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Topic of Research: **Ion Induced Formation of Nanostructures at Surfaces**

Abstract

We have developed reliable protocols for the synthesis of uniform, high density, metal nanostructures by the ion beam irradiation of thin metal films. Our work was motivated by the need to develop a method of size-controlled nanostructure formation by a self organized process, so as to address the concerns regarding resource conservation and preparation time that are encountered in traditional top-down methods of synthesis. We have used the intrinsic differences in surface energy between the substrate and the metal films to drive the morphological change, using the elevated temperature of the ion track to trigger mass motion. This results in the transformation of the continuous films into nanoscale structures, whose sizes are determined by the intrinsic properties of the material, with particle densities governed by ion fluence.

Our choice of materials was driven by considerations of the wide scale applicability of the materials to be synthesized and the easy availability of standard substrates. Nanostructures made from the metals we have chosen - cobalt, nickel and tin, have all been identified as critical in catalysis of a range of chemical reactions and in novel areas such as fuel cells and battery technologies. We have examined the consequences of ion irradiation in different energy regimes from keV to MeV for a variety of ions, and we

wished to establish the energy and mass ranges over which this method of nanostructuring is applicable for metal films. We have characterized the samples with three well established techniques- AFM, XRD and RBS, so as to obtain a complete picture of the morphological, structural and compositional transformations resulting from ion irradiation.

Important Findings

In the case of cobalt films, we find that well defined high density nanostructures are formed upon irradiation of films grown on single crystal silicon (100) substrates with ions in both the keV and MeV energy regimes. The grain size distribution of the partiles formed peaked in the 30nm region in all cases, and the grain density increased with ion fluence.

For tin films, we have found that sputtering is the dominant mechanism that drives structural change, and the continuous converted to an array of well defined nanostructures of about 40nm in base width.

In case of Nickel films, upon higher mass irradiation at the highest fluences, XRD reveals silicide formation on these nickel films. This is due to enhanced energy loss from the higher mass films in nickel, which crosses the threshold for beam induced reactions.

The general observation from our experiments with films grown on quartz substrates is that the uniformity of the structures formed is not as clear as with the silicon substrates. The presence of oxygen in quartz induces reactivity at the interface and inhibits the rearrangement of the metal films into nanostructures.