Success Story
COMET

ImPACts
Industrial Methods for Process Analytical Chemistry - From Measurement Technologies to Information Systems
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Chemical maps in HD

Researchers at JKU Linz, a partner of the Austrian research network „Process Analytical Chemistry“ PAC, are using lasers to measure the chemical composition of complex materials. Ultrashort and extremely intense laser pulses are focused on a sample and material is removed from its surface. The different atoms emit light of characteristic color which enables determining the type and concentration of chemical elements in the sample. Chemical maps showing the element distribution of the sample can be measured with high spatial resolution using this new method.

The Laser

Since its invention in 1960s, the laser is an indispensable tool for science and technology. Even in everyday life lasers are almost ubiquitous: at the supermarket checkout, in various drives from CD to Blu-ray, or in light barriers. For these purposes, lasers are used that generate light with a certain color and a constant intensity. The JKU scientists however are using new types of lasers which produce short flashes of light. The duration of the laser pulses is typically in the range of micro- to nanoseconds, i.e. from a millionth to a billionth of a second. Extreme examples are ultra-short pulse lasers that generate light pulses with duration of a few femtoseconds. A femtosecond is one millionth of a billionth of a second! By comparison, light travels in one second about 300000 km, in a nanosecond, only 30 cm, and in one femtosecond tiny 0.0003 mm! These (ultra)short and very intense light pulses are achieved with sophisticated technology and by skillfully utilizing the physical properties of the laser media.

The Method

When short and intense laser pulses are directed onto a sample, a small amount of sample material can be removed by the interaction of laser light and material. This process is known as laser ablation. It creates a so-called "plasma" that contains atoms of the sample material. These atoms emit light of characteristic color (spectral lines). Examples include copper atoms that glow with green to purple color and sodium atoms that glow orange-red. With a spectrometer these spectral lines can be measured and the different atoms in the plasma can be identified. The measured spectrum thus makes it possible to analyze the chemical composition of the sample material. This method is called laser-induced breakdown spectroscopy (LIBS).

Chemical mapping

Researchers at the Institute of Applied Physics at JKU Linz are driving this process to the extreme. They try to determine the spatial distribution of chemical elements in the sample by measuring ever smaller sample volumes with LIBS.

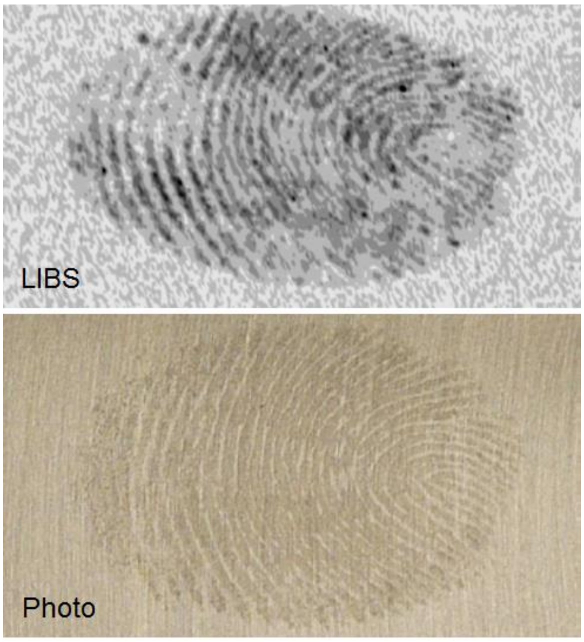

Fig. 1: Chemical image of a fingerprint measured by LIBS (carbon, upper part) and photo of fingerprint for comparison (lower part).

The sample is measured at many points and thus a chemical map with the spatial distribution of various chemical elements is retrieved. For example, a fingerprint on a surface can be reconstructed by measuring the light intensity of carbon atoms in the plasma as the nanosecond laser scans over the surface (Fig. 1).

This imaging technique can be improved further using ultrashort femtosecond lasers. These laser pulses ablate much less sample material than nanosecond laser pulses. Thus, smaller structures of the sample can be measured and chemical maps with higher spatial resolution can be obtained. The Linz researchers have carried out measurements with a spatial resolution of less than 0.01 mm. This enables to determine the distribution of the chemical elements magnesium and barium in a micro-structured sample (Fig. 2), for example.

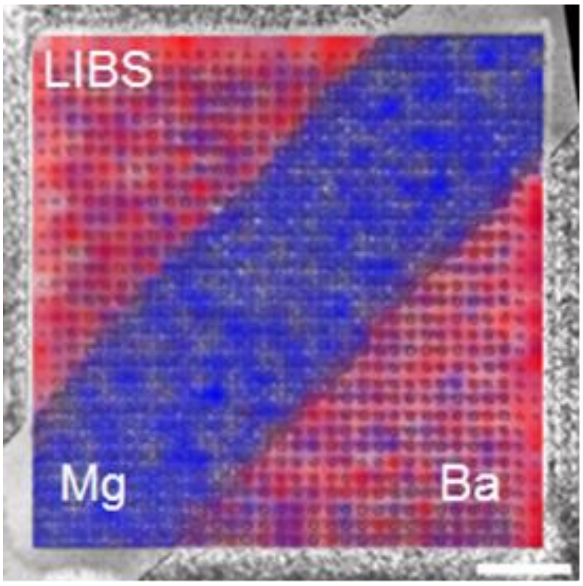

Fig. 2: High-resolution chemical map of a sample (total dimensions only approx. 0.3 x 0.3 mm). In the diagonal region the concentration of magnesium is high (shown in blue), while the lateral regions contain much barium (in red).

The high-resolution chemical imaging technique is a laboratory method at the moment. Since LIBS is widely used today as a non-contact and almost non-destructive analysis method, a process-oriented application of this new LIBS method is to be expected in the near future. Possible applications include elemental analysis and chemical mapping of complex structured materials in metallurgy, geology, biology and many other fields.

Contact and information

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K-Project imPACts

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