

## Nanoindentation on wear-resistant DLC coatings applied to engine components

In order to reduce emissions in combustion engines without sacrificing performance, manufacturers are continually working to improve the ability of the moving components (e.g. camshafts, valve lifters, piston rings and gears) to resist abrasion and reduce friction. Protective coatings such as diamond-like carbon (DLC) are increasingly used in such applications. As DLC coatings can have a wide range of hardness depending on the deposition process it is important to measure the fundamental mechanical properties of this tough, low friction coating.

Traditional hardness measurements involve applying a load through a sharp indenter and measuring the residual imprint under a microscope. Due to the elastic nature and dark color of the DLC coating, determining the hardness of the coating with the miniscule residual indent optically is almost impossible and therefore unreliable.

The most accurate method for testing DLC coatings is nanoindentation, during which the force and displacement are continuously measured for both the loading and unloading phases. The software calculates the hardness and other quality determining characteristics, such as the modulus of the coating. High depth resolution allows for shallow indents to be performed preventing the substrate material from influencing the measurement results.



Fig. 1: DLC-coated engine components

In this example, the measurement results of a 3 µm thick DLC layer is shown, as determined using the FISCHERSCOPE® HM2000. The values for indentation hardness ( $H_{IT}$ ) and the resultant converted Vickers hardness (HV) value indicate the plastic properties of the coatings. The Martens hardness (HM) value takes the plastic and elastic deformation of the sample into account. The indentation modulus ( $E_{IT}$ ), however, also allows conclusions to be drawn regarding the elastic behaviour of the sample.

DLC coating	HM N/mm <sup>2</sup>	$E_{IT}/(1-\nu_s^2)$ GPa	$H_{IT}$ N/mm <sup>2</sup>	HV
X	8442.98	173.71	19398.17	1833.13
s	785.22	15.89	2320.85	219.32
V/%	9.3	9.15	11.96	11.96

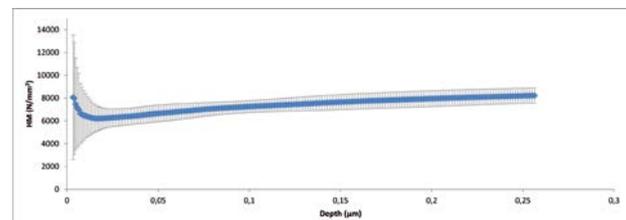


Fig.2: Martens hardness (HM) and other parameters of the DLC coating. The table shows mean value, standard deviation and coefficient of variation of 12 measurements; the graph shows the depth-dependent profile.

The standard deviations and coefficients of variation illustrate the accuracy with which these quality-related parameters can be determined, even on rough samples with thin coatings. The instrument's rigid frame eliminates device compliance even while testing very hard materials like DLC. Most importantly, the FISCHERSCOPE® HM2000 simplifies these highly sophisticated measurements through the intuitive WIN-HCU software interface, minimal sample preparation and short measuring times.

**The FISCHERSCOPE® HM2000 is the ideal tool when it is crucial to determine the mechanical properties of DLC coatings with speed, accuracy and precision. For further details, please contact your local FISCHER representative.**