Application Note AN MIC415

Quality Control of DLC Layers

Keywords	Instruments and Software
Diamond Like Carbon (DLC)	LUMOS II FT-IR microscope
Coating	OPUS spectroscopic software
Contactless and non-destructive analysis	Layer thickness determination function
Homogeneity	Chemical imaging functionality
QC and failure analysis	

DLC-coatings (DLC - Diamond-Like-Carbon) have gained significant importance due to a steadily rising number of applications. For instance, DLC-coatings are applied on tooling components, parts of motorcycle engines, hard-disk read heads, medical implants and high precision watches. The main desirable features are hardness, wear resistance and low friction. The properties of the coating can be determined and altered to some extent by changing parameters in the deposition process.
One major property is the thickness of the DLC-layer. Its geometry and profile on technical components like toothed wheels or injection nozzles can be rather complicated. DLC coatings are generally deposited from a gas phase. To obtain the desired properties the thickness of the DLC layer has to be monitored very closely.

Determination of layer thickness

The „ball grinding“ process is commonly used to determine the thickness of a layer. A rotating sphere is used to grind a calotte into the layer. The thickness is calculated from the optical grinding pattern measured usually with a microcsope. This method is destructive and only feasible on flat even surfaces. This procedure requires a significant amount of time and is prone to operating errors.
The determination by interferometric measurements in the infrared spectral range has several major advantages for

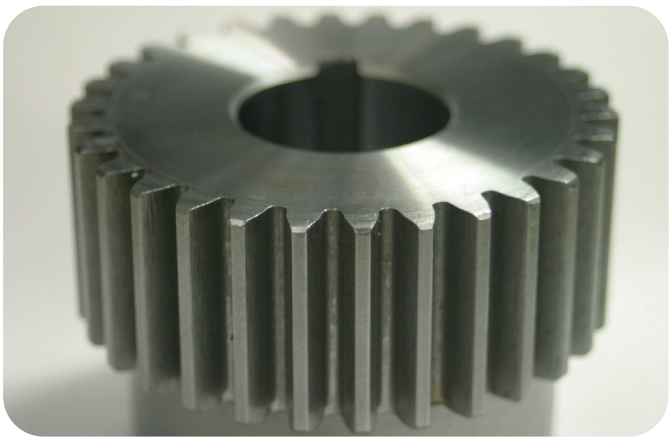

Figure 1: Crown wheel with DLC coating.

being non destructive, much faster, contact-free and without limitations regarding the shape of the workpiece.

DLC analysis by IR-microscopy

For the interferometric DLC analysis by IR-microscopy no sample preparation is required. The sample is just placed on the stage of the microscope and the IR-focus is set on the sample surface. Then, the FT-IR measurement is performed in the reflection mode. The measurement result is a spectrum with a sinusoidal baseline which originates from the multiple reflections of the IR-beam within the DLC layer (see figure 2). The distances between the maxima of this interference pattern contain the information about the thickness of the coating.

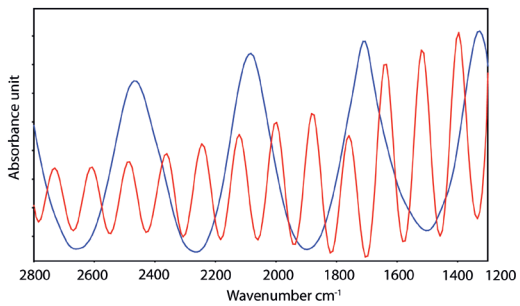

Figure 2: Interference pattern of two different DLC layers measured with an infrared microscope.

Instrumentation

The Bruker IR-microscope LUMOS II (figure 3) allows a fast and effective analysis of DLC coatings. Due to the very large working distance of the LUMOS II positioning of the sample is very easy and provides access even to rather bulky objects. Thanks to the high visual image quality, setting the focus on the sample surface is clear and simple. As the operator is guided through the microscopic workflow by a software assistant the LUMOS II can be used after a brief introduction. Therefore, the system is very suitable to be utilized not only for R&D but also for routine applications in quality control.

The determination of the thickness of the DLC-coating is performed using the "layer thickness" function, that is integral part of the OPUS spectroscopic software, which also is used to control the LUMOS II. To obtain an accurate analysis result of the layer thickness the refractive index of the sample material has to be entered into the evaluation function. This value is well defined in case of DLC layers and can be derived from literature (n=2.41).

Figure 3: Sample on the stage of the LUMOS II FT-IR microscope.

Due to the motorized stage of the LUMOS II not only single point measurements are possible but also automatic analyses at different selected sample positions or of defined areas. Such so-called mapping measurements allow to generate chemical images that show the homogeneity of the DLC coating (figure 4).

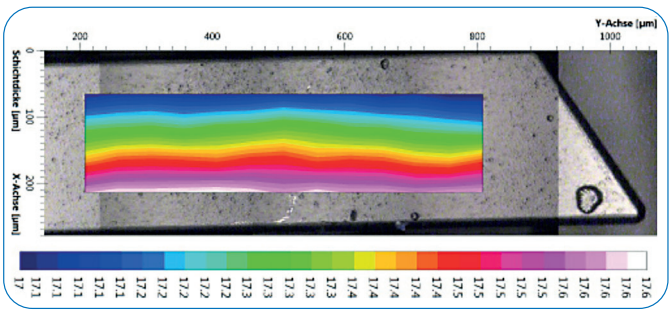

Figure 4: Chemical image, showing the layer thickness of a DLC-coating on a blade. The color coding visualizes the variance of the coating thickness from 1.70 µm (blue) to 1.76 µm (pink/white).

Summary

DLC coating is widely used especially for increasing the hardness of materials. One important characteristic of such layers is their thickness. FT-IR microscopy is a non-destructive, fast and precise analytical method for quality control and failure analysis. Even on unevenly shaped samples (e.g. diesel fuel system injector nozzles) this technology can provide very accurate results from smallest areas. Furthermore the homogeneity of the DLC-coating can be measured and be visualized in chemical images.

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