Status of ECR2: Development of aluminum beam using the ECR2 high-temperature oven and reduction of the reflected microwave power with a new copper back plate

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The ECR2 development work this year was mainly concerned with the production of a high-intensity aluminum beam for use in experiments at the Cyclotron Institute, and also the development of a new copper microwave plate to reduce the reflected power measured from the 14.5 GHz klystron.

The development of the high-temperature oven for axial mounting on ECR2 described in the last two progress reports continued [1,2]. Last year, it was found that liquid aluminum was migrating from the tantalum crucible onto the oven heat shields and onto the wall of the plasma chamber. This was happening because aluminum, unlike titanium and other metals, has a lower melting temperature (660° C) than its temperature (820° C) for a sufficient vapor pressure for the ion source. Several ideas were tried to prevent the heated, liquid aluminum from leaking out of the crucible. These ideas included covering the aluminum source material with a tungsten mesh, different tantalum crucible designs, and the use of different ECR source support gases such as “air” instead of the usual pure oxygen. The most effective of these ideas was to seal the ends of the tantalum crucible as tightly as possible. This prevented the aluminum liquid from leaking out of the ends of the crucible when it was heated, although, some liquid still escaped through the exit hole. With this improvement, it was possible to extract observable amounts of aluminum from ECR2 with high temp oven powers as low as 83.3 W (0.920 V, 90.6 A on power supply), whereas previously more than 100 W was needed.

During typical operation, the aluminum load lasted about four days. An ECR source scan showing the aluminum-charge states just after an increase in the oven power is shown in Fig. 1. Typical

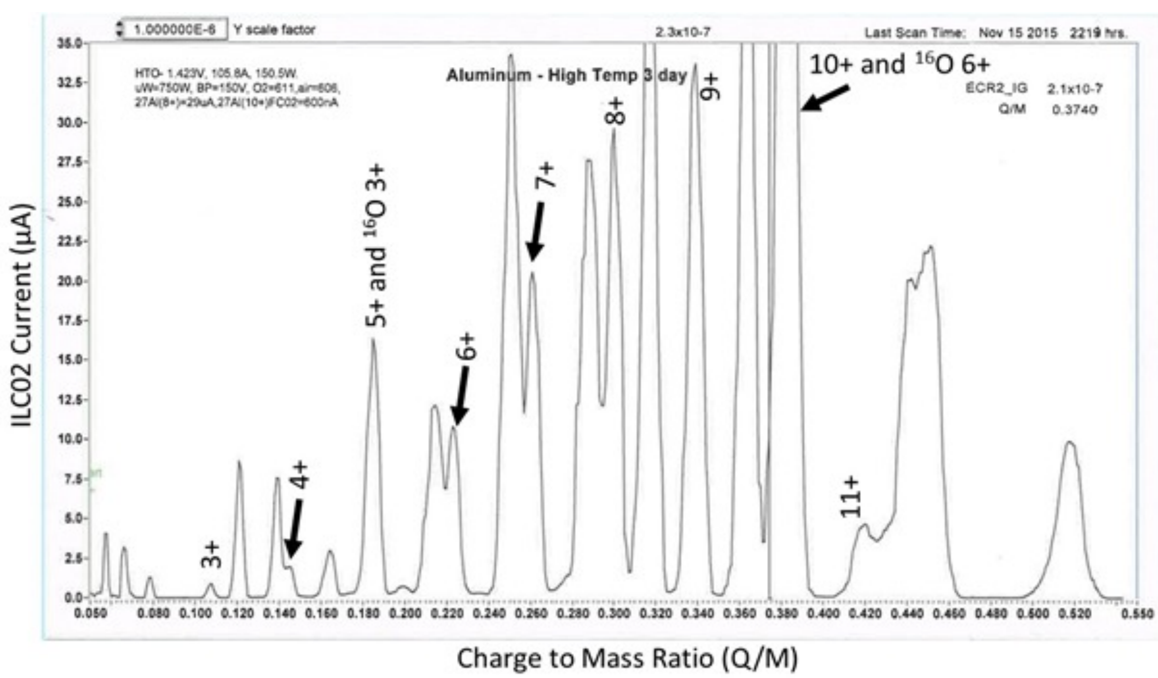

FIG. 1. Scan showing the Aluminum spectrum obtained from the High Temperature oven with ECR2. Aluminum charge states are labeled. This scan was taken when the 10+ charge state was optimized.

source outputs from ECR2 were 20 μA for $^{27}Al^{7+}$ and 29 μA for $^{27}Al^{8+}$. To maintain the beam output, the power on the heater of the high temp oven needed to be increased 10 W - 20 W every 12 hours. Leaking some "air" into the source in addition to pure oxygen as the support gas helped to stabilize the beam output, although, over time, only a power increase on the oven would restore the beam. It was possible to restore the aluminum beam output with an oven power increase up to 170 W. Above that amount of power, it was observed that the aluminum source material had been depleted.

Also this year, it was observed that there was a large amount of reflected power from the 14.5 GHz Klystron when the dual-frequency back plate, made of stainless steel, is mounted to the back of ECR2. More than 20% reflected microwave power was measured. This large amount of reflected power contributed to the instability of the ion source output and limited the amount of forward microwave power that could be used to produce high-charged ion beams. However, it was noticed that while the high temp oven back plate, made of copper, was mounted, the reflected power was much reduced. In light of this observation, a new dual-frequency back plate made of copper has been constructed. Initial testing has shown that the reflected power from the 14.5 GHz klystron has been reduced to about 6% of the total forward microwave power. This allows the klystron to operate with forward microwave power up to 1.5 kW while maintaining the ion source stability.

A comparison of the reflected microwave power measured from the 14.5 GHz klystron between the stainless steel dual-frequency back plate, the copper high-temp oven back plate, and the new copper dual-frequency back plate is shown in Fig. 2.

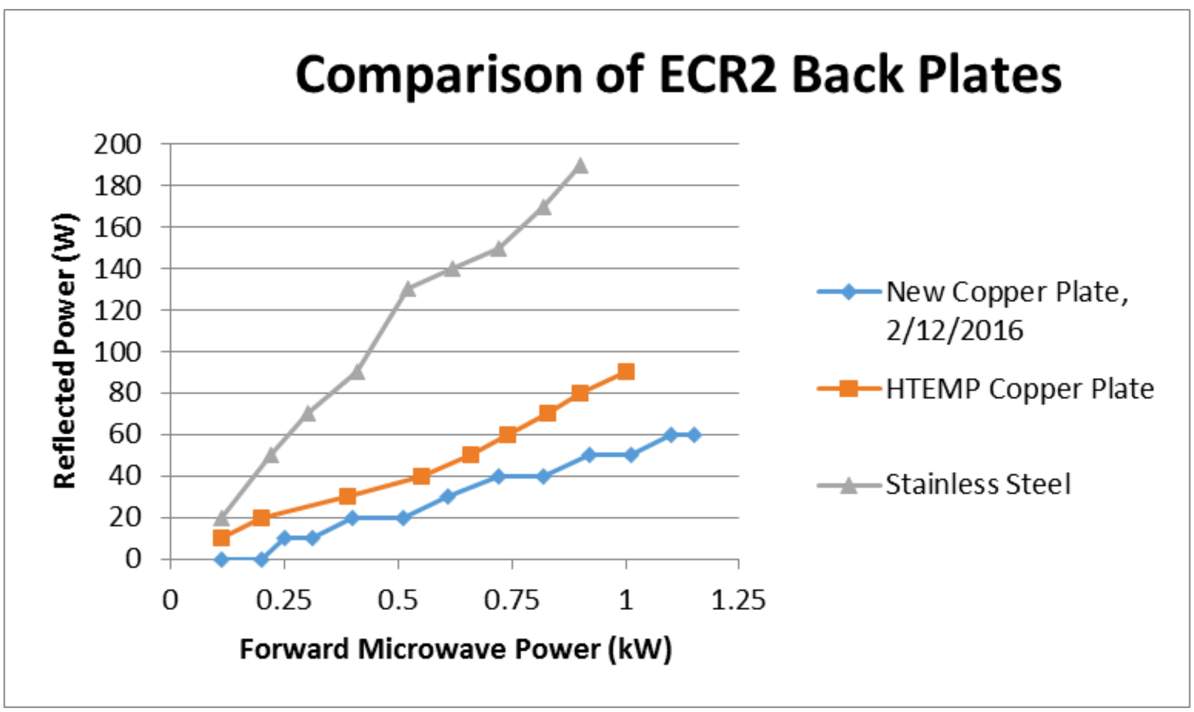

FIG. 2. Plot showing the increase in reflected microwave power for the 14.5 GHz Klystron for different back plates. The reflected power was much lower for when the new copper back plate was used.

[1] H. Peeler *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2014-2015), p. IV-7; http://cyclotron.tamu.edu/2015 Progress Report/index.html.
[2] F.P. Abegglen *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2013-2014), IV-3; http://cyclotron.tamu.edu/2014 Progress Report/index.html.