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P4.3007 Picosecond laser-induced ablation techniques for depth-resolved quantitative analysis of plasma-facing components

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Monitoring the fuel content in plasma-facing components is essential to get a detailed understanding of the plasma-wall interaction. Laser-induced material analysis is frequently used in fusion devices [1, 2], but there is a lack of diagnostics which can provide depth resolved and quantitative information when no reference sample can be manufactured. We present a post mortem analysis using laser-induced breakdown spectroscopy (LIBS) combined with quantitative residual gas analysis (RGA) after picosecond laser ablation for this challenge.
Using a laser spot diameter of 700 μm on the sample and an intensity of ~150 GW/cm^2, typical material ablation rates are ~100 nm per laser pulse for graphite and ~30 nm per pulse for tungsten. With short pulse durations of the laser (τ= 35 ps) and a wavelength of λ= 355 nm, the ablation rates are in the same order of magnitude as heat and optical penetration depth of the laser. Thus, sequential ablation steps offer a depth-resolved analysis of the material composition using picosecond laser-induced breakdown spectroscopy (ps-LIBS). Volatile components are detected by a calibrated quadrupole mass spectrometer, providing quantitative concentrations without the need for reference samples. The simultaneously operated techniques are applied for post mortem analysis of plasma-wall interaction processes like erosion, deposition and fuel retention of Wendelstein 7-X graphite tiles [3]. In this work we focus on the application for retention measurements of deuterium in tungsten as preparation of a potential in situ application in fusion devices. Particle densities as low as 1x10^20 deuterium atoms per cm^3 could be quantified.

References
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