NANOSCALE LASER PROCESSING USING NEAR-FIELD OPTICS COMBINED WITH ELECTRON MICROSCOPY

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The fabrication of nanostructures and their organization into functional macroassemblies remains a grand challenge in nanoscience and nanotechnology. This requires a unique combination of advanced atomic-scale imaging and controlled nanoscale materials processing. Achieving a fundamental understanding of the nucleation and growth phenomena at the nanoscale is critical to meet this challenge.

Confinement of optical energy to small dimensions can be achieved by coupling laser irradiation to near-field scanning optical microscopes (NSOMs). Since laser sources are available with different photon energies and pulse lengths, matching with the absorption properties of the substrate can be dictated, in order to accomplish local chemical and structural modification with precision, accuracy and without detrimental thermo-mechanical side effects. Surface nanomachining has been accomplished by utilizing pulsed lasers coupled through both apertureless[1,2] and apertured[3] configurations. Both schemes were employed to explore the nanoscale melting and crystallization phenomena.[4] We have utilized tip-based nanoindentation, and nanoscale laser CVD to define metal nanodots as catalysts of the subsequent growth. We have defined seeds for subsequent growth by using the probe tips to irradiate and decompose deposited metal-organic layers on the substrate. We have then grown nanostructures via laser chemical vapor deposition.

In addition to ex situ fabrication schemes, we have implemented a new method of coupling the pulsed laser beam into and SEM instrument by use of lensed fiber.[5] Truly *in-situ* SEM monitoring of the samples under laser processing was achieved with full compatibility of the lensed fiber with the dual beam system composed of the focused ion beam (FIB), the electron beam (SEM). By further integrating NSOM tips with the electron microscope and FIB system, we have constructed a unique tool for observing the nanomachining, deposition and growth as well as for analyzing the deposit composition. To understand the microstructural evolution of a sample under laser processing we have also carried out *in-situ* nanoscale laser materials processing inside a TEM where the evolving microstructure could be monitored in real time.

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