OPTICAL (REMOTE) SENSING FOR NUCLEAR SECURITY AND RADIATIONAL SAFETY

OBJECTIVE: Tritium is produced in large quantities in nuclear reactors, nuclear tests, and is a vital component of several modern nuclear weapon designs. Tritium can be detected using low-energy charged particle radiation detectors. However, the feasibility of this method is limited; the mean free path of beta particles produced in tritium decay is on the order of several mm in air. Therefore, practical detection of tritium poses a challenge not only because of the low rate of characteristic beta particle emission, but also because no highly penetrating ionizing radiation (β-ray) is emitted in tritium decay. Laser-induced breakdown spectroscopy (LIBS) technique may overcome this limitation of detection range and the relatively low signal intensity associated with the traditional radiation detection method.

METHODS: An Nd:YAG laser 10 ns, 10 Hz rep. rate, at 1064 nm was used. The single-pulse (SP) ablation experiments using 75 ml pulses, whereas DP experiments used 55 ml and 75 ml for the first and second pulse, respectively. Interpulse (IP) delay in the DP configuration was varied between short (50 ns) and long (1000 ns). The samples were prepared by mixing deuterated water (D2O) with deionized water. The atomic fraction of deuterium in the mixture was set to 40%. The frozen mixture was mounted on a 40 x 40 mm2 Petlar cooler to ensure the longevity of the 3 mm thick samples. The collection fiber bundle was coupled to the 50-μm slit of a Cary-815 spectrometer with a 0.5-mm-focal length and a resolving power greater than 10⁴. The detector was an intensified charge-coupled device matrix detector (CCD) cooled down to -25°C. Plasma imaging (1-1) was performed by using a 50-mm-diameter achromatic lens.

REFERENCES:

This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534.