experiments such as the visualization of surface ligands.

Conclusion
Current graphene TEM grids often lack the necessary quality for advanced experiments. Our in-house produced graphene TEM grids demonstrate significantly higher quality, enabling a set of previously unfeasible experiments.

Keywords:

Graphene TEM substrate

Reference:

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