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NEW METALLIC STABLE ION BEAMS FOR GANIL

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Abstract

GANIL has been producing many stable beams for nearly 40 years. Constant progress has been made in terms of intensity, stability and reliability. The intensity for some stable metallic beams now exceeds or approaches the pμA level at an energy up to 95 MeV/u: 1.14 pμA for ^{36}S (65% enriched) at 77 MeV/u, 0.35 pμA for ^{58}Ni (63%) at 74 MeV/u.

Constant developments are being made to broaden the range of available beams for physics [1]. The presentation highlights recent results obtained for ^{28}Si, ^{184}W and ^{130}Te using the GANIL 's LCO (Large Capacity Oven) [2] on the ECR4 ion source. To produce the tungsten beam, two injection methods were compared. For the first one, we evaporated some tungsten trioxide (WO_3) with GANIL 's LCO. For the second one, the injection in the plasma chamber was made by using MIVOC (Metallic Ions from Volatile Compounds) [3, 4, 5] with a tungsten hexacarbonyl ($W(CO)_6$) compound. It was the first time that we used metal carbonyl compounds and the result is promising. All the tests have been qualified to obtain the level of intensity and beam stability. Theses good results led us to propose them for Physics experiments.

EQUIPMENT CONFIGURATION

The "Oven configuration" of the ECR4 Ion Source

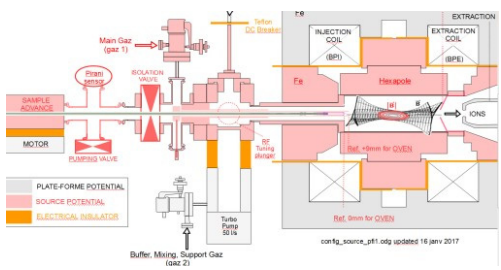

Figure 1: Oven in the ECR4.

The MIVOC Configuration of the ECR4 Ion Source

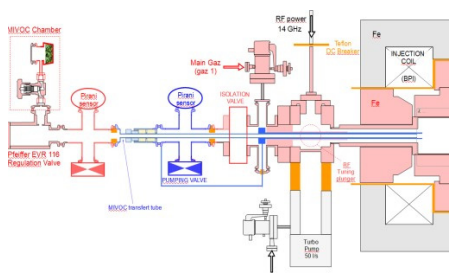

Figure 2: MIVOC chamber with transfer tube connected to the ECR4.

SILICON BEAM WITH ECR4 ION SOURCE

Introduction

The silicon beam was produced using the natural silicon monoxide (SiO) compound which was evaporated with the large capacity oven (LCO). The ^{28}Si beam can also be produced with SiH_4 gas but it's highly flammable and for the safety reason, we don't use this compound.

The Sample Preparation

The compound is a sticky brown powder. This form of compound can be found for several isotopes of silicon (^{30}Si, ^{29}Si). We use an alumina crucible with a useful capacity volume of 140 mm^3. The powder is lightly pressed in the crucible. After filling, we have 130 mg of the SiO in the crucible. To evaporate the compound, we use the high temperature version of the LCO. Before the introduction of the sample in the ion source, we heat the sample up to 500°C for outgazing in the vacuum chamber.

To obtain a vapor pressure of 10^{-2} mbar the temperature of compound should be of 1080°C (1705°C for the melting point).

Production of ^{28}Si with ECR4 Ion Source

Test has been first performed with the natural silicon monoxide. Due to the high temperature required for evaporation we decided to fix, in the first time, the oven position at +9 mm, see on Fig. 1. For the first test, we measured a high consumption (2.45 mg/h of ^{28}Si) with the spectrum op- timized on $^{28}Si^{5+}$. For the second test, we changed the oven position at 0 mm (Fig. 2). The intensity of $^{28}Si^{5+}$ has been delivered by changing various source parameters: RF power, gaz, oven power, we used, like buffer gas, O_2 and we easy obtained the beam stability during 48 hours. The main parameter, which is optimized was the electrical power oven to keep the level of the beam intensity.

The charge state distribution has been optimized on $^{28}Si^{7+}$ with 20μA.e, see on Fig. 3. The consumption was 0.56 mg/h of ^{28}Si with the total ionization efficiency of 6%.

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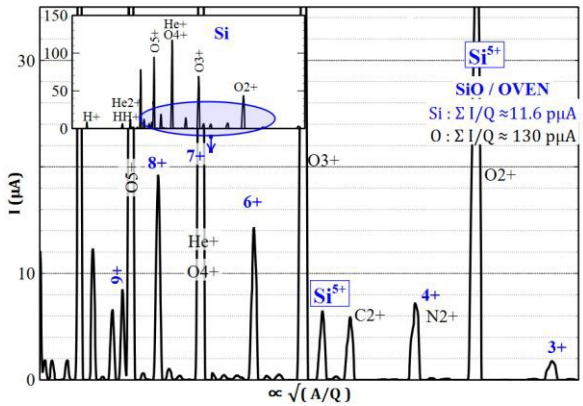

Figure 3: Spectrum optimized on $^{28}Si^{7+}$ (20 μA). RF power: 350 W, buffer gas O_2: 7.4×10^{-6} mbar at injection, 2.3×10^{-7} mbar at extraction, 24.6 kV/1.65 mA, platform 60.5Kv, axial magnetic coils: 1070A/1050A, oven power 23.3 W (~800°C off-line), oven position: +0 mm inside the plasma chamber, no bias. Transport efficiency up to the faraday cup: ~35%.

Conclusion

An intensity of 6μA.e $^{28}Si^{5+}$has been produced for 48 hours. The charge state distribution was better for the second test with 20μA $^{28}Si^{7+}$ due to the change of oven position and more gaz buffer (O_2). With these results, we will be able to increase the list of available beams at GANIL.

TUNGSTEN BEAM WITH ECR4 ION SOURCE

Introduction

Two tests have been scheduled to produce tungsten beam. We choose two different molecules to inject in the ion source. For the first test, we produced the tungsten with the injection of the tungsten hexacarbonyl and for the second we injected the tungsten trioxide. The goal of this experiment is to compare the performance of the beam production with the two injection methods.

Production of ^{184}W with Tungsten Hexacarbonyl Compound

It was the first time that we produced some ions with a neutral carbonyl molecule. To inject the tungsten hexacarbonyl in the plasma chamber, we used the MIVOC method. The scheme of injection is on Fig. 2 and the installation is shown in Fig. 4.

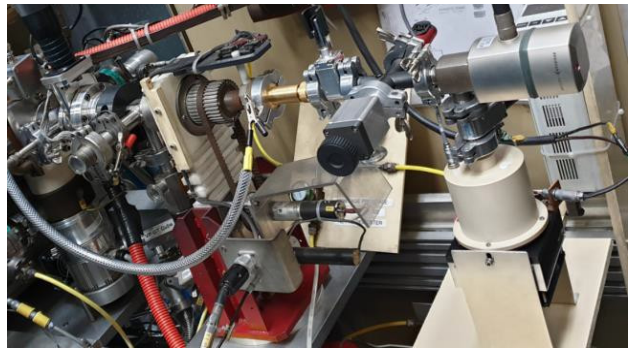

Figure 4: MIVOC process is connected at ECR4 ion source.

Before the production of the beam, we analyzed the compound with the analyser mass spectrometer to see the different atomic masses of molecules and the pollution. The presence of water was important but it was decrease thanks to pumping in MIVOC chamber and the time.

The production test lasted several days, starting the source in the morning and switching it off in the evening, for a cumulative runtime of 33h. A mean intensity of 1.2 μA for $^{184}W^{18+}$ has been maintained.

It corresponds to a total particles current of 0.55 pμA see on Fig. 5. The measured beam transport efficiency of 47% - assumed to be the same for all charge states and spe- cies - leads to an ion flow extracted from the source of about 1.2 pμA. The consumption of ^{184}W was 0.2mg/h and an ionisation efficiency around 5%.

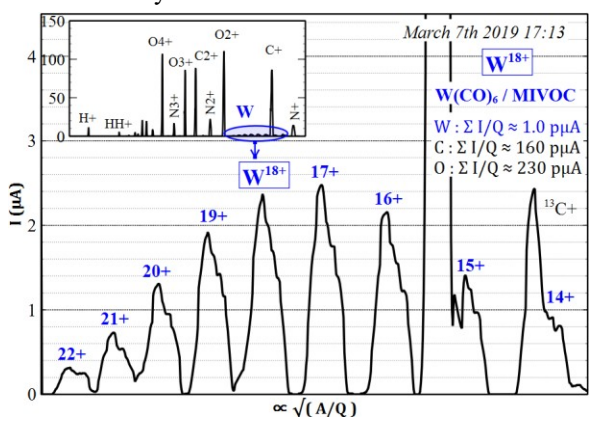

Figure 5: Spectrum obtained with ECR4 ion source and optimized on 184W18+ (2.3 μA). RF power: 170 W, biased tube : -100V/0.0mA, no buffer gas, MIVOC flow 500 mbar.L/s, 4.0×10^{-7} mbar at injection, 2.0×10^{-7} mbar at extraction, source 25 kV/1.7 mA, platform 50 kV, injec- tion coil 1060 A, extraction coil 1050 A. Total transport to Faraday cup 47%.

Production of ^{184}W with Tungsten Trioxide

For this test we chose the natural compound of tungsten trioxide (30.6% of 184W). The sample was a very fine green powder which was difficult to stock in the oven's crucible. We obtained a stable beam during 24 hours with 2.8μA of 184W20+ see on Fig. 6. The consumption of 184W was 1mg/h with the total ionization efficiency around 1.4%.

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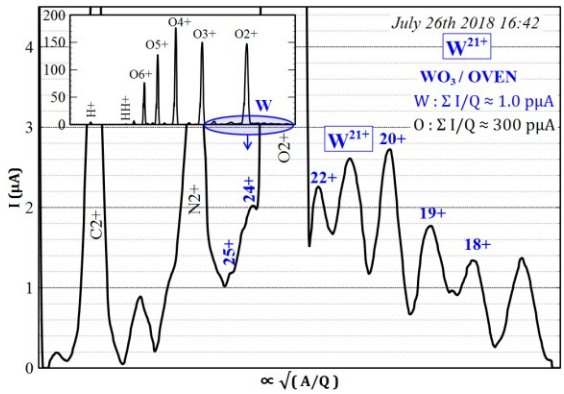

Figure 6: Spectrum obtained with ECR4M and optimized on $^{184}W^{21+}$ (2.5 μA). RF power: 278 W (reflected 110 W), 18 kV/2.0 mA, buffer gas O_2, oven power 33.1 W (~1100°C off line), oven position: +4 mm inside the plasma chamber, no biased tube, coils: 960A/730A. Transport efficiency up to the faraday cup: ~47%.

Conclusion

If we compare the two methods of production, we can see that we have the same level of intensity with a better charge state distribution for the oven methods. We could try to do another test with the oven to reduce the consumption. For the two compounds, if we find the isotopically enriched sample, we will be able to multiply by three the intensity and thus have 7.5μA of $^{184}W^{21+}$.

TELLURIUM BEAM PRODUCTION WITH ECR4 ION SOURCE

Introduction

This beam was developed to answer of the new project of experiment for Agata detector. To produce this test, we took a metallic isotopically enriched sample of 130Te (99.8%).

The Sample Preparation

We use an alumina crucible with a useful capacity volume of 140mm^3. The sample was a metallic form and we put 100mg of the ^{130}Te in the crucible.

To obtain a vapour pressure of 10^{-2}mbar the temperature of compound should be of 360°C (452°C for the melting point). To minimise the influence of plasma heating, a plug with an aperture of 1mm-diameter has been put at the extremity of crucible.

Production of ^{130}Te with ECR4 Ion Source

Due to chemical reaction between oxygen and heated tellurium, we decided to inject nitrogen as a buffer gas

This test has been performed continuously during one week. The charge state distribution has been optimized on $^{130}Te^{18+}$ with 8μA like the spectrum in Figure 7.

The consumption was 0.2 mg/h of 130Te with the total ionization efficiency of 8%.

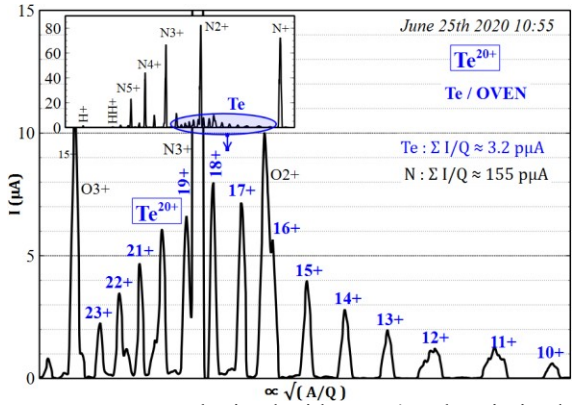

Figure 7: Spectrum obtained with ECR4 and optimized on 130Te18+ (8 μA). RF power: 220 W, buffer gas N2, oven power 2 W (~200°C off line), oven position: +0 mm inside the plasma chamber, no biased tube, coils: 1065A/1065A. Transport efficiency up to the faraday cup: ~35%.

Conclusion

An intensity of 8μA 130Te18+has been produced for 50 hours. The use of Nitrogen gas buffer is good solution to optimise the charge states distribution and to obtain a good stability of the beam. With these results, the AGATA experiment can be programmed for the year.

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