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EDITORIAL

# 10th European workshop on laser ablation

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Since the development of lasers 50 years ago, laser ablation, as a sampling technique for direct emission spectroscopy (LIBS) or in combination with inductively coupled plasma atomic emission spectrometry (LA–ICP–AES) or inductively coupled plasma mass spectrometry (LA–ICP–MS), has become a very attractive and efficient sampling technique for direct analysis of solids. The combination with ICP–MS, first introduced by Gray in 1985, has, especially, attracted much attention in the past 25 years and much progress has been reported. The direct and high-spatial-resolution analysis of major, minor, and trace elements and isotope-ratio determinations make the technique widespread and applicable to a wide variety of fields of research.

The driving force of LA–ICP–MS has been geochemistry, which remains one of the major fields of application of this technique. However, the technique is gaining more attention in material science, biology, medical and forensic sciences, and archaeology. This is mostly because a large number of uncertainties during the ablation, transport, and excitation of laser-generated aerosols have been studied and have been substantially reduced, so that quantitative results with very good precision and accuracy can be achieved. This is mainly because of technological progress in laser technology. Today, almost all wavelengths used in LA–ICP–MS are in the low UV region, which enable representative sampling of a large number of materials. The short wavelength of 193 nm introduced in 1995 is well established and very successful in representative sampling of all non-conducting samples. In addition, the use of femtosecond laser ablation, with very short pulses, improved the sampling of conducting samples and substantially increased the field of applications . Most interesting, a number of applications have been reported in which non-matrix matched calibration strategies have been successfully applied. This feature, in particular, which is rather difficult to perform in other direct solid analysis techniques, makes the use of laser ablation very attractive. In conclusion, LA–ICP–MS for in-situ analysis of solids can be placed in the same group of successful analytical techniques as ICP–AES or ICP–MS for liquid sample introduction.

From the beginning of LA–ICP work, research was directed in two major directions: fundamental and applied studies. The fundamental research focused on the ablation process itself—the interaction of laser light and matter. Progress was made with regard to understanding the energy transfer, plasma generation, formation of particles (laser aerosol) from this plasma, and their transport phenomena. After the initial use of IR lasers low-UV became the spectral range of choice. A gradual reduction of wavelength from 1064 nm, via 266 nm and 213 nm, towards 193 nm improved the performance of LA units substantially. This is because of reduction of thermal effects at the site of ablation, making generation of the aerosol more tolerant of the actual sample composition. Applied studies contribute to a deeper understanding of geochemistry, material and biomedical sciences, and take advantage of the direct analysis of samples at micrometer spatial resolution. More

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and more specialized methods have been developed, emphasizing the flexibility of laser ablation. Some of these methods have been optimized for precise simultaneous analysis of several elements down to deep ultra-trace concentrations. Others have attempted to reveal the spatial distribution of chemical constituents or the direct determination of isotope ratios. Large amounts of LA-generated analytical data can now be obtained automatically and routinely, so that new techniques for the visualization of spatially distributed data are emerging.

What are, currently, the major limitations and what do we need to discover/solve next? These questions stimulated very enthusiastic and extremely controversial discussion at the 10th European Workshop on Laser Ablation.

Currently, "hype" on femtosecond (fs) laser ablation has started and many different results have been observed and reported. Is the aerosol stoichiometric, and are particle sizes smaller than those from nanosecond (ns) laser ablation? And are the statements found in the literature generally applicable? As indicated in the literature, aerosol structure and quantitative results for nanosecond and femtosecond LA strongly depend on the matrix of interest and a generally applicable rule cannot currently be given. Most quantitative data show that femtosecond LA leads to reduction of the problems reported in nanosecond LA, but not to complete elimination. Therefore, further detailed and systematic studies must be carried out to bring more light to these phenomena. The problem of suitable aerosol transport systems (ablation cells design, geometries), a hot topic in the literature over the past 10 years and finally thought to be solved, was discussed again. Unfortunately, the many solutions published in the literature are only partially commercially available, or not commercially available. This is difficult to understand, because many nebulizers are available for different matrices in solution nebulization ICP–MS. The same flexibility is required in solid sample analysis. Possibly a few more years are needed to bring the ablation cells, currently ready on paper and in prototype stages, into action.

