INTERFACIAL ADHESION OF COMPOSITIONAL GRADIENT TERNARY FCC ALLOY FILMS

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Combinatorial materials design of thin films allows for the investigation of fundamental mechanic relationships and optimization of thin films for engineering applications. By depositing a wide range of compositions on a single sample, a systematic study of the full alloy composition of particular material system can be investigated for a number of different properties in a relatively short amount of time. Using an integrated shutter controller, specifically designed and manufactured to allow for precise control over coating design, ternary alloys with the full compositional range can be deposited on a single wafer. By specifically programming the shutters it was possible to create multilayered thickness gradients of three elements, which were then annealed to create thin films with a large compositional gradient across the wafer. The adhesion strength of an Al_2O_3 ALD coating on two such compositional gradient FCC alloy adhesion layers, AlCuAu and AuAgPd, was investigated as a function of the changing composition. The AlCuAu alloy sample consists of multiple phases and intermetallics across the wafer which are dependent on composition; whereas the AuAgPd alloy is a solid-solution across the compositional gradient. For this investigation, instrumented indentation with a conical diamond tip was used to locally measure the adhesion of the ALD coating with different adhesion layer compositions. By performing small arrays of indents over the surface of the coating, it was possible to test the adhesion-promoting properties of a broad spectrum of interface compositions in a single sample.

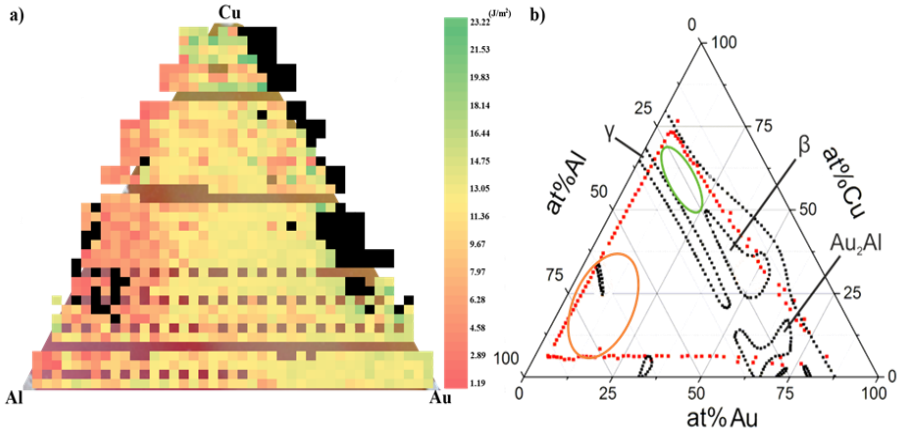

Figure 1 – Color gradient of interfacial adhesion energy values calculated using the Hutchinson and Suo model [1] and correlation to specific areas on the ternary phase diagram (right).

Ultimately, the solid-solution alloy showed a gradual change in interfacial adhesion energy as the composition changed, while the AlCuAu sample, which has numerous intermetallics and unique phases, showed specific areas correlating to relative poor and good adhesion. Furthermore, the AlCuAu sample showed an order of magnitude higher interfacial adhesion energy when compared to the solid-solution, noble-metal adhesion layer. The results of this combinatorial material study showed that this method is a convenient and efficient way to quickly screen for an ideal composition for a specific property of interest, with significantly fewer resources and quicker result turnaround than traditional sample preparation and testing methods.

[1] J. W. Hutchinson and Z. Suo, “Mixed mode cracking in layered materials,” Adv. Appl. Mech., vol. 29, pp. 64–191, 1992