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Elasto – Plastic Materials Behavior Evaluation According to Different Models Applied in Indentation Hardness Tests

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Instrumented Hardness Tests (IHT), also know as nanoindetation, establishes itself throughout the years as a standard method to characterize superficial elasto – plastic properties of materials, with a greater capability to evaluate thin films. The main advantage of this test lies on the application of dynamical load – unload cycles, generally with values of few mN and displacements below 200 nm, granting more information about the material beyond hardness, as elastic modulus, creep, fracture resistance, among others. However, the difficulty to achieve an adequate contact between sample and penetrator complicate the interpretation of its results. Several theoretical models were developed in order to diminish this effect achieving relative success. Each theory takes in consideration different aspects of the phenomenon and its application produces diverse mechanical properties values, which makes difficult the comparison among them. The aim of this work is to measure materials mechanical properties in accordance with ISO 14577 Martens model, the Oliver – Pharr (OP) method and the approximation developed by Gong, Miao and Peng (GMP) which are typically used on IHT, in order to find a possible relation among them.

Aluminium, soda-lime glass, and silicon bulk materials and titanium nitride thin films were measured using a Fischerscope HV100 equipment with a Berkovich indenter. Dynamical load – unload cycles were applied to the samples with its maximum value ranging between 5 mN and 100 mN, during a total time of 120 s each cycle. The hardness calculation was performed according to the ISO 14577 Martens hardness model with indenter tip correction and considering the indentation size effect (ISE). The Oliver – Pharr method was calculated contemplating the non-linearity of the unload curve, adjusted by a power law. The Gong – Miao – Peng approximation was very similar to the OP technique, differing by the use of a virtual contact load and an indenter response based on a conical geometry instead the revolution paroboloid one, which is typically used.

The results obtained confirm the hardness values variations among the models, which differ mostly at low load cycles. The comparison between the hardness calculations made by each model and the indenter response are presented as final result.

Keywords

Nanoindentation

Hardness models

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