Surface and Coatings Technology 127 2000 9]17

Determination of elastic properties of thin films by indentation measurements with a spherical indenter

T. Chudoba, N. Schwarzer, F. Richter
Technische Universitat Chemnitz, Institut fur Physik, D-09107 Chemnitz, Germany
Received 15 March 1999; accepted in revised form 13 February 2000

Abstract
Indentation is an important method for the determination of mechanical properties of surfaces and thin films. It is well known that the measurement results from thin layers are strongly influenced by the substrate properties. For hardness measurements it is frequently quoted that the indentation depth should be less than one-tenth of the film thickness (1/10th rule). This rule is often not practicable for thickness values below 1 μm. Therefore a correction method is required that allows the separation of substrate and film properties from the load-depth data. Moreover, the calculation is complicated if plastic deformation occurs. The use of a spherical indenter allows one to remain completely within the elastic range if the indenter radius is large enough and the load is low enough. In this case a novel analytical solution for the elastic deformation of a film on a flat substrate can be used to simulate the load-depth data. With this solution the determination of Young's modulus of thin layers is possible independent of indentation depth and film thickness. Measurement data from a UMIS-2000 indentation system for different film substrate combinations are compared with theoretical results. It is shown, that a separation of the elastic film properties is possible. For metal films on Si the load-depth data did not differ from that of uncoated substrates. This can be explained mainly by delamination.

Keywords: Mechanical properties; Spherical indenter; Indentation measurements; Young's modulus