LASER INDUCED BREAKDOWN SPECTROSCOPY STUDIES OF FUEL RETENTION ON ITER-RELEVANT WALL MATERIALS

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Laser-induced breakdown spectroscopy (LIBS) has been actively developed within the European fusion programme to be used as a diagnostics tool for monitoring retention of plasma fuel on the wall structures of the ITER fusion reactor. The main advantage of LIBS is that it can be applied without removing components from the reactor for surface analyses. To this end, the target components are ablated using high-power laser pulses and the elemental composition of the layers on them is spectroscopically determined.

The Finnish research units VTT and Aalto University have, together with Estonian and Slovakian collaborators, designed and constructed a laboratory-scale LIBS system that can be used for studying fuel retention in ITER-relevant materials, mainly beryllium (Be) and tungsten (W) and different mixed compounds of the two elements. Since 2013, the focus of the LIBS research has been on reliable recording of depth profiles and relative concentrations of hydrogen (H), deuterium (D), and helium (He) – the main constituents of the plasma fuel – on test coatings simulating deposited layers and surfaces facing the plasma in ITER.

Here, we report our LIBS results on the comparison of fuel retention in different Be- and W-containing layers. In addition, the differences in the retention properties of Be and aluminium (Al), a commonly used non-toxic proxy for Be, are discussed. As samples, we have used mixed Be:W (67:33) and Al:W(67:33) as well as pure W coatings (thickness ~1.5-2 μm) with and without D in the film matrix. Also, W coatings loaded with He have been analysed. The LIBS measurements have been done using a Nd:YAG laser operating at 1064 nm and producing 5-ns laser pulses at fluences ~4-5 J/cm^2.

The LIBS results indicate much higher retention, by a factor of 10, in Be than in Al and the retention is further decreased by a factor of 2 for W. One should, however, note that the W and Al samples were much softer (easier to penetrate with laser pulses) than the Be films, an issue potentially related to the manufacturing process of the coatings. Another possibility is the special chemistry of beryllium compared to the other materials. Also porosity may play a role: ion-beam analyses of different types of W coatings show that the retention becomes larger as the porosity of the samples increases or as more nanoscale crystallites are being formed. Finally, preliminary results suggest the retention of helium being more than 10 times higher than that of deuterium in W samples, in terms of the relative elemental composition of the analyzed layers. The significance of this finding will be discussed after detailed analyses.