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IMPROVEMENTS IN ANIS AND INVERTED SPUTTER SOURCES

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In this article two sputter sources, i.e. an ANIS and an inverted sputter source are described. The ANIS has been changed into a SNICS-like configuration and measurements of the output current for different sputter target geometries are presented. In the inverted sputter source an immersion lens was placed between the ionizer and the sputter target. This source is provided with a modified revolving target head with eight targets.

1. The ANIS sputter source

The ANIS source, as used in several tandem laboratories, can produce many different ion beams. Although it has a low emittance and a high brightness [1,2], it has also some disadvantages. At high negative ion currents (dense plasma mode) the arc and ion current often show a slow and continuous increase in time, finally causing the source to run out of control *. This effect can be explained by warming-up after which too much cesium evaporates. Only at lower ion currents (thin plasma mode) is the long term stability of the source very good. Another observed effect is that the sputter targets do not show a small circular erosion spot, but a broad rectangular-shaped one. This influences the emittance of the source, which becomes more "asymmetric".

Other sources with high efficiency are the Middleton source [3] and the SNICS source [4]. The latter has an emittance comparable to that of the ANIS source. Both use a helical ionizer between the sputter target and the extraction aperture. In accordance with this idea, a three-turn helix of 1 mm tantalum wire has been mounted in the discharge chamber of an ANIS source. In this case both filaments and the magnet has been removed (see fig. 1).

In order to study the focusing conditions of the source a computer program has been used [5]. Given a set of boundary conditions with either cylindrical or planar symmetry the program solves Laplace's equation to determine the potential distribution in a grid of 2145 points. After specification of the starting conditions (mass, charge, energy, starting coordinate and angle) the trajectories of the positive cesium ions and the extracted negative ions can be plotted. Fig. 2a shows the geometry of the source with a flat sputter target and fig. 2b shows a sputter target with a pit. Due to the stronger curving of the equipotential lines a stronger focusing action is obtained, and hence the loss of negative ion current is reduced at the aperture plate.

* Danfysik, Denmark, has redesigned the 915 ANIS source to improve this point.

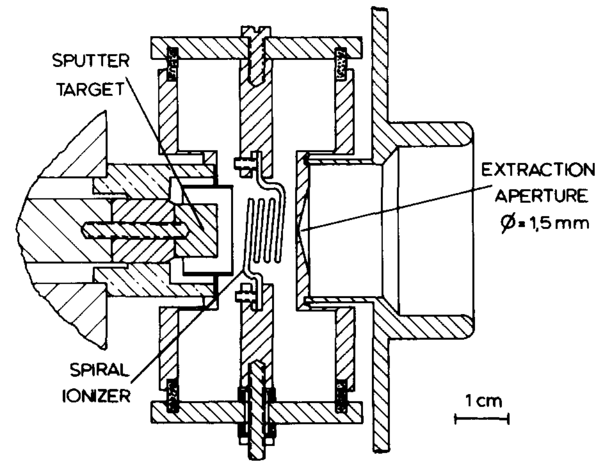

Fig. 1. The modified ion source. A spiral ionizer is used in an ANIS source geometry.

2. Measurements

Measurements were made with this source, using a sputter target with a 6 mm pit. The depth d of the pit has been varied between 0, 1, 2, 3 and 4 mm, for three spacing distances S. Carbon and copper were chosen as target materials. The erosion spot of the sputter target was about 2 mm in diameter, indicating that most of the Cs^+ ions are well focused. The results of the measurements are shown in fig. 3. The optimum depth $d = 1$ mm is equal for the two masses. This can be expected, as the shape of the equipotential lines in both cases is the same, and the focusing action is mass independent in a given electrostatic field. In fig. 3 the results of varying the spacing distance S between the sputter

