Nanosculpting devices with electrons in the transmission electron microscope and applications, Marija Drndic, University of Pennsylvania

Manipulation of matter on the scale of atoms and molecules is an essential part of realizing the potential that nanotechnology has to offer. In this talk I will describe the fabrication nanostructures and fully integrated devices on silicon nitride membrane chips by nanosculpting evaporated metal films, graphene and other materials with electron beams. This methods works by directly exposing materials to an intense and highly focused beam of electrons inside the transmission electron microscope (TEM). The effect of electron irradiation can be used to shape the material with resolution on the scale of tens of atoms per exposure. In situ TEM imaging of the ablation action with atomic resolution allows for real-time feedback control during fabrication. Specific examples presented here include the fabrication and characterization of nanogaps, nanorings, nanowires with tailored shapes and curvatures, and multi-terminal devices with nanoislands or nanopores between the terminals. These nanostructures are fabricated at precise locations on a chip and seamlessly integrated into large-scale circuitry. The combination of high resolution, geometrical control and yield make the TEM an attractive fabrication tool for many applications including nano- and bio-electronics. I will specifically discuss applications in nanoelectronics and DNA sequencing pursued in our laboratory in the last six years. I will also discuss the integration of a measurement setup inside of the TEM and the in situ electrical measurements the resulting nanostructures. One example includes the measurements of graphene nanoribbon conductivity as a function of nanoribbon width, as the ribbon is continuously measured and narrowed in the TEM.