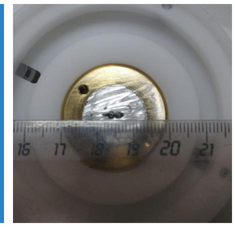
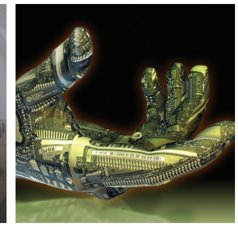
GDOES

Analysing drill bits with Glow Discharge Optical Emission Spectrometry





Application Note

Material Science GD40

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Abstract: Pulsed Radio Frequency Glow Discharge-Optical Emission Spectrometry was used to analyse a commercial drill bit. Due to the peculiar shape of the sample, a specific preparation had to be carried out. Thanks to the combined use of the indium kit and the 1 mm anode, even a very small sample could be analysed. The flexibility of the spot size and a dedicated sample preparation make RF GD-OES a successful technique for the analysis of mixed-shaped samples.

Key words: Hardening, Depth Profile Analysis, GD-OES, Elemental composition, small samples

Introduction

Drill bits are cutting tools used to remove material to create holes, almost always of circular cross-section. These kinds of cutting tools, used in wood or metalwork, are usually made from medium to high carbon steel (cast steel) which is hardened and tempered during the manufacturing of the tools. While the purpose of hardening is to enable the tool to resist wear and make it hard enough to cut other materials, tempering is carried out as a second step, to reduce the brittleness which results from hardening the steel. Materials are used for drill bits, such as tungsten carbide. However, this material is much more brittle than steel and for this reason additional coatings may be used in order to harden the tool. Indeed, surface coatings such as TiN, TiAlN or Diamond-like-carbon, allow greater feeds and speeds when operating at higher temperatures, increasing the tool lifetime, and thus productivity, sometimes by 4 or 5 times.

Instrumentation and sample preparation

The GD Profiler 2 (Figure 1) couples an advanced Radio Frequency (RF) GD source to a high resolution, wide spectral range Optical Emission Spectrometer. This technique relies on the precise and fast (typically μm/min) sputtering of a representative area of the investigated sample. All elements of interest are simultaneously measured, as a function of the sputtering time, using a spectrometer.

Figure 1: GD Profiler 2

Thanks to the use of the RF as an excitation source, with the GD Profiler 2 it is possible to analyze conductive, insulating and hybrid materials.

In GD-OES, the sample is mounted directly against the anode and the RF source is applied at the back. Therefore, the key point for an efficient GD-OES analysis is to have a flat surface facing the anode.

Drill bits come in many sizes and shapes (Figure 2). The best geometry to use depends upon the properties of the material being drilled.

Figure 2: Different examples of drill bits

Manufacturers of drill bits could easily use GD-OES to optimize/control their production process by depositing the different coatings on some flat pieces. However, competitive analyses require measurements to be performed on the final products.

The principal characteristics of these cutting tools are the spiral, which controls the rate of chip removal, the point angle, which is determined by the material to be drilled, and the lip angle, which determines how «aggressively» the bit cuts the material to be drilled. Moreover, in some cases, the coatings are not uniformly deposited on the whole tool, but only on the spiral.

For these reasons, the difficulty to find a flat surface makes drill bits challenging for GD-OES analyses.

An efficient solution comes from the combination of the «Indium kit» (Figure 3) and a diamond saw, which is crucial to cut the drill bit and obtain the small pieces to be analyzed.

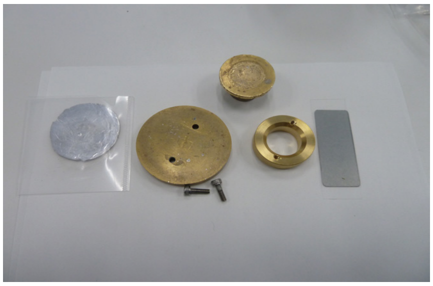

Figure 3: Image of the Indium kit

The Indium kit allows the easy and efficient analysis of very small samples. The idea is to embed the sample inside solid indium (Figure 4) and to place the surface of the sample in front of the anode using a movable positioning system.

Thanks to this tool, all air leakage inside the anode will be avoided as the o'ring will rest on the surface of the Indium (the red circle in Figure 4).

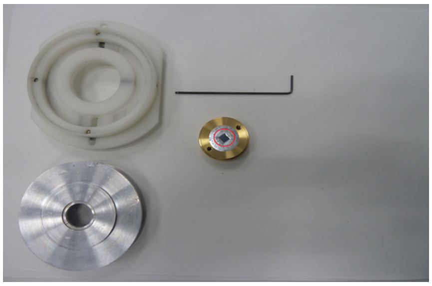

Figure 4: Image of a sample embedded inside solid Indium. On the left, the two dedicated tools for mounting and centering the surface of the sample on the anode

Results

To analyse drill bits, the key point is to couple the Indium kit and the 1 mm anode, as the helical part of the bit is very small. To do so, the drill bit was cut using a diamond saw and the pieces embedded inside solid Indium. The resulting sample is presented in Figure 5, where the 1 mm craters are also visible.

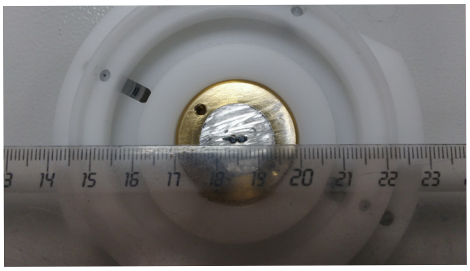

Figure 5: Image of the drill bit coated inside solid Indium and of the 1 mm craters performed by GD-OES

Thanks to the indium kit an efficient GD-OES analyses could be performed, as a good airtight seal was obtained. Moreover, thanks to the 1 mm anode, two different analyses could be performed on the same piece. Results are presented in Figure 6.

The sample is a tungsten carbide drill bit, coated with several layers in order to improve the hardening and reduce the wearing of the cutting tool.

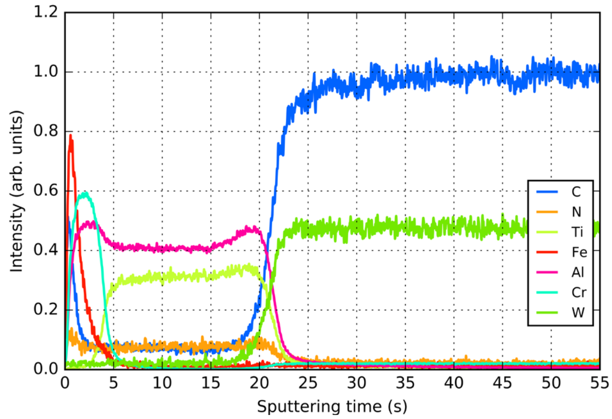

Figure 6: Elemental depth profile of a tungsten carbide drill bit obtained with the 1 mm crater. The tungsten carbide core is covered by several layers in order to improve the hardening and reduce the wearing of the cutting tool

Conclusion

Key aspects of pulsed RF GD-OES are the dedicated tools for handling peculiar shapes, such as the «Indium kit», and the flexibility of the spot size (several diameters, ranging from 1 mm to 7 mm). The combination of these features can be easily implemented to find alternative ways for an efficient analysis of complicated-shaped samples such as drill bits. These kinds of samples, featuring a homogeneous coating or several more complicated layers, would benefit from a profiling technique such as GD-OES.