Title
Development of a high intensity 48Ca ion beam for the heavy element program

Authors
Wutte, Daniela
Leitner, Matthaeus
Lyneis, Claude

Publication Date
2002-02-02

Development of a high intensity ^{48}Ca ion beam for the heavy element program*

D. Wutte, M. Leitner, C. M. Lyneis

A high intensity ^{48}Ca ion beam has been developed at the 88 Inch Cyclotron for the synthesis of ^{283}112 using the reaction ^{238}U(^{48}Ca, 3n). An ion beam intensity of ~ 700 pnA was delivered on target, resulting in a total dose of 2 x 10^{18} ions over a six day period. Since ^{48}Ca is a very expensive and rare isotope minimal consumption is essential. Therefore a new oven [1] and special tantalum liner [2] have been developed for the AECR-U ion source during the last year to improve the metal ion beam efficiency.

Both the LBL ECR and the AECR-U ion sources are built with radial access. Six radial slots between the sextupole magnet bars provide additional pumping and easy access to the plasma chamber for ovens and feedthroughs. Two types of radial ovens have been used at LBNL in the past, operating at temperatures up to 2100 °C.

Although the radial ovens are a very convenient and reliable way of introducing metal vapor into the ion source plasma, the efficiencies are typically fairly low. For medium to high intensity ion beams, consumption rates for the radial ovens are between 1 and 3 mg/hr, resulting in an ionization efficiency into a single charge state of about .1 to .2 % for the high temperature oven and .2 to .6% for the low temperature oven. These low efficiencies are due to the radial oven geometry, where the vapor has to diffuse through a 6 mm wide and 4 cm deep narrow slit in the water-cooled sextupole housing. Therefore, the major part of the metal condenses on the cold surfaces of this slit channel. If inexpensive metals are used, consumption rates are not critical since the oven crucible volume of about 1 cm^3 is large enough to produce high intensity ion beams for 1 to 2 weeks of continuous operation. However, for high intensity ion beams of rare, the consumption has to be minimized.

With the new axial oven the metal vapor is directly dispersed into the plasma volume. Consequently, the ion source efficiency could be improved by a factor of 3 by using the axial oven. As a next step a tantalum-liner was installed inside the plasma chamber. The liner, which is heated by the lost plasma particles and microwave power, minimizes the condensation of metal vapor on the chamber wall. At a microwave power of 300 W the liner reached a temperature of about 400 C, which corresponds to a vapor pressure of 10^{-4} mmHg for Ca. With the liner installed the peak charge state was shifted to 9+ (from 11+), which is still sufficient to reach the required energy of 5MeV/nucleon with the 88-Inch Cyclotron. An efficiency of about 3.1 % was achieved for Ca^{9+} and about 2.9% for Ca^{8+}.

In Table 1 the measured ionization efficiencies are summarized and compared with results from other groups.

	Q	euA	mg/h	Eff. %		Hours
LBNL	11	9	.31	0.4	Radial oven	97
LBNL	11	53	.6	1.2	Axial oven	25
LBNL	9	36	.2	3.1	Hot liner	45
LBNL	8	30	.2	2.9	Hot liner	45
LBNL	10	48	.25	3.4	Hot liner	200
DUBNA[2]	5	50	.7	2.6-3	Hot liner	>1000
DUBNA[2]	5	100	.6	6	Hot liner	Test
JYFL[3]	11	30	.3	1.4	axial oven	Test

Fig.1. Measured ionization efficiencies for Ca into a single charge state in comparison with results from other groups. The efficiencies given represent the overall system efficiencies (ion source and transport line).

1. D. Wutte et al., RSI **73**, 521 (2002)
2. V. B. Kutner et al., RSI **71**, 860 (2000)
3. H. Koivisto et al., Proc. of Cyclotrons 2001, East Lansing, Michigan