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A NEW TECHNIQUE TO DETERMINE THE TRUE PROJECTED CONTACT AREA USING NANOINDENTATION TESTING

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Nanoindentation technique requires the determination of projected contact area under load for calculation of modulus and hardness of materials. This projected contact area is usually calculated by models which take into account the pile-up or sink-in phenomena around the tip. The most commonly used model was developed by Oliver and Pharr [1] which can precisely model the sink-in around the tip, but cannot account for pile-up. Another model developed by Loubet et al can be used [2]. It can take into account the pile-up and the sink-in phenomena and can precisely measure the projected contact area for a large range of materials, except for materials with high strain hardening exponent. Other techniques, like post mortem measurements, can be used. However these measurements do not take into account the elastic recovery during unloading.

A new technique to estimate the true projected contact area will be presented. It consists of combining two models (The Dao et al. model and the Kermouche et al. model) that are used normally to calculate the representative stress and the representative strain in indentation. Consequently, the projected contact area calculation does not depend on any contact area model. Moreover, it can account for the pile-up or sink-in phenomenon and the strain hardening of the material, which is not possible with the actual models used. This new technique requires measuring indentations parameters like the maximum load, the contact stiffness and the loading curvature. It requires also the use of two tetrahedral indenters: a Berkovich tip and a tetrahedral tip where the included semi-angle is 50°.
The method was tested on three different samples: glass, PMMA and 100C6 steel. For indentations on glass and PMMA samples, the projected contact area was precisely measured. For indentations on 100C6 steel sample, the method was adapted to take into account the Indentation Size Effect observed at small indentation depths. The projected contact area values measured with this new technique will be presented and compared to the values calculated with classical literature models. Also, the limits of the technique will be discussed.

[1] Oliver WC, Pharr GM. Measurement of hardness and elastic modulus by instrumented indentation: Advances in understanding and refinements to methodology. J Mater Res 2004;19:3–20.

[2] Loubet JL, Bauer M, Tonck A, Bec S, Gauthier-Manuel B. Nano-indentation with a surface force apparatus. NATO Adv Study Inst Ser E 1993:429–47.