Deuterium Analysis in Zircalloy Using ps Laser-Induced Low Pressure Plasma

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Abstract

An experimental study on picosecond laser induced plasma spectroscopy of a zircaloy sample with low-pressure surrounding helium gas has been carried out to demonstrate its potential applicability to three-dimensional quantitative micro-analysis of deuterium impurities in zircaloy. This was achieved by adopting the optimal experimental condition ascertained in this study, which is specified as 7 mJ laser energy, 1.3 kPa helium pressure, and 50 μs measurement window, and which was found to result in consistent D emission enhancement. Employing these operational parameters, a linear calibration line exhibiting a zero intercept was obtained from zircaloy-4 samples doped with various concentrations of D impurity, regarded as surrogates for H impurity. An additional measurement also yielded a detection limit of about 10 μg/g for D impurity, well below the acceptable threshold of damaging H concentration in zircaloy. Each of these measurements was found to produce a crater size of only 25 μm in diameter, promising its application for performing less-destructive measurements. The result of this study has thus paved the way for conducting a further experiment with hydrogen-doped zircaloy samples and the further technical development of a three-dimensional quantitative micro-analysis of detrimental hydrogen impurity in zircaloy vessels used in nuclear power plants.