"Which of the standard materials are most suitable for high spatially resolved analysis and which standards are available for LA–ICP–MS?" are among the standard questions in LA–ICP–MS and are difficult to answer. These questions have been raised since the beginning of LIBS, LA–ICP–AES, and LA–ICP–MS and will possibly remain a hot topic until reference materials certified for microanalysis become available for a wide range of materials. The only reference materials everyone is familiar with are the NIST glasses. However, the glass standards do not satisfy all needs in LA–ICP–MS. Raising these questions and listening to the answers it becomes obvious that the LA–ICP–MS community is very diverse. Whereas geochemists have participated in microanalytical round-robin exercises for some time, other interdisciplinary communities are not so aware of such possibilities. Furthermore, geoscientists are working on different approaches to perform high-temperature and high-pressure experiments, which could also be used to generate reference materials with very flexible composition.

These details were discussed within "a broader audience" and, therefore, it was great to meet in Kiel at the 10th European Workshop on Laser Ablation. The "European" has less and less meaning in the title of the meeting, because LA–ICP–MS is an internationally applied technique. All news and progress of the different laser-based techniques are of "global interest" which was apparent from the number of delegates—more than 100 from 15 countries throughout the world.

This special issue provides a selection of papers presented at the 10th European Workshop on Laser Ablation (EWLA) held in Kiel, Germany, in the summer of 2010. This workshop series was started by a first meeting organized at the BGS in Keyworth, UK, in 1994. While focusing on the more fundamental questions of laser ablation's analytical use in its early years, applied studies dominated the program of EWLA today. Furthermore, the workshop enables users and manufacturers, newcomers, and experts to exchange ideas on laser ablation. The next workshop is going to be held in Gijón, Spain, in the summer of 2012, and we are convinced that further progress will be reported. The focus might change toward different laser optics and excitation sources, because the ablation process itself—not fully understood—will not be the major process contributing to progress in LA. Innovative optics and excitation sources need further attention to finally access nanoscale-resolution with detection capabilities for trace elements. First approaches have been demonstrated for major elements and we look forward to hearing more about such topics in Gijon (Spain) in 2012.

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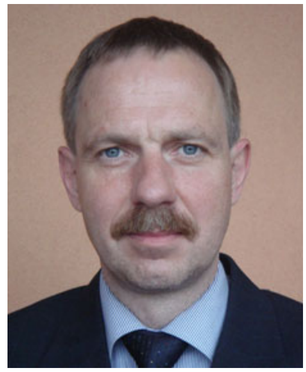
**Jan Fietzke** received his PhD in physics from Heidelberg University in 2000. Working as a laboratory manager at IFM-GEOMAR, Kiel, Germany, his research focuses on the application of LA–ICP–MS in studies of non-traditional stable isotopes in biogenic carbonates.



**Detlef Günther** is full professor for Trace Element and Micro Analysis in the Laboratory of Inorganic Chemistry at ETH Zurich and currently Chair of the Department for Chemistry and Applied Biosciences. His research program focuses on fundamental and applied studies in inductively coupled plasma–mass spectrometry (ICP–MS) and laser ablation–inductively coupled plasma–mass spectrometry (LA–ICP–MS), which includes studies on laser-sample interaction, aerosol transport, and plasma-related excitation processes. The fundamental understanding of UV-ns and UV-fs laser ablation in combination with Q–ICP–MS, SF–ICP–MS, ICP–TOFMS and more recently MC–ICP–MS and alternative excitation sources has been demonstrated in a wide variety of applications, e.g. analysis of fluid inclusions, gemstones, metals, minerals, ceramics, and other industrial materials.