High pressure cold gas target system with large capacity for low-energy beam at RIBF

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The use of low-energy beams (20 to 50 MeV/nucleon) with large atomic numbers ($Z > 40$) in experiments at RIBF has been attracting attention in recent years. We are developing hydrogen and deuterium targets for cross-section measurements at a low beam energy. For the cross-section measurements, the uniformity of the target thickness is very important. Polyethylene and deuterated polyethylene films are often used as hydrogen and deuterium targets since it is easy to produce those targets with good uniformity. However, the carbon nuclei in such polyethylene targets create a background signal in the cross-section measurement. In RIBF, a cryogenic proton and alpha target system (CRYPTA) has been developed and used in experiments with high-energy beams.[1)] Since CRYPTA uses thin harbor foils as the target window, the background from carbon nuclei is lower than in the conventional film targets. However, it is difficult to realize a thin and uniform-thickness target cell with a liquid target system, owing to the bulging of the window. The non-uniformity becomes considerably large especially in a thin target for low-energy beams. The current liquid target system does not satisfy the requirements of the cross-section measurement with low-energy beams. In order to reduce the non-uniformity, a high-pressure cold gas target was employed instead of the liquid target. Since the density of the hydrogen in the gas phase is much lower than that in the liquid phase, we can make the length of the target longer than that of the liquid target with the same substantial thickness. Owing to the high length of the target, the effect of the bulging becomes small and the non-uniformity is reduced. We developed a high-pressure cold gas target system with large capacity by modifying CRYPTA. The stability of this system during a cross-section measurement with a low-energy beam was studied.

There were mainly three improvements made to CRYPTA for the gas target: (1) Total power of the heating system was increased from 10 W to 25 W by adding three heaters. (2) New target cells for a high-pressure gas with large capacity were built. The length of the target cells are 50 mm and 70 mm. A heat shield from radiant heat was attached to the cell with 50-mm length. The heat shield was not attached to the 70 mm cells owing to the geometrical limitation. (3) The target windows were also replaced with new ones with a Harvar foil of 10-μm thickness and 36 mm diameter in oder to endure the high pressure. A thermometer was installed at the target cell and the lowest temperature of the system. The error of the thermometer is 0.01 K. To keep the target thickness constant, we isolated the target cell. We applied feedback to the lowest temperature in the system so that the gas did not transform into the liquid phase. In order for the gas target to be stable, it is required that the changes of target temperature and pressure are small and that the pressure is not more than 5.0×10^5 Pa, at which the target has never been tested.

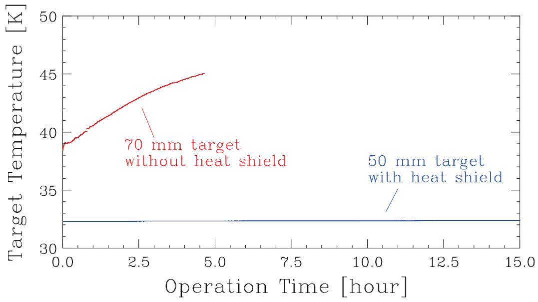

Fig. 1. Correlation with operation time and temperature change during the experiment.

Figure 1 shows the change of temperature at the target cells during the experiment. The temperature of the target cell with 50-mm thickness was stable, while that of the 70-mm cell increased by 1.28 K/h. Because the 70-mm target cell was not covered with the heat shield, molecules floating in a circumference of the chamber were attracted to the surface of the cold cell, which is expected to be a source of heat. The conditions of operation are summarized in Table 1. Because the pressure change becomes 4.3×10^5 Pa or less even in the two weeks of operation, this is very useful for experiments in RIBF. In conclusion, high-pressure and large-capacity cold gas target systems were constructed for cross-section measurement at a low beam energy at RIBF. By using this system with a heat shield, we confirmed its stability.

Reference

1) M. Kurata-Nishimura *et al.*, RIKEN Accel. Prog. Rep. **46**, 165 (2013).

Table 1. Summary of the operation of the new target cells

Gas	Target Length	Temperature	Pressure	Target Thickness	Heat Shield	Operating Time	Rate of Temperature
H_2	70 mm	39.25 K	4.03×10^5 Pa	18.78 mg/cm^2	×	4.4 h	1.28 K/h
H_2	50 mm	32.29 K	4.04×10^5 Pa	17.23 mg/cm^2	○	90.5 h	0.13 K/day
D_2	50 mm	35.99 K	4.01×10^5 Pa	28.63 mg/cm^2	○	60.5 h	−0.01 K/day

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