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Laser Ablation ICP-MS for Spatially Resolved Element Analysis

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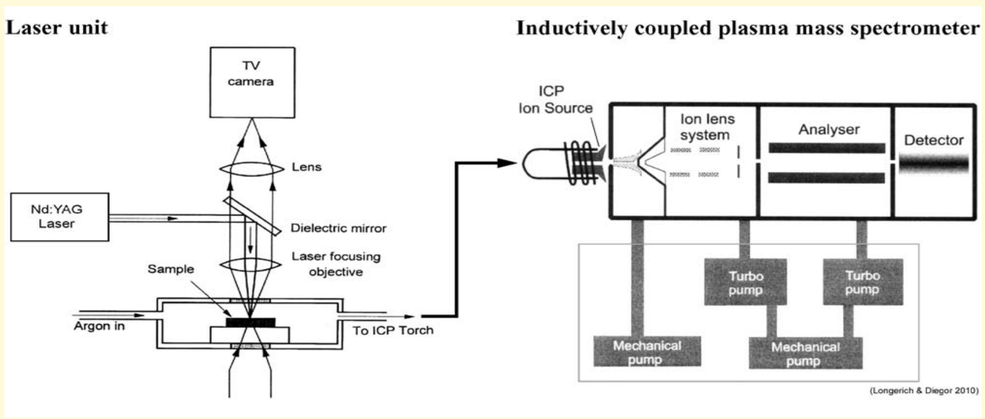
Motivation

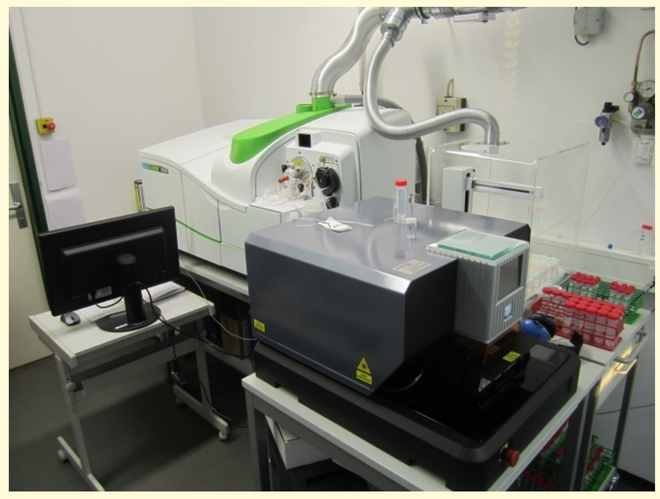
In combustion processes in power plants, the optimization of energy production is obviously of paramount importance. Corrosion effects and combustion residues also affect operating efficiency. The combustion residues mainly consist of silicates and aluminates. Additionally, they contain chlorides, sulfates and various heavy metals, strongly dependent on the coal used and the reaction conditions.

This poster introduces a new analytical method, Laser Ablation Mass Spectrometry with Induced Coupled Plasma Ionisation (LA-ICP-MS) which enables the investigation of such combustion residues. The main advantages of this method are the small amount of specimen material required and a minimal specimen preparation.

In collaboration with the Institute for Energy Systems at the TU München, first measurements have been performed in a project on the gasification of solid fuel.

The Instrument



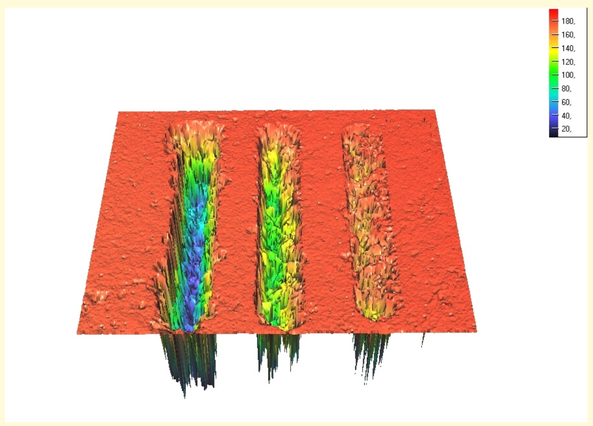


The laser systematically removes material from the specimen surface. If the distribution of particular elements on the surface is of interest, a spatially resolved evaluation is possible. The laser spot can be varied from sizes of 5 up to 300 µm which defines the spatial resolution. The depth of material removal is about 20 µm. The material is transferred to the ICP-MS with helium as a carrier gas. The ICP-MS is a highly sensitive analytical instrument and is able to quantify a broad range of elements.

The specimens can be embedded in an organic matrix and pressed into tablets or, if the solid specimen is on a substrate, it can be analyzed directly. Specimen up to 10 x 10 cm^2 will have enough room in the measuring cell.

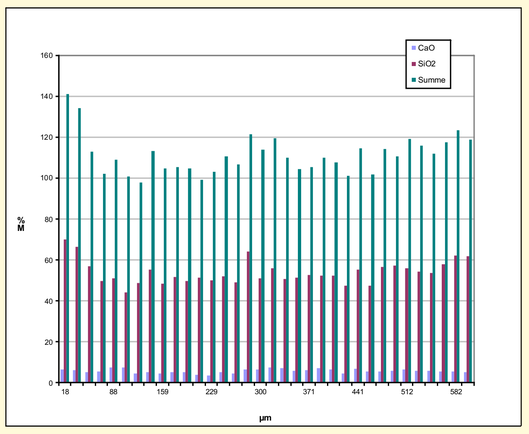
Application example

Example of a multi-sample holder for the ablation cell. The specimens here are mainly embedded in an organic matrix and pressed into tablets



Surface of a tablet after laser ablation, measured with a laser scanning microscope. The ablation lines were measured with different laser energies to find the optimum ablation depth.

	sample 1	sample 2
Na2O	2,59	2,83
K2O	0,66	3,06
CaO	50,40	5,76
MgO	14,40	2,80
Fe2O3	18,89	11,92
Al2O3	3,26	27,02
SiO2	18,86	53,97
P2O5	0,06	0,25
SO3	0,89	0,36
TiO2	0,67	1,68
BaO	1,43	0,82
SrO	0,64	0,19
MnO	0,38	0,12
Cr2O3	0,02	0,03
V2O5	0,01	0,08
ZnO	0,04	0,04



Results of the analysis of combustion residues from gasification processes (pressed tablet):
left: element content of combustion residues for two different coal deposits.
right: distribution of CaO and SiO_2 of sample 2 along the ablation line

Conclusion

Laser Ablation ICP-MS can be applied to analyse all kinds of specimen The only limitation is the size of the ablation cell. Working with organic matrixes makes it necessary to optimize the laser energy. For each material the appropriate reference has to be used. Apart from H, He, F and Ar it is possible to analyse a broad range of elements at low detection limits.

In this example, the composition of combustion residues were analysed, showing their dependence on the coal deposit used. For the analysis the material was embedded in organic material. The element distribution along the ablation line characterizes the homogeneity of the pressed tablet.

In an other application on the penetration of de-icing agents into concrete[1], the distributions of Cl, Na and K in a concrete sample after storage in a NaCl solution was determined.

Laser Ablation ICP-MS is a powerful method for analysing surfaces. The method combines low detection limits with a high degree of spatial resolution. It may be applied in a broad range of applications in materials science and engineering.

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