Optical Techniques for Security Technology . . .

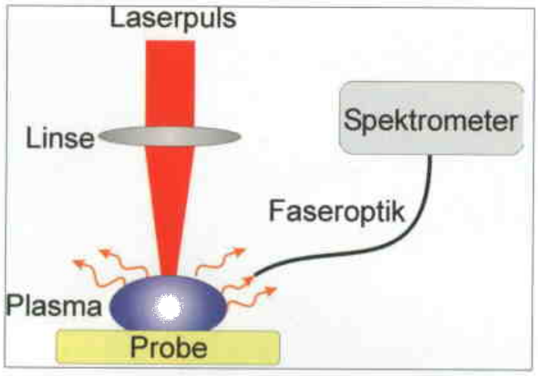

Illustration 1:
The principle of laser-induced breakdown spectroscopy (LIBS): a highly energetic laser pulse generates a plasma plume, whose emission is characteristic for the sample examined.

Illustration 2:
LIBS makes it possible to detect even a sub-surface anti-personnel mine (exposed here).

An emergency call was received on 27 April 2002: at the fire house in Clausthal-Zellerfeld. A suspicious substance had leaked from a package in the post office. Fire fighters cordoned off a perimeter around the entire area; wearing protective suits, they approached and took a sample of the substance. Later on, exhaustive laboratory tests would be performed on the sample. Decontamination efforts were undertaken since a biological or chemical endangerment could not initially be ruled out, and two individuals were taken to the hospital for examination as a precautionary measure.

Such scenarios, which were also frequent occurrences in Germany above all in the wake of the anthrax letters in the United States in 2001, clearly show that, alongside highly precise methods of laboratory analysis, fast analysis methods are needed so that tactical decisions can be made on site by operational units. However, fast-working on-site detectors are required not only for hazardous biological and chemical substances and warfare agents, but also in the area of explosive materials. The development of a combination device addressing so-called BCE (biological, chemical, explosive) hazards overall would be ideal. This presupposes that the used analytical procedure can be applied across the board to detect a wide variety of different substances. Here the methods of optical technologies will offer promising solutions in the near future.

Modern laser technology methods have now become tools of everyday life in many areas. They help transmit data, process materials, calculate distances and perform many other tasks. Specially adapted laser beam sources permit the analysis of chemical substances. As early as the mid 19th century, Fraunhofer, Bunsen, and others discovered that the chemical composition of samples could be identified by using the spectral analysis of light. Further development of these technologies has yielded today's laser spectroscopy, which allows extremely precise qualitative and quantitative measurements. Laser spectroscopic methods are increasingly being employed in a wide array of roles such as environmental diagnostics or industrial process control where rapid (online) analysis is crucial without the need to take (in situ) samples in advance. It was an obvious conclusion that these methods could also be applied in the area of security technology. A number of scientific working groups are now carrying out basic research in this field. In translating the very promising laboratory results into equipment for practical use, particular attention must be focused on the development of compact and stable hardware, above all laser sensors. Another decisive aspect is fully automatic data analysis. While a „nice" spectrum is enough to satisfy the laboratory scientist, first responders in emergency teams are in urgent need of unequivocal verdicts such as „suspicion of TNT."

An example of such a development is the „Laser Mine Detection Prodder" project that was developed by a consortium comprising the Technical University Clausthal (AG Prof. Schade), the Bundeswehr Research Institute for Materials, Explosives, Fuels, and Lubricants (WIWEB), and SECOPTA GmbH. The technology employed is the so-called „Laser Induced Breakdown Spectroscopy (LIBS)." A fiber coupled laser source is used to generate plasma as hot as several 10,000°C on the surface of the sample to be examined. Since the laser's pulse duration amounts to only a few nanoseconds, nearly no energy is transmitted to the sample, thus ruling out combustion or the trigger ing of an explosive substance. The plasma emission is analyzed in a spectrometer to identify the emission lines of individual atoms. The data are evaluated with the aid of self-organized neural networks developed by the CUTEC Institute at the Technical University Clausthal (Prof. Reuter). For the purposes of mine detection, the fiber coupled LIBS sensor is integrated in a conventional mine detection prodder allowing measurements to be taken of unknown objects hidden in the soil. Field tests carried out in 2006 and 2007 demonstrated the capabilities of the sys tem to function and in November 2007 it was awarded the German defense industry's technology prize.

Further development efforts are now being undertaken, also with an eye to other operational scenarios, above all the detection of even the slightest biological, chemical, and explosive contamination on surfaces. On the sidelines of this year's technical meeting in Hanover on „clearing explosive ordnance" there were discussions on the extent to which optical technologies might also be used to detect explosive ordnance. It was recognized, in particular, that little is known about the contamination of the surface by explosive substances. Light is to be shed on this area in the future by studying real scenarios and identifying the direction for further technological progress. ■