CHARACTERIZATION OF INTERFACIAL ADHESION PROPERTIES OF DUCTILE MATERIALS: A CROSS-SECTIONAL NANOINDENTATION METHOD

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ABSTRACT
Cross-sectional nanoindentation is a recent method for adhesion measurement for coating and substrate systems with dissimilar material parameters. In the present work, finite element simulation with the cohesive elements is used to combine with the cross-sectional nanoindentation test to characterize the adhesion of two dissimilar elastic-plastic materials. The objective of this study is to determinate the relationship between the indentation responses, materials mechanical properties and the interfacial adhesion energy. It is suggested that these relationship can be potentially possible used to extract the interface adhesion properties of a film/substrate system.

Keywords: nanoindentation, finite element simulation, cohesive zone, adhesion energy.

INTRODUCTION
Interfacial adhesion of thin coatings or films to substrates is a critical reliability parameter of microelectronic and optoelectronic devices (Volinsky et al. 2002). Cross-sectional nanoindentation (CSN), developed by Sanchez et al (Sanchez et al. 1999), is a new technique to access the adhesion of thin film on blanket and patterned structures. Elizalde et al (Elizalde et al. 2003) developed an analytical model combined finite element modeling for elastic-plastic thin film deposited on the elastic substrates. Roy et al (Roy et al. 2007) qualitatively analyzed the adhesion energy of Cu film deposited on elastic substrate, evaluating the adhesion using the geometrical ratio of blister dimensions at the crack initial. All these investigations were conducted to calculate the adhesion properties based on fracture mechanics which has the limitation that inconsideration the plastic deformation of the coatings and substrates. Recently, the cohesive zone model that conquer this limitation are adopted by some researchers to study the adhesion energy of the coated systems.

In the present work, finite element simulation with the cohesive elements is used to combine with the cross-sectional nanoindentation test to characterize the interfacial adhesion of two dissimilar elastic-plastic materials. In this paper, we study the effect of indentation parameters, material parameters of the coating and substrate, and the parameters of the cohesive elements on the critical indentation depth at which separation initiated.

RESULTS AND CONCLUSIONS
The critical indentation depth increases strongly with the normalized interface strength as shown in Figure 1. It means that the stronger the interfacial strength, the more energy need to consume when the crack initial in the process of indentation.
The critical indentation depth is approximately proportional to the interfacial toughness and is sensitive to the elastic mismatch parameter $\alpha$ (Figure 2).

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**REFERENCES**


