Development of Thin Solid HD Target for Polarized Nuclear Laser Fusion Study:I

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Among possible spin alignments in the collision of D and T nuclei, the process for anti-parallel spin combination of T to D is forbidden to form a spin 3/2 compound nucleus ^{5}He*. Therefore, only 2/3 fraction of the DT interactions contributes to the reaction rate in the conventional unpolarized fusion scheme. Instead, if D and T could be polarized in parallel, all interactions will contribute to the reaction rate [1,2]. However, we face to a fundamental question: Does the polarization persist in a fusion process?

In advance to a polarized DT fusion study, polarized DD experiments will be instructive since DD laser fusion experiments are in progress with detecting fusion neutrons in a sufficient intensity [3]. The recent studies on a polarized HD target will be directly applicable to DD fusion experiment based on the technical achievement of the polarized target project in our laboratory [4] with the "brute-force method" for proton polarization at 10 mK in the magnetic field of 17 T and the polarization transfer to deuteron.

Our experimental setup for the thin target development consists of a target cell fixed on a 3 K refrigerator cold head inside of a vacuum chamber, a 150 cc gas cylinder outside of the vacuum chamber, and a gas feed capillary line connecting them with control valves. One of the experimental results with the first version of a thin cell for H_2 solidification is shown in Fig. 1, where the arrows indicate the time sequence starting at the pressure of about 1050 mbar. The pressure decreased just below the triple point of H_2, indicating solidification.

For the next step to the DT fusion experiment, a new polarization scheme was undertaken since the decay beta heating in a DT target induces serious difficulty to cool down to the temperature around 10 mK. We started experimental study with employing ferromagnetic complex of Prussian blue analogue with the high capability of hydrogen adsorption [5] and a high internal magnetic field with a high Curie point beyond 20 K [6]. Table 1 shows the preliminary result with the complex $Ni_3[Fe(CN)_6]_2$ prepared in our laboratory at the Department of Chemistry. The Curie point of the sample was assured with a SQUID measurement. The ultra-high purity HD gas [8] with the impurity components below 10^{-4} showed no detectable purity decrease [8] after the adsorption and recovery processes.

The third step of our target development to prepare a bare solid layer without substrate is now going on applying the direct solidification from gaseous H_2 [9] to grow on a tiny hole of a target plate in a cell.

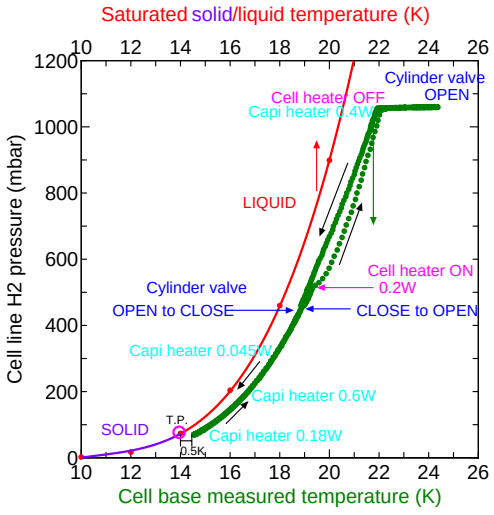

Fig. 1: T-p-plot of H_2 condensation.

HD adsorption and recovery records

Experiment		2013/11/06−07	2014/01/10, 17 & 23	
Degas		11/06 at 60℃	01/10 & 17 at 50℃	
1st	Complex temp.	77K	24K	22K
	HD adsorb (litre) [pressure: bar]	0.0120 [1.558 bar]	0.0172 [1.637 to 0.354 bar]	0.0131 [0.496 bar]
2nd	Complex temp.			47K
	HD adsorb (litre) [pressure: bar]			0.0063 [0.046 bar]
Evaluation (Complex: 0.3g)		0.0018mole/g-Comp =0.36weight% for H_2	0.0026mole/g-Comp =0.51weight% for H_2	0.0020mole/g =0.40weight%

Remark: Volumes of Capillary, Connections, Gauges and Valves tentatively neglected.

Table 1: Experimental results of HD adsorption in ferromagnetic Prussian blue analogue.

References

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