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Quartz Crystal Microbalances (QMBs) for Quantitative Picosecond Laser-Material-Interaction Investigations – Part I: Technical considerations

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Abstract

In this work the technical suitability of Quartz Crystal Microbalances (QMBs) for in situ, pulse resolved mass removal measurements is demonstrated for picosecond laser ablation of magnetron sputtered coatings. The QMBs show a linear characteristic of the sensitivity for layer thickness of different metals up to several microns. Laser pulse resolved measurements of the mass ablated from the metal layer were performed. About 400 ng of chromium was ablated during the first laser pulse while in subsequent pulses less than 220 ng were removed. This is compared with previous findings. The sensitivity for ablation of the QMBs is found to be larger than for deposition, which is explained by the radial sensitivity of the QMBs. Future refinements of the setup and the benefits of the pulse resolved mass loss measurements for laser based methods like LIBS and LIAS are discussed and will be presented in part II currently in preparation.

1. Introduction

Laser based material diagnostic techniques like Laser Induced Breakdown Spectroscopy (LIBS, [1-4]) and, more specifically in the context of nuclear fusion application, Laser Induced Ablation Spectroscopy (LIAS, [5] and references therein) relies on the laser ablation process. Subsequent excitation of the ablated atoms leads to line emission which is observed spectroscopically.

In case of nuclear fusion research there is an urgent need to quantify the number of released atoms solely based on spectroscopic observation [6-8]. Interpretation of observed spectra is complicated by the fact that the surfaces of Plasma Facing Components (PFCs) in nuclear fusion experiments are strongly modified during operation, thus showing changes in their material composition over time and inhomogeneity both in lateral direction and in depth. Additionally, layers formed on top of the PFC surfaces are of high relevance for plasma wall interaction studies but have material properties dependent on the plasma processes.

We note that this challenge is not only relevant to the field of nuclear fusion but appears in different forms in different topics ranging from archaeology [9] to astrophysics [10].