Nanoindentation on intermediate layers in thin foils

Measuring the true mechanical properties of micron-scale intermediate layers in thin multilayer foils – without influence from the surrounding layers – is a challenge that very few instruments can meet. It takes highly responsive nanoindentation technology and very precise positioning of the indenter.

Determining the hardness and elastic characteristics on the intermediate layers of multiplex foil systems presents several challenges. A normal “top-down” style indentation will yield composite properties for the entire sample, but not those of the individual layers, which requires measurements to be performed *within each layer* on a cross-sectioned sample. Due to the thinness of these layers, it is crucial to control the measurements precisely and to use extremely small indentations. Fortunately, nanoindentation technology, employing indents on the micron and nano scale, now allows hardness and elastic modulus measurements even on thin interior layers. Coupled with a high magnification microscope and a very precise positioning stage, nanoindentation is ideally suited for testing micron-scale components and films.

In this example, a 30 µm thick metallic foil sandwiched between a polymeric sheet and a rubberized top coat is analyzed. Because the free-standing sample was not structurally rigid, to minimize sample compliance the part was mounted in epoxy and polished to a mirror finish to expose the metallic inner layer cross-section.

Fig.1: Left: Free-standing foil piece. Right: Foil mounted in epoxy

The PICODENTOR® HM500 was chosen for this test due to its sensitive load resolution (≤100nN) and precise positioning capability (≤0.5µm). The values for indentation hardness (H_{IT}), Vickers hardness (HV) and indentation modulus (E_{IT}) were recorded for the metallic layer. The Martens hardness (HM) was measured as well and plotted as a function of indentation depth; variation in HM is an indicator of potential influence from surrounding layers. The cut edge of the metallic layer was identified under the integrated microscope (with magnification up to 1000x) and a series of indentations were made – located precisely in the center of the 30 µm thick target layer.

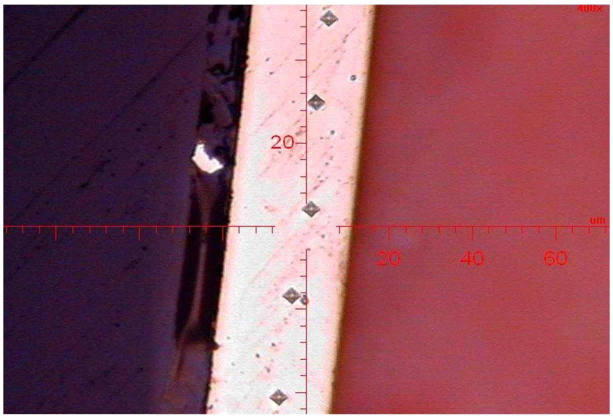

Fig.2: Indents performed precisely at the center of cross-sectioned layer

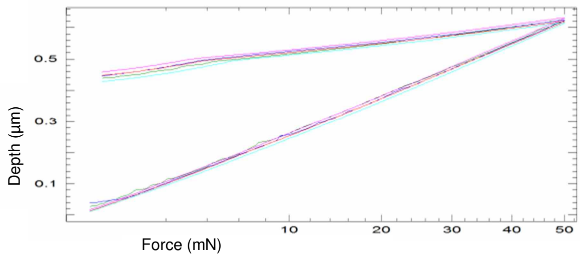

Fig 3: The graph shows reproducible load-displacement curves from each indent in Fig. 2.

Metallic layer	HM N/mm²	$E_{IT}/(1-vs^2)$ GPa	H_{IT} N/mm²	HV
X	4734.2	151.8	6961.9	657.8
s	223.9	8.8	263.6	24.9
V	4.7%	5.8%	6.0%	6.0%

Tab.1: Mean value X, standard deviation s and coefficient of variation V of mechanical properties measured from the indents in Fig. 2

With its ultra-sensitive measuring head, high-resolution microscope and precise stage, the PICODENTOR® HM500 makes it easy to accurately determine the hardness and elastic properties of micron-scale features, like cross-sectioned foils. For further details please contact your FISCHER representative.