

## §92. Evaluation of Tritium Doping using Ultraviolet Irradiation for Laser Fusion Target

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The goal of the Fast Ignition Realization Experiment (FIREX) project is to scale the coupling efficiency of the core heating. Measuring the ion temperature leads to neutron diagnostics. Because the cross-sections of D-D and D-T reaction have different temperature dependence, the ion temperature can be estimated from the yield ratio of the D-D neutrons with 2.45-MeV energy and the D-T neutrons with 14-MeV energy. A deuterated-polystyrene (CD-polystyrene) shell target doped with ~ 1 % tritium (D:T = 99:1) is used to implement this neutron diagnostic measurements. Polystyrene shell targets are fabricated by the water-in-oil-in-water (W/O/W) emulsion method at the Institute of Laser Engineering. Doping tritium before target shell fabrication offers an advantage on the doping ratio accuracy; however, this doping preparation leads to a high tritium consumption (several TBq at an instant) and requires management of radioactive compounds such as water and its solvents. In order to circumvent these problems, the Wilzbach (gas-exposure) method is adopted for tritium doping. This method also enables doping without varying the shape of polystyrene shell targets. In this regard, we present the results of tritium doping enhancement by UV light and hydrogen plasma irradiations of polystyrene film. Polystyrene film are irradiated with 266-nm and 355-nm laser and hydrogen plasma during tritium incorporation.

The Wilzbach method was implemented to dope polystyrene film with tritium. For the UV irradiation, the protonated polystyrene (CH-polystyrene) films were then loaded inside a chamber connected to a tritium getter and a vacuum pump. Placed inside a glove box, the chamber was then filled with  $4.8 \times 10^4$  Pa tritium gas which desorbs to the Zr-Ni bed after evacuation. The UV irradiation was derived from the third or fourth harmonics of a Nd:YAG laser. The incident beam has a wavelength of 266 nm ( $4\omega$ ) or 355 nm ( $3\omega$ ), a repetition rate of 10 Hz, and a pulsed duration of 10 ns. Before reaching the chamber, the laser passes through a 2.3-mm aperture for spot-size correction. The polystyrene films were irradiated with 266-nm and 355-nm lasers for 2 hours. Moreover, for the hydrogen plasma irradiation, the polystyrene film was then loaded inside the glow discharge chamber for plasma irradiation. Since the chamber wall was chosen as the cathode, the film was set on a stage serving as the anode. The chamber was eventually evacuated and was filled with 120 Pa of a hydrogen gas mixture (H:D:T = 82:13:5). A direct current voltage of 250 V and a plasma current of 0.06 mA were applied to create a hydrogen glow discharge plasma. The polystyrene film was exposed to the hydrogen plasma for 1 hour. After irradiation, the films were placed on an imaging plate (IP) for 15 minutes. The radioactivity of the films were also determined from the PSL signals calibrated in reference to a tritium standard. Figure 1 shows the PSL images from the imaging plates of the

non-irradiated, UV laser-irradiated, and hydrogen plasma-irradiated polystyrene films. The film irradiated by 266-nm laser show high luminescence intensity at the spot of laser irradiation. In contrast, the part of this film with low intensity is the one ablated during laser beam alignment. Aside from the irradiated spots, other parts of the sample have higher PSL intensities compared to the non-irradiated sample. The film irradiated by 355-nm laser has also intense luminescence at the laser irradiation spot. Compared to all samples, the hydrogen plasma-irradiated film has uniform and intense PSL all over its surface.

Figure 2 shows the specific radioactivity of the different

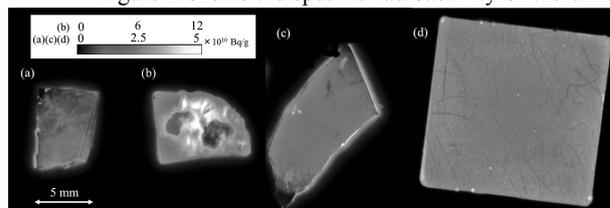


Fig.1 PSL images from imaging plates of (a) non-irradiated, (b) 266-nm-laser-irradiated, (c) 355-nm-laser-irradiated, and (d) hydrogen plasma-irradiated polystyrene targets.

films calibrated in reference to a tritium standard. The 266-nm-laser-irradiated film has 10 times more specific radioactivity than the non-irradiated film. On the other hand, the specific radioactivity of the 355-nm-laser-irradiated polystyrene is only  $2 \times 10^{10}$  Bq/g. This value is smaller compared to that of the 266-nm sample although the irradiation energy of the 355-nm laser (25 mW) is higher than the 266-nm laser (17 mW).

To dope a polystyrene target with 1 % tritium, almost one week (~170 hr) is needed without any irradiation and with the present experimental conditions. With 266-nm and 355-nm laser irradiations, the doping time is greatly reduced to 13 and 73 hours, respectively. For plasma irradiation, the required time for doping is only 36 hours. It should be noted that this plasma irradiation is carried out in 5 % tritium partial pressure. The tritium doping can increase to as much as 20 times when pure tritium is used. For plasma irradiation with pure tritium, the required time for doping is estimated to take only 1.8 hours. With

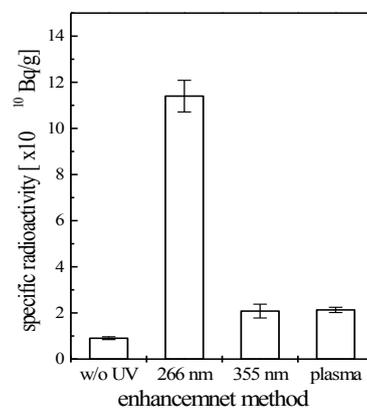


Fig.2 Specific radioactivities of irradiated polystyrene targets calibrated with respect to a tritium

these results, a 1 % tritium-doped target can be fabricated with 266-nm laser and hydrogen plasma irradiations in less than 24 hours. Handling the tritium for a shorter period of time decreases tritium consumption and safety management costs. These enhancement methods are necessary for 500- $\mu$ m diameter polystyrene shells for laser fusion experiments. Nevertheless, these results give helpful insights in enhancing tritium doping of polystyrene targets through 266-nm laser and hydrogen plasma irradiation.