Lithography and in situ elucidation of conductivity in graphene structures using scanning helium ion microscopy

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With the recent development of commercial-level single-crystal graphene layers, the potential for manufacturing household graphene-based devices is improved, but significant challenges still remain with regards to patterning the graphene into devices. Traditional nanofabrication techniques such as optical and e-beam lithography (EBL) can be used on graphene with great success, but the multi-step processes they require can result in contamination of the graphene with resists and solvents, and the conductivity of graphene is subject to modification by surface contamination. Here we will discuss the utility of scanning helium ion lithography for fabricating conducting graphene structures that are supported by silicon oxide. The lithography is performed in a single step, dry, using high-resolution He- and Ne-ion milling directly on the supported graphene. These structures can have feature sizes ranging from multiple micrometers to less than 20 nanometers. Further we demonstrate that ion beams, due to their positive charging nature, may be used in conjunction with the graphene work function and secondary electron yield to observe the conductivity of graphene-based nanoelectronic devices in situ.