Unconventional graphene and hexagonal boron nitride membranes

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The implementation of graphene and other two-dimensional materials in nanoelectromechanical systems and electronic applications requires not only techniques to fabricate high-quality monolayers, but also methods to process these layers. Nondestructive processing is especially challenging in the case of fragile suspended monoatomic membranes.

To address this issue we developed a direct writing method for transparent two-dimensional materials on germanium that yields suspended layers without the need to transfer the ultrathin layer. We employ laser-induced photoelectrochemical etching which is highly selective and dissolves only germanium leaving the two-dimensional material intact. Only a focused continuous wave laser beam and water are required for the etching to proceed (see Fig. 1).

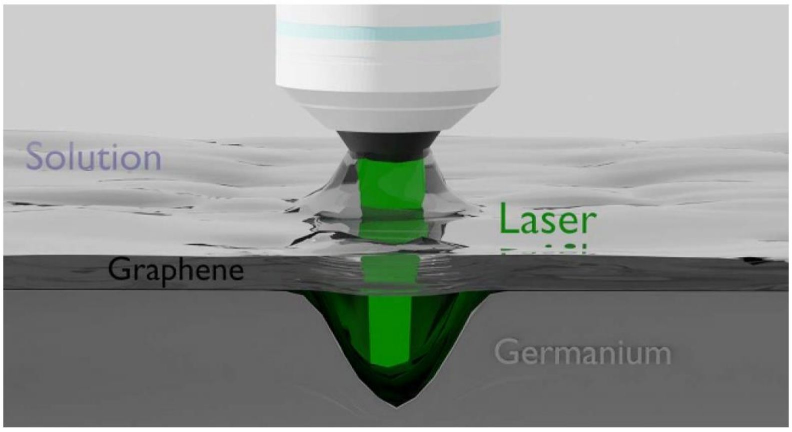

Fig. 1 Three-dimensional illustration of the setup used for the direct-writing etching process [1].

In this presentation I will explain the mechanisms that govern the photocorrosion of germanium and demonstrate how structures can be directly milled into bulk germanium. I will further show how this technique can be used to fabricate suspended graphene layers directly on germanium [1] and how the etching can be monitored via in-situ Raman spectroscopy.

Finally I will discuss the possibilities of extending this technique to other two-dimensional crystals and present recent results on hexagonal boron nitride.

[1] J. Binder, J. Rogoża, L. Tkachenko, I. Pasternak, J. Sitek, W. Strupiński, M. Zdrojek, J. M. Baranowski, R. Stępniewski, A. Wysmołek, *2D Materials* **8**, 035043 (2021).