

Low-Energy Electron Microscopy of 2D Materials: From Graphene to Electron Microscopy Applications

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Two-dimensional (2D) materials exhibit unique electronic and surface properties that are strongly influenced by thickness, surface chemistry, structural imperfections, grain boundaries, and electron–matter interactions. Their characterization therefore requires techniques that combine high surface sensitivity with reduced electron-beam-induced damage. Ultra-high-vacuum scanning low-energy electron microscopy combined with time-of-flight electron spectroscopy (UHV SLEEM/ToF) provides a powerful approach for investigating these properties at low electron energies. Its application to graphene, hexagonal boron nitride (h-BN), MoS₂, and Ti₃C₂ MXene enables spatially resolved investigation of surface features, interfaces, and electronic excitations, providing information complementary to conventional high-energy electron microscopy.

Graphene has a particularly important role in this context. In addition to being a prototypical 2D material, its exceptional electrical, mechanical, and electron-transmission properties make it a promising material for electron microscopy itself. Graphene can serve as an ultrathin TEM/STEM substrate, a free-standing membrane, a protective layer, or a component of electron detectors. This dual role of graphene—as a material to be studied and as an enabling material for electron microscopy—opens new opportunities for connecting fundamental research on 2D materials with the development of advanced microscopy technologies.

Building on this concept, the Graphembo – Graphene for Electron Microscopy initiative focuses on translating knowledge of graphene and 2D materials into new components and applications for electron microscopy. The initiative is rooted in Brno, an internationally recognized centre of electron microscopy and an emerging European “electron microscopy valley”, where research institutions, academic laboratories, and leading microscopy companies form a unique ecosystem for research, development, and technology transfer. The combination of low-energy electron microscopy, 2D materials research, and graphene-based technology development creates a direct link between understanding materials at the nanoscale and developing new tools for their investigation, establishing a feedback loop between fundamental research and innovation in electron microscopy.

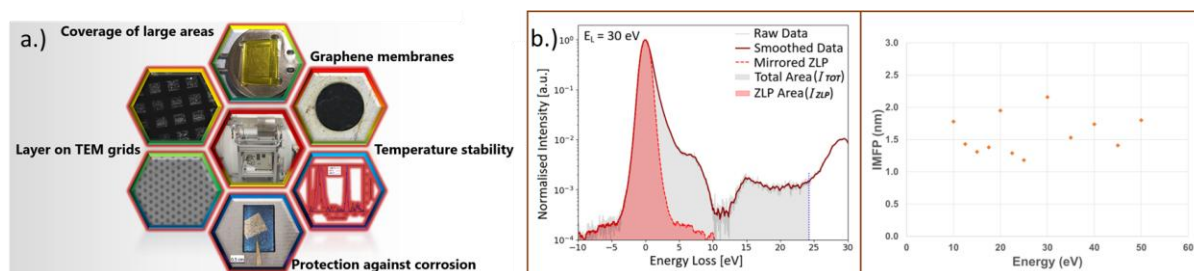


Fig. 1. (a) Applications of graphene in advanced electron microscopy; (b) EELS spectrum at 30 eV and graphene IMFP determined using the log-ratio method.

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References

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