FRACTURE AND ADHESION OF ULTRA THIN PATTERNED FILMS

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This presentation summarizes the unique cracking problems associated with micro- and nano-patterned thin film devices fabricated via soft lithographic methods. Soft lithography encompasses a group of techniques, such as microcontact printing (μ-CP) and nanotransfer printing (n-TP), that use a flexible elastomeric stamp to form patterns of self-assembled monolayers (SAMs) on the surfaces of substrates. The SAMs can then serve as resists for selective etching or templates for selective deposition to form the final thin film device. These additive methods of patterning are used to create complex 2-D and 3-D structures with feature sizes ranging from hundreds of microns to tens of nanometers for a broad set of applications in electronics, sensors and MEMS. Although the mechanics of thin films have been widely investigated, the emphasis has been on reliability issues associated with the microelectronic industry and films processed by conventional photolithographic methods. The advent of device fabrication via soft lithography has introduced several new challenges with respect to understanding film cracking.

Adhesion and fracture of the patterned films is dominated by two key properties: interfacial failure strength and processing induced stresses/shrinkage. We have developed two experimental methods for characterizing these properties and their relationship to cracking in patterned sol-gel films. The interfacial strength is measured using a laser spallation technique. In this method, a pulsed laser launches a high amplitude stress wave from the substrate side of the sample, providing a loading force that does not damage or otherwise affect the test film before the failure event occurs. The rapid, high strain-rate loading minimizes inelastic deformation in the films, providing an intrinsic estimate of the interfacial strength. The role of processing induced residual stress/shrinkage is investigated using a novel digital image correlation technique. In situ strain measurements are made during drying and heat-treatment of a sol-gel film on a functionalized substrate. The critical strain at cracking is assessed for several different interface conditions and film thicknesses.

Keywords: thin-film, patterned, fracture