

Production of intense high charge state ions with an aluminum liner in the Advanced Electron Cyclotron Resonance Ion Source *

Z.Q. Xie and C.M. Lyneis

The basic physics of an electron cyclotron resonance (ECR) ion source involves coupling microwave energy to plasma electrons confined by a magnetic bottle which then produce singly or multiply charged ions by electron impact ionization. The neutrals and ions are mainly stepwise ionized by electron impact ionization and the ionization process provides the primary electrons to compensate the escaped electrons to maintain a dynamic equilibrium plasma in which the plasma loss is electrically neutral. Early experiments on ECR sources demonstrated that adding extra electrons to the ECR plasma with a microwave-driven first stage or by using electrons emitted from the plasma chamber walls coated with materials of high secondary electron emission can substantially enhance the production of high charge state ions. Since the AECR source was built, we have explored various techniques to provide more electrons for the plasma. The early methods used, such as coating the plasma chamber walls with SiO₂ or Al₂O₃ and using an electron gun to axially injecting electrons to the plasma, substantially enhanced the performance of the AECR source.^{1,2,3}

Enhanced production of high charge state ions due to the aluminum oxide wall coating has been demonstrated in various ECR sources. Empirically speaking, a good chamber surface should have high secondary electron emission, long lifetime in against plasma etching and low material sticking coefficients to minimize the surface memory. Aluminum oxide not only has high secondary emission but it is also very resistant to plasma etching. The previous aluminum oxide coating, done by running an aluminum plasma, did not entirely cover all the chamber copper surfaces in the AECR source and only had about one month lifetime. In this test, a 0.38 mm thick aluminum liner was installed in

the copper plasma chamber. The tests with this aluminum liner and two-frequency heating produced an increase of up to 60% in beam intensity of the high charge state ions was achieved. Shown in Table I are the measured beam intensities for a few example elements.

Footnotes and References

- *Condensed from Proc. 6th International Conference on Ion Sources, Whistler, BC, Canada, 1995.
- ¹Z. Q. Xie and C. M. Lyneis, Rev. Sci. Instrum. **65**, 2947 (1994).
- ²Z. Q. Xie, C. M. Lyneis, R. S. Lam, and S. A. Lundgren, Rev. Sci. Instrum. **62**, 775 (1991).
- ³T. Nakagawa, T. Kageyama, M. Kase, A. Goto and Y. Yano, Jpn. J. Appl. Phys. **32**, 1335 (1993).

Table I. Ion beams produced from the AECR source with an aluminum chamber liner

Q	I (eμA)	Q	I (eμA)
16O ⁶⁺	510	197Au ²⁴⁺	41.7
16O ⁷⁺	210	197Au ²⁶⁺	34
40Ar ¹¹⁺	238	197Au ²⁹⁺	20
40Ar ¹²⁺	158	197Au ³⁰⁺	14.3
40Ar ¹³⁺	84	197Au ³¹⁺	10
40Ar ¹⁴⁺	47.5	197Au ³²⁺	6.6
40Ar ¹⁶⁺	4.7	197Au ³⁴⁺	3.5
209Bi ²⁸⁺	33	197Au ³⁵⁺	2.4
209Bi ³¹⁺	26	197Au ³⁶⁺	1.3
209Bi ³⁴⁺	14	197Au ³⁸⁺	0.4
209Bi ³⁶⁺	6.6		

All ion beams are extracted at 10 or 15 kV extraction voltage and through an 8 mm aperture.

