Theoretical and Experimental Investigation of the Indentation Size Effect

abstract

This thesis discusses in theoretical and experimental level the investigation of the so-called indentation size effect (ISE), a phenomenon appeared in Nanoindentation experiments in ultra-low penetration depths. In the first chapter, some basic concepts of the Nanoindentation technique are discussed, along with the theoretical background, the methods typically used and the main factors affecting the measurements. In the second chapter, a literature review is conducted, related to the theoretical models that have been developed regarding the ISE, with emphasis in Gradient theories. In the third chapter, ISE observed in the measurements acquired this way, is studied with the use of gradient theory. It is shown that the ISE is rather an artifact of the geometry of the tips used, than a phenomenon related to the material tested. As a result, a novel 2D gradient model is developed, capable of predicting the ISE behavior. In the fourth chapter, the experimental procedure is analyzed in order to investigate the effect of the geometry of the tip in the analysis of the mechanical properties of some control materials, as well as of a thin film-substrate system. Finite Element Analysis (FEA) is also used to model the experimental results of the nanoindentation technique. Finally, the results of this thesis along with some new concepts for further research are demonstrated.