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Fracture Toughness of Thin Films Estimated by Rockwell C Indentation

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Description:

The work in this Ph.D. thesis focuses on analysis of indentation-induced fracture in hard, brittle thin films. A method for determining thin film fracture toughness from the cracking pattern arising from a Rockwell C indentation is proposed.

This thesis consists of three parts covering the work to develop the proposed fracture toughness test method. .

Firstly, the stress in the film around the indentation is analysed. A number of theoretical solutions are investigated. The thin film stress state is determined by a finite element simulation of the indentation process. The simulation includes contact, nonlinear material behaviour, large strains and large displacements. The indentation process for both a bulk substrate and a film/substrate system is analysed. It is investigated if film bending has influence on the results. The influence of the indentation depth on the accuracy of the result is treated. Substrate plasticity and the effect of plasticity on the indentation depth and film stress state is also analysed. Secondly, the driving mechanisms and important material parameters regarding crack propagation in thin films are described in detail. Relevant crack propagation models are presented and compared. The influence of substrate plasticity and crack spacing on crack propagation is investigated. During film cracking, bending of the film occurs. This effect is investigated and compared with literature models for crack spacing. .

Thirdly, the indentation stress simulations and crack propagation models are coupled in order to create a model for determining the thin film fracture toughness. The influence of residual stress is described and illustrated. The model and the transition from crack propagation to crack arrest is illustrated. The model is tested on two different film/substrate systems, a TiN-ASP23 and an Al_2O_3 -AISI 316L system. The crack patterns from these two systems are used to discuss the validity of the model.

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