Focused ion beam milling directed by BASIC-like code

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FIB is an ideal instrument for milling micron- and submicron-size structures on a wide range of substrates. Important applications require structures with mill profiles that follow a mathematical function, such as microlenses for photonics and x-ray focusing.[1-4] Previous works[1,2] have reported a method for milling curved surfaces using FIB; however, they lack a description of the specific software and interface used to achieve their results. Implementation of such method with a standard FIB interface is time-consuming and rigid. We have developed a simple and versatile approach for milling structures in FIB systems interfaced to the Nanometer Pattern Generation System (NPGS).[5]

NPGS mills areas defined in DesignCAD, a computer-aided-design (CAD) software. Any curved surface $z = f(x, y)$ can be reproduced by decomposing it into a set of discrete areas. The BasicCAD feature of DesignCAD allows to implement the surface discretization in a BASIC-like algorithm, which not only makes this task simple, but which also allows testing different milling strategies and fine-tuning milling parameters for the highest fidelity with design.

Recently, this technique has been used to show that graphene grows on Ru films deposited on curved surfaces (see Fig. 1),[6] which has potential applications, for example, for focusing atomic beams (He and H_2) in He-atom microscopes.[7] Additionally, with this approach and the metal ion beam assisted deposition capability of most FIB systems, it is feasible to construct 3D structures of arbitrary shape.[8]

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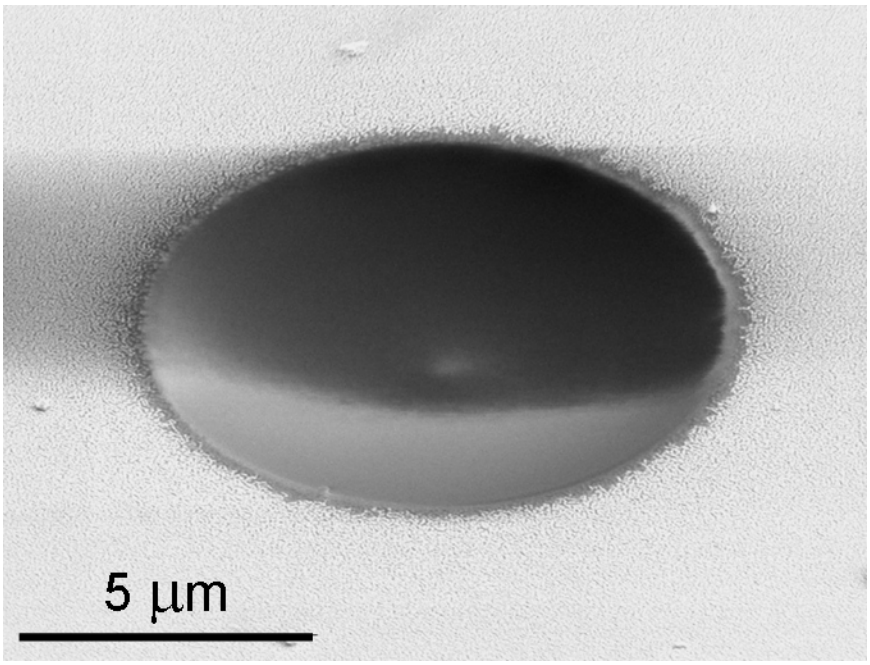

Figure 1: SEM image (tilt=52°) of an inverted spherical cap milled on fused silica: The grainy bright area is a gold coating needed to reduce charging effects during milling. Graphene was synthesized on Ru film deposited on this and other curved structures.[6]