Summary

Laser-induced breakdown spectroscopy (LIBS) is an emerging method for material analysis. A high-energy short laser pulse is focused on the sample, a small portion of which evaporates, and is converted to plasma. The elemental composition of the sample can be determined by the optical emission spectrum of the plasma. This method has many advantages, gives an almost immediate result, can detect all elements, needs minimal or no sample preparation, etc. therefore it is optimal for industrial and in situ field applications. Further advantage of LIBS, that it can be combined with other laser-based techniques such as Raman spectroscopy, laser cleaning and material processing. LIBS is capable of both quantitative and qualitative analysis.

The scope of my work was to study the feasibility of laser ablation and LIBS technique on silicate glass samples for material analysis and leaser cleaning. The reason for focusing on silicate glass was its great economic importance and that it is less studied in LIBS literature.

My research goals were the investigation of laser-induced damage during LIBS analysis and laser cleaning in connection with it, the analysis Lithium content in glass, and to carry out the laser-cleaning of a discolored silica optical window of a Rubidium-vapor cell.

Well-known shortcoming of LIBS, that some damage to the sample is inevitable during the analysis, but its extension can be decreased by appropriate measurement settings. My first goal was therefore the study and optimization of laser induced damage. Commercial window glass samples were used in the experiments, the laser beam was focused in front of the sample, directly onto the sample surface and into the bulk of the sample, furthermore the effect of laser wavelength was considered. Minimal damage to the sample was obtained by focusing 532nm laser beam in front of the sample. With these settings, no damage beyond the ablation crater was observed, not even after 100 consecutive shots.

Second objective was the analysis of Lithium content in glass. It is a relevant industrial problem: Lithium is widely used in glass manufacturing as an additive, but the measurement of its actual concentration is challenging. Here a univariate regression analysis was carried out based on 670.8nm spectral line of Lithium. The measurement was calibrated with a “home-made” sample set, and the limit of detection together with the accuracy of the quantitative analysis was determined.

The third goal of my research was to remove a layer of unknown origin from the internal surface of the optical window of a Rubidium vapor cell used in homogenous plasma experiments. The cell had been used in experiments for real-time diagnosis of Rubidium plasmas, where it was replaced due to discoloration of an optical window. Main difficulty was, that the cell could not be opened.

I realized that the layer could be ablated by focusing the laser beam through the intact (not discolored) window and gradually increasing its energy. Using my experiences with crater formation on glass samples I focused the laser beam in front of the target surface. As a result, the cleaning was achieved by the divergent beam decreasing heat stress of the material of the window. By this method, the layer was ablated without opening the cell or damaging the window.

The removal of the layer was verified by optical microscope and subsequent Raman spectroscopy analysis. Thorough investigation of the layer by Raman spectroscopy revealed that its material was Rubidium-silicate.