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IT CAN BE MEASURED FRACTURE TOUGHNESS FROM REPETITIVE NANO-IMPACTS TEST?

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The design of coatings in the field of engineering applications aims at a progressive shift to the development of “hard but tough” coatings. The difficulty in assessing their mechanical behaviour by conventional methods is behind the growing relevance of “in situ” experiments using instrumented microindentation technique. This technique is one of the few able to investigate the mechanical properties along of whatever length range, i.e. from small volume to bulk material. Information from the load-depth curve of indentation has proven to be abundant and varied and it can be used to determine several mechanical properties such as: hardness, Young’s modulus, yield strength, viscoelastic properties, etc [1].In fact, from this technique the evaluation of wear-resistance by hardness and/or scratch testing have become in a routine in a multitude of different materials [2]. Nevertheless, the results are not always accurate, particularly when the surfaces are subjected to erosive wear during service and fail by a fatigue process. For the purpose of providing a solution, impact technique have been developed to extend the capability of depth-sensing indentation/scratch instrumentation to perform fatigue testing in a wide variety of surfaces, such as DLC and amorphous carbon [3], plasma electrolytic oxidation surface[4], polymers [5] and numerous coatings for cutting tools [6]. Along the experiment, this technique produces a repetitive impact with a high stresses and high strain rates, simulating the fatigue conditions under repetitive contact conditions, at the nano or micro-scale. Depending on the material ductility and the load magnitude, fracture of the surface may be achieved. Therefore, the question is whether from these tests it is possible to calculate fracture toughness values, K_C, since conventional ways to determine fracture toughness by single edge notched beam (SENB), chevron notched beam (CVNB) and double cantilever beam (DCB) are not applicable for systems whose dimensions are between a few hundreds of nanometers to a few microns.

Along this work, it will be studied the feasibility of using impact tests with a cube-corner tip using low loads, assuming that the indented coatings resembles the pattern for the fracture mode type I considered in the classical fracture toughness tests. For this purpose, fracture toughness calculation by impact test will be analysed first in a brittle bulk Al_2O_3 material, since its mechanical properties are well known. After this, fracture toughness of Al_2O_3 coating on ductile metallic substrate will be analysed for chequing the substrate contribution and the applicability of the classical indentation models, IM, in case of impact done at low loads. Finally, a novel method to determine the fracture toughness in metallic nanomultillayer coatings by impact test will be show.

[1] W. C. Oliver, G. M. Pharr. J. Mater. Res. 1992;7:1564.
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