Fabrication of cupper containing deuterated material target for laser plasma diagnostics

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Fast ignition (FI) is an advance concept of Inertial Confinement Fusion to realize Inertial Fusion Energy (IFE) which can optimize fuel implosion and heating processes, respectively to achieve high gain. In FI, the understanding the mechanisms of the energy transfer from fast electrons to the compressed plasma core is critical for efficient fusion fuel heating. In these experiments, characteristic X-rays produced by the laser-accelerated fast electrons are utilized to understand the mechanisms of the electron transport in dense plasma and neutrons generated during the IFE experiment are utilized to investigate the fusion reaction as well as the temperature of the core compressed. Characteristic X-rays and neutrons are measured by using fuel targets containing tracer atoms that generate a specific signal during a fusion reaction in the IFE experiment. The amount of tracer is important to avoid resonant self-absorption of the X-ray. The deuterated ratio of target materials is also essential for efficient fusion reaction. For these purposes, several targets such as high deuterium concentration, metal foams, and low Z materials with transparency had been developed.[1-3] The type of tracer atom contained in the target depends on the purpose of the experiment.

It has been pointed out that experiments involving X-rays and neutrons require different experimental conditions mainly because inorganic materials such as Cu and organic materials with deuterium are generally incompatible with each other. However, the simultaneous achievement of Cu doping, deuterated polymer, mechanical toughness and chemical robustness for the fabrication process is not so simple. The glow discharge polymer (GDP) method was applied for a Cu-doped deuterated target. GDP method polymerize deuterated Copper (II) acetylacetonate radically on a solid sphere by vapor deposition. However, this method has a problem that the complicated shape of the target is difficult to be fabricated, because it requires a base part to deposit the target. Therefore, there is no bead target that contains both Cu and deuterium and no simultaneous measurements involving both characteristic X-rays and neutrons. Here we will introduce an example to satisfy these specifications with chemical and laser plasma characterizations. The target material will open new characterizations of the next fast ignition progress.

Doping inorganic elements into organic compounds is difficult because the interface between an inorganic and an organic substance generally has a poor affinity, and it is also difficult to combine the two substances in the condition with a large interfacial effect such as a dispersion system of fine particles. The concentration of tracer atoms should be adjustable from 1 to10 wt.% depending on the experimental conditions since too much Cu concentration more than 10 wt.% leads to weak Cu-Kα emission due to resonant self-absorption and X-ray measurement will be difficult. In this regard, we report the fabrication of Cu-doped deuterated methyl methacrylate (MMA) and methacrylic acid (MAA) targets (Cu-dMA targets) as a novel target for laser fusion experiments. The Cu-dMA is soluble in the solvents to facilitate processing into various shapes as shown in fig.1.[4] The Cu concentration in the Cu-dMA targets is studied using inductively coupled plasma optical emission spectrometry (ICP-OES). The Cu-dMA targets is characterized by simple dissolution tests, differential scanning calorimetry (DSC), and fourier transform infrared spectroscopy (FTIR). Our results suggest that the Cu-dMA targets can be used as targets to provide valuable insights in the IFE experiments.

References

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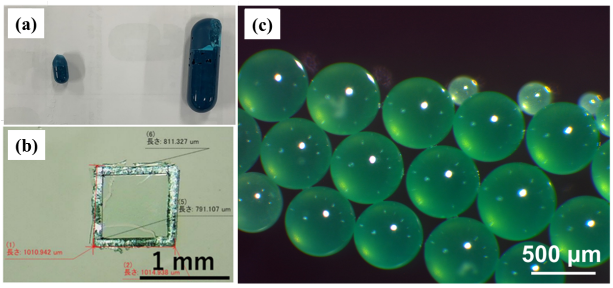

Figure 1. (a) Cu-dMA (left) and Cu-hMA (right) samples taken from the oven and the test tube. (b) Cu-dMA thin film with a thickness of 10 µm cut to a size of 1 mm × 1 mm. (c) photograph of the Cu-hMA spheres fabricated by dropping the Cu-hMA solution into 10wt.% PVA aqueous solution.