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Surface mechanics: facts and numerical models

Foreword

Surface mechanics essentially concerns the mechanical problem of contact between solids through interfaces. It is the link between mechanics of materials and surface science or tribology. So, it combines the complexity of both these sciences and is today recognized as a separate discipline.

Understanding the mechanical properties of the first layers on the surface of materials, and also at the interface between two solids is a research topic whose importance has grown steadily over the last few years. More and more researchers and research teams all over the world are focusing on the subject. The reasons for that are simple.

First, the mere existence of a surface or an interface forces us to think that the organization of the material in their vicinity, and thus its properties, is different from that in the volume. There is an issue of knowledge that the academic world took over. Surfaces and interfaces, due to their geometrical complexity or their spatial structure, to local chemical reactions and also to the history of mechanical and physical solicitations, can lead to uncommon material states and properties. If sometimes this can be an obstacle to obtain the properties of underlying thin layers, it may also open the way to new fields in the use or manufacture of materials.

Therefore, in order to improve or provide new functions to materials, surface treatments or the deposition of thin films (a few micrometers thick) or even very thin (several tens of nanometers thick) are widely used in industry. The knowledge of the mechanical properties of the treated layers or of the deposits is at the center of the manufacturing approach.

The extraordinary development of microelectronics through the unrestrained miniaturization of its components, involves a drastic reduction of the dimensions and volumes and also an increase in the number of interfaces. This encourages engineers and scientists to measure assemblies of materials whose internal scale is about 100 nm today. If the acquisition of the knowledge of the properties of these very small unit volumes is already a vast scientific and technological challenge, it is strongly increased by the interactions between these elementary volumes and their interfaces. The challenges of "knowledge" and "know-how" posed by the micro and nano structuring of matter are on an equal footing with the expected performance of these new components.

Because of its implementation facility and nondestructive character, the indentation test has long been used to characterize mechanical properties such as elasticity, plasticity, viscosity and damage. Moreover, as far as the behavior of interfaces is concerned, and more specifically the abrasive wear resistance, wear or friction tests reproducing real use conditions must be developed. However, as these tests are very costly, an alternative consists in using the scratch test which enables to understand the deformation mechanisms of materials submitted to an elementary abrasive solicitation. Unfortunately, the implementation facility of these trials precludes the difficulty in interpreting the results from a theoretical perspective.

Great progress has been made both in the intrinsic capabilities of the equipment (resolution, repeatability) and in the analysis of tests results. The tests are more and more automated and more and more parameters (temperature, loading, ...) can be taken into account. Refined mechanical quantities can be measured. The aim is that these measures become even more complete and accessible to scientists belonging to the community of mechanics of materials.

The development of numerical simulations is of great help to analyze the results. Indeed, the numerical simulations provide all the mechanical fields which enable to better understand the complex phenomena involved. It is now successfully applied for identifying the mechanical properties of surfaces (material behavior law) or interfaces (adhesion, friction) from indentation or scratch simulations as well as to investigate the functionality and sustainability of surfaces (sealing, wear phenomena, ...).

The technological and scientific importance of "Surface mechanics: facts and numerical models" in modern solid mechanics justifies that the "Comptes Rendus Mecanique" devotes a special issue to this topic. The present issue gathers nine peer-reviewed contributions of specialists of the domain.

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We hope that this special issue brings to the readers' knowledge the new points of view and advances in this central domain of mechanics both on fundamental questions and on practical resolution techniques.

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