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Graphene: Two-dimensional carbon at atomic resolution

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Graphene is a crystalline single layer of carbon atoms that can be viewed as an individual atomic plane extracted from graphite. Freely suspended mono-layer graphene is the thinnest possible membrane that is conceivable with currently known materials. Yet, it is remarkably stable under electron irradiation and thus opens unprecedented opportunities for electron microscopic studies. First, the graphene membrane structure and its defects are of outstanding interest for science and applications of this promising new material. Static deformations, topological defects, various vacancy configurations, substitutions, adatoms, and the two-dimensional equivalent of dislocations are detected by transmission electron microscopy (TEM). Further, graphene membranes can serve as a perfect sample support for transmission electron microscopy. Its contribution to the TEM image signal can be filtered out completely and adsorbed atoms and molecules on the graphene sheet can be imaged as if they were suspended in free space. Finally, graphene membranes constitute an ideal test object for microscopic developments due to the precisely defined structure and high stability in an electron beam at energies below the knock-on threshold. Numerous results from aberration-corrected transmission electron microscopy, showing precise atomic configurations in graphene, are presented, and new insights into various aspects of defects in graphene are discussed.