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Invited Presentation

EFFECTS OF INTERFACIAL TOPOGRAPHY ON ADHESION AND FRACTURE AT THE NANOSCALE

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Interfaces play a critical role in determining thin film component performance and reliability. They are defined by composition, structure and the nature of bonding at the atomic scale, and by the variations in surface topology at larger scales. These variations are used to great advantage in improving reliability of thin film devices at the micron and sub-micron scales. However, limitations in test capabilities have prevented a direct measure of surface topology contributions to adhesion of thin films at the nanoscale. We have therefore begun a program integrating nanomechanics tests and finite element-based simulations to develop an understanding of how patterns of small-scale interfacial heterogeneities affect interfacial crack nucleation and crack propagation. For this work, tungsten films were deposited onto smooth silicon substrates and substrates with an array of low adhesion polymer structures to define the effects of bond area on interfacial fracture resistance. Films were then deposited onto nanopatterned silicon substrates to determine the effects of surface topology. The tests showed that adhesion decreased for the films on substrates with low adhesion polymer structures and increased for films on the nanopatterned substrate. Detailed finite element analyses were conducted in parallel with these tests to define the effects of nanopatterned surfaces on fracture resistance. In this presentation, we will use the test results and finite element simulations to show how small-scale variations in topology affect resistance to fracture thus providing a means to tailor nanoscale film device performance. This work was supported by Sandia National Laboratories under USDOE grant DE-AC04-94AL85000.

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