SCANNING NANO-METROLOGY OF ULTRA THIN FILMS

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Traditional techniques of tribological and mechanical characterization of coatings are limited to friction, wear and scratch tests on a micro-level with balls or pins having much larger sizes, and loads-displacements much larger, than the film thickness. Lately-popular nano-indentation allows for testing of thinner films, but its pressure distribution is concentrated under (in the front of) the indenter and thus makes it vulnerable to substrate effects for ultra-thin films, while ultra-shallow depths would require unachievable-yet resolution of tip and system calibration. Common AFM-based techniques use smaller tips and displacements, but limited to nano-dimensional and topographic characterization of surfaces.

Moreover to detect the nano-non-homogeneities, a high-resolution surface mapping is required. Use of traditional nano-indentation for surface mapping is limited by the duration of a required series of numerous indents and their spacial resolution (the minimum space between indents is typically three times the diameter of the tip, or over 100 nm, to avoid the effect of the preceding indent). This makes nano-indentation unsuitable for studies of local nano-defects, or non-homogeneity

To overcome the shortcoming of traditional nano indentor a novel new tool, nano analyzer, was developed. It measures scratch-hardness of ultra shallow films where the pressure distribution (still in the front of the indenter) in the same surface layer where the indenter is sliding. As post-scratch detection of the shallow nano-scratches is challenging, it utilizes the same tip for both scratching and nano-imaging for nano-scratch-hardness testing of ultra-thin films. And to detect homogeneity of films the tool uses technique of nano-mapping, where a diamond nano-tip is vibrating in a tapping mode, frequency and phase of its vibrations are monitored and analyzed, and simultaneous topographical and stiffness (Young's modulus) maps of surface are produced with nano-resolution in both vertical and horizontal directions (Figure 1). Thus a novel new technique nano-analyzer enables effective quantitative tribo-mechanical characterization of ultra-thin films.

Examples of the nano-analysis of various thin hard films are discussed in detail (Figure 4). The paper also discusses mechanical property analysis of bump like structures under different loading conditions (figure 2,3). The tool is used to indent a bump and then do non destructive nano mapping of cracks Young's modulus. This paper compares touches on the fundamental constraints of the current techniques, and throws light on new technologies.

REFERENCES

1. D. Tabor (1996). Indentation hardness: Fifty years on. - Philosophical Magazine A, V. 74, No 5, pp. 1207-1212.
2. Nano and Micro Indentation and Scratch Tests of Mechanical Properties of Metals Dr. Norm Gitis, Dr. Ilja Hermann, Dr. Suresh Kuiry and Vishal Khosla

Figures

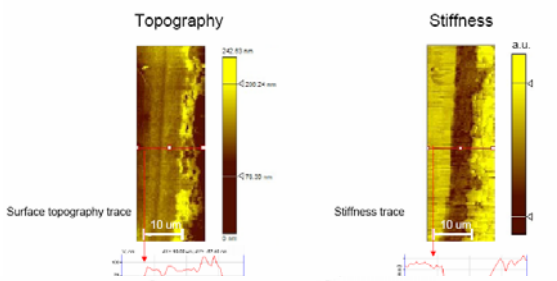

Figure 1. Topographical and stiffness map by Nano-analyzer NA-1

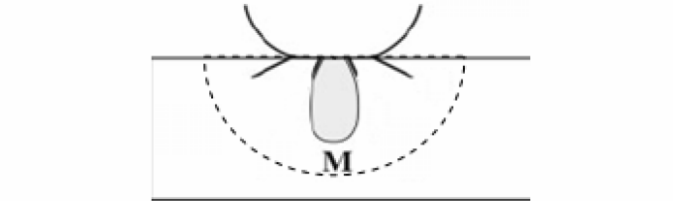

Figure 2. Cracks propagation mechanism when indenting on top of a bump

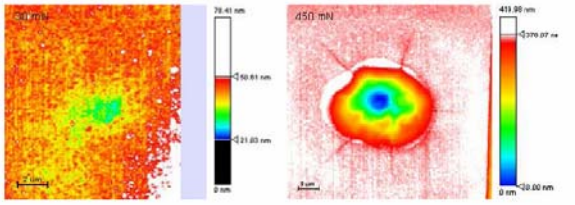

Figure 3. Results obtained after indenting a bump. Mechanism shown at different load with modulus mapping of the surface after the indent.

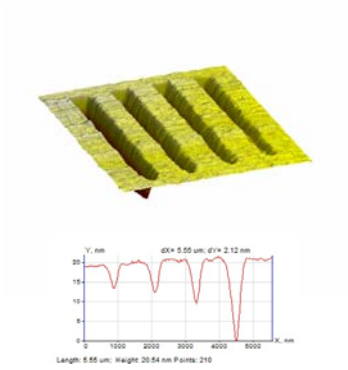

Figure 4 Ultra Shallow scratches in order of nm to find the scratch hardness of the low k materials