AFM local anodic oxidation studied by spectroscopic microscopy

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The fabrication of state-of-the-art semiconductor nanostructures is of great interest both for basic research and device applications. Besides the traditional lithography techniques, local anodic oxidation (LAO) by atomic force microscopy (AFM) is emerging because of its low cost and high resolution. Nevertheless, little information is available on the chemical and structural properties of the grown oxide, because of the lack of reliable microscopic techniques in order to perform a chemical analysis on such small structures.

We address this open issue by a spatially resolved photoemission spectroscopy study of AFM oxidised silicon. Oxide patterns of different widths and thickness were produced on n-type silicon by scanning an AFM tip, biased up to 15V negative with respect to the Si surface. The morphology of the structures was studied immediately after the oxidation by AFM. The oxide geometry is equivalent to the geometry used to fabricate AFM defined nanodevices such as quantum point contacts and single electron transistors. Photoelectron spectroscoscopy was performed with the SPELEEM at Sincrotrone Trieste. We monitored the binding energy of the Si 2p peak to study the different levels of oxidation of the AFM oxidized pattern and of the native oxide on the unpatterned surface. We were able to resolve spatially and chemically the two oxide areas.

The AFM induced oxidation produces a stoichiometric silicon dioxide, independent of the oxidation bias. The grown lines are chemically uniform within our spatial resolution, and the observed charging effects suggest that the dielectric properties of the AFM oxide lines are comparable to those of thermal silicon dioxide.