§14. Microwave Heated Li Ion Source

Iguchi, H.,
Kojima, A. (JAEA),
Kakiuchi, H. (Tsukuba Univ.)

Lithium neutral beams with the current level of 0.1-3 mA have been utilized for plasma diagnostics in various magnetic confinement devices, especially in their edge regions. Recently an intense beam at the current level of 10 mA has been developed at General Atomics (GA) in U.S.A., which extended its diagnostic potential to current profile measurement with high spatial resolution. A porous tungsten disk containing lithium β-eucryptite has been used. The tungsten disk is heated by an electron beam up to the temperature above 1,200 ℃.

Our target is to develop a lithium neutral beam of 10 mA by the use of a 2.45 GHz microwave as a heating power source for the Li-doped tungsten disk. The advantage of using the microwave is its easiness in operation and control as well as high voltage isolation for the ion source power supply. Research processes are divided into two steps. First: Doping lithium β-eucryptite into a porous tungsten disk. Second: Extracting lithium ion beam of 10 mA from the Li-doped porous tungsten disk. A silicon carbide (SiC) is used as a microwave absorber and heat radiator.

Figure 1 shows the schematic arrangement for the experiment. The microwave source is a 2.45 GHz, 1.3 kW/CW magnetron, which is connected to a vacuum chamber via wave-guide components and a vacuum window. Vacuum windows for the upper chamber are also equipped with microwave screens. Two top ports are without microwave screen but are equipped with 200 mm long and 38 mm diameter (cut-off size for 2.45 GHz) extension tube. Microwave power leakage is measured to be less than 0.1 mW/cm^2 at 1 kW operation. Radiation thermometers measure the temperature of the furnace through the two top ports and the bottom port.

A small furnace as shown in Fig. 2 is used, which consists of a thermal insulator made of ceramic fibers and the SiC microwave absorber. A 10 mm diameter hole is drilled at the top and the bottom of the furnace, through which radiation temperature is measured. A 30 mm diameter and 3 mm thickness porous tungsten disk with 70 % dense has been heated as a test piece. In a typical heating scenario, microwave power was increased at the rate of roughly 0.2 kW every 10 minutes. Reflected power was minimized by the use of the 3-stub tuner and was suppressed to less than 0.1 kW. Temporal variation of the net input power and the temperature of the tungsten disk are shown in Fig. 3. The tungsten disk temperature reached above 1.400℃ in 50 minutes. After keeping the disk temperature above 1.400℃ for about 15 minutes, the microwave power was gradually decreased and was shut down at 110 minutes after the starting time. It has been demonstrated that this small furnace can be used to dope the lithium β-eucryptite into a porous tungsten disk. However, the vacuum pressure is not good for use in a real ion source. An insulator material has to be selected to keep the vacuum pressure low at high temperature operation.

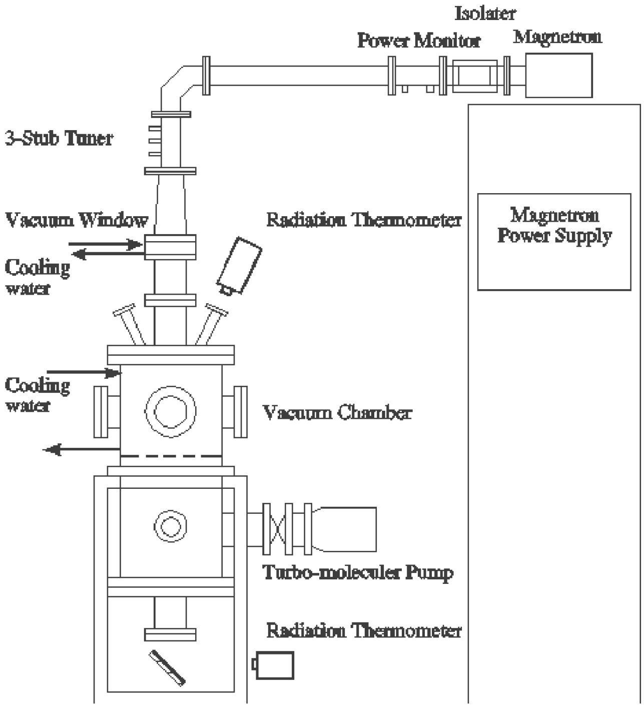

Fig. 1. Schematic arrangement of the 2.45 GHz vacuum microwave furnace for lithium ion source production.

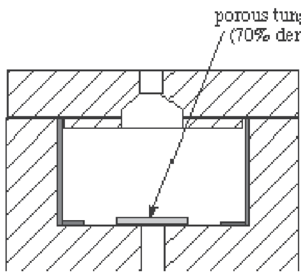

Fig. 2. Cut view of the microwave furnace. Inside wall is coated by SiC fine particles as microwave absorber.

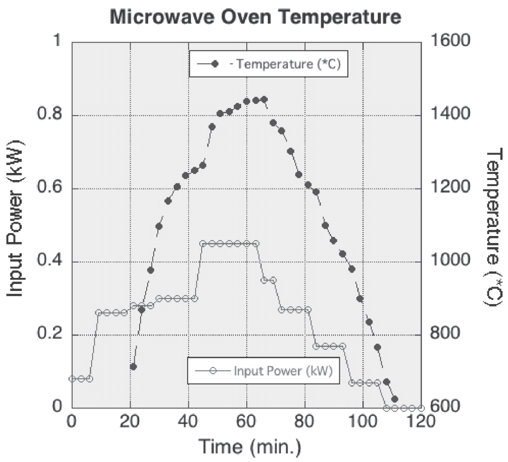

Fig. 3. Temporal variation of microwave input power and surface temperature of the porous tungsten disk in a typical heating scenario.