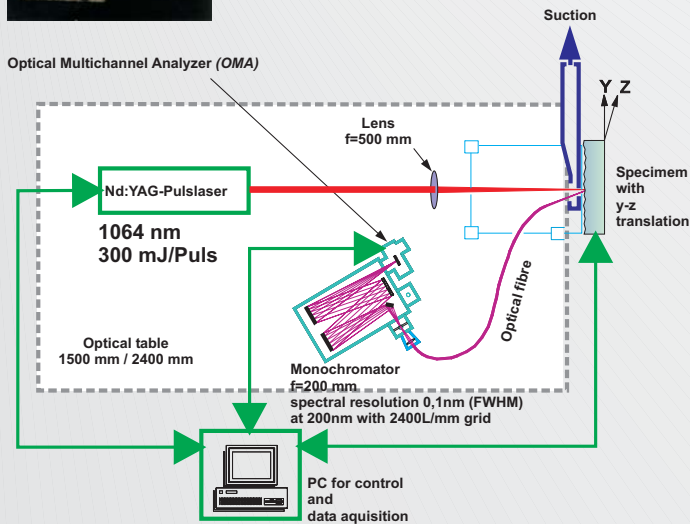




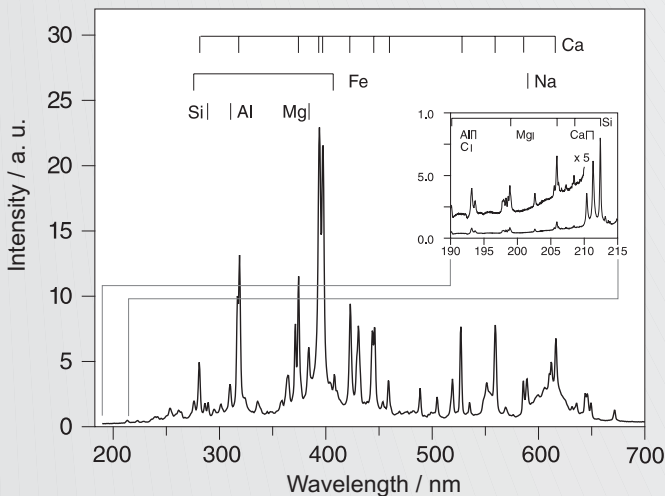
The characterization of building materials using LIBS (Laser Induced Breakdown Spectroscopy) is based on the determination of the elements in the material. Concrete analysis is visualized plotting the LIBS results in a Rankin diagram. Depending on how much cement and aggregate is measured with each laser pulse, a scan on the surface of a concrete specimen produces a distinct distribution of points in the Rankin diagram for the concrete under investigation.



## Experimental Setup

The LIBS equipment used at BAM is shown on the left. The radiation of a pulsed NdYAG-laser ( $\lambda = 1064 \text{ nm}$ , pulse energy 300 mJ, pulse width 10 ns, repetition frequency  $< 20 \text{ Hz}$ ) is focused on the target surface by means of a quartz-lens. A very high energy density ( $> 2 \text{ GW/cm}^2$ ) is thus produced at the focal point, leading to plasma generation (evaporated mass  $10^{-8} \text{ kg/pulse}$ ). The light of the plasma is collected by a fiber-optic and guided to the entrance slit of the spectrometer and at the exit slit detected by an optical-multi-channel analyzer (OMA). The data is collected in a time window with variable width and delay.

During the measurements the target can be moved in the plane perpendicular to the optical axis formed by the laser beam. Thus points along arbitrarily oriented lines on the surface can be measured.

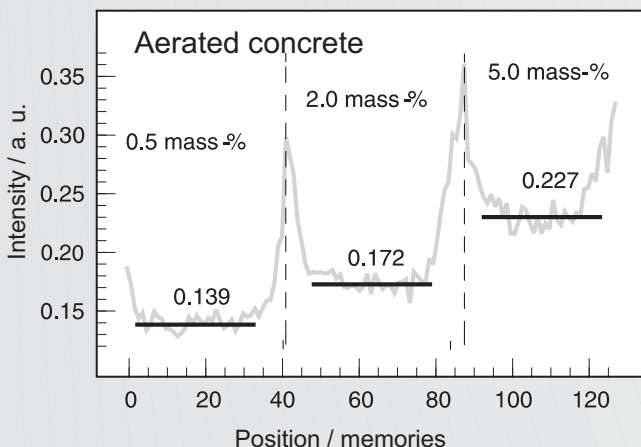


## Typical Spectrum of Concrete

Building materials such as cement, gravel, sand, concrete, mortar, natural stones or bricks are composed of various chemical elements which can be used to identify the material but also complicate the spectra by the overlap of many spectral lines of the elements.

A typical spectrum measured on concrete is shown here on the left. Due to the low spectral resolution ( $\lambda_{FWHM} = 2.4 \text{ nm}$ ), only the dominant lines of some elements are resolved as indicated by the arrows (Ca, Si, Fe, Mg, Al, Na). For a detailed analysis, spectra with higher resolution ( $\lambda_{FWHM} = 0.12 \text{ nm}$ ) are measured in a spectral region, where the elements under investigation emit radiation (see insert). The recorded spectra are analyzed by fitting the line profiles of the elements of interest. The area under these fitted lines is taken as a measure for the relative intensity of the element.

## Experimental Results



### Salt Measurements

LIBS can measure solids with high geometrical resolution and the results are readily available. As an example the result of measuring the salt content in aerated concrete is shown in the left diagram.

The samples were stored in solutions with different salt (NaCl) concentrations and re-dried. Then they were broken and line-scans across the surface were made (length 115 mm with a point resolution of 0.9 mm). Each point was averaged over five lasershots. The scans were done across three specimens positioned side by side.

Due to the spectroscopic properties of sodium, the well-known Na-doublet at 589 nm cannot be used for LIBS analysis and therefore the lines at 818.3 nm (Na I) and 819.4 nm (Na I) must be utilized. The line shows the relative signal intensity of the Na spectral line along the measurement position. Additionally, the average value over the center position of the corresponding specimen is shown.