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# The Manufacture of van der Waals Heterostructures Using He Ion Beam Patterning


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Polaritons in two-dimensional materials exhibit enhanced light-matter interactions, which makes them interesting for low-loss, highly confined light transport. A polariton is a quasiparticle that combines a photon with a dipole-carrying excitation in matter and is strongly dependent on the type and geometry of the material. The hybridization of polaritonic modes in different 2D materials may provide strong localization of plasmonic excitations with long propagation distances of phonon modes [1]. By modifying the geometry of van der Waals (vdW) heterostructures at the nanoscale, we tune hybrid polaritonic modes.

We fabricate and patterning of heterostructures based on single crystalline gold or silver flakes, graphene, and hexagonal boron nitride (hBN). For dry transfer we used polydimethylsiloxane (PDMS) and poly(propylene) carbonate (PPC) films due to their strong adhesion to 2D materials at room temperature. Therewith, single-layer to few-layer 2D materials were successfully transferred onto thin electron transparent membranes of silicon nitride.

To modify the geometry of the heterostructures at the nanoscale, a Zeiss Orion Nanofab microscope is then used for patterning by He and/or Ne ion beam milling (cf. fig. 1). As polaritonic modes are not only strongly influenced by geometry, but also by material quality, an important step in the study is therefore to investigate different currents, acceleration voltages, and ion types to determine what damaging effects they have on the crystalline lattice and the corresponding m material response. The optimization of the patterning routines is carried out with the help of FIB-o-Mat, which provides complete control over the beam path [2].

In the following step, monochromated, low-loss scanning transmission electron microscopy (STEM), electron energy-loss spectroscopy (EELS) [3] is used to map the optical properties of the fabricated heterostructures, and the results are compared to near-field optical methods.

[1] A. Woessner, M. B. Lundeberg, Y. Gao, A. Principi, P. Alonso-gonzález, M. Carrega, K. Watanabe, T. Taniguchi, G. Vignale, M. Polini, J. Hone, R. Hillenbrand, and F. H. L. Koppens; Nature Materials 14 (**2015**), 421.

[2] V. Deinhart, L. Kern, J. N. Kirchhof, S. Juergensen, J. Sturm, E. Krauss, T. Feichtner, S. Kovalchuk, M. Schneider, D. Engel, B. Pfau, B. Hecht, K. I. Bolotin, S. Reich, and K. Höflich; Beilstein J. Nanotechnol. 12 (**2021**), 304.

[3] O. L. Krivanek, N. Dellby, J. A. Hachtel, J. Idrobo, M. T. Hotz, N. J. Bacon, A. L. Bleloch, G. J. Corbin, M. V. Hoffman, C. E. Meyer, T. C. Lovejoy; Progress in ultrahigh energy resolution EELS; Ultramicroscopy Volume 203 (**2019**), 60.

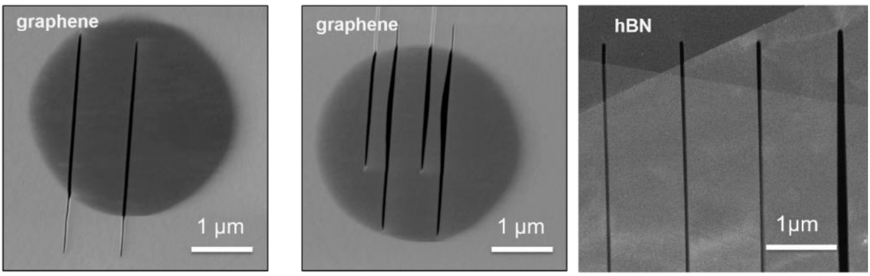


Fig. 1: SEM images of an example graphene flake and hBN flake after He ion beam patterning with different doses.