Thermal Analysis of Thin Films with Atomic Force Microscopy-based Local Anodic Oxidation

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Atomic force microscopy-based local anodic oxidation (AFM-LAO) is widely used in scanning probe lithography (SPL) for nanofabrication, which is the only lithography that enables the direct and resist-less nanoscale patterning of a large variety of materials. Applications include the development of sophisticated electronic and nanomechanical devices such as quantum dots/point contacts, working as transfer-processing etching masks, molecular template growth of organic semiconductors and fabrication of silicon nanowire field-effect transistors (FETs). However, the potential applications of this technique in the thermal management of thin-film-based devices are neglected. In this work, the device layer of a commercial silicon-on-insulator wafer is locally oxidized by AFM-LAO to form effective heat guiding patterns. In practice, varied local oxidation patterns can suppress the in-plane thermal transport as drilled nanoporous patterns and deposited metal nanopillars, while eliminating the requirement of a mask for the fabrication and keeping the possibility of local thermal property modifications on a fabricated electronic device. These AFM-LAO patterns can be customized anywhere and used to protect the heat-sensitive part of a chip when electrical properties can be preserved. Such these thin-film-based devices with customed local oxidation by AFM-LAO open up new opportunities for thermoelectric applications with better heat dissipation as the dramatically reduced lattice thermal conductivity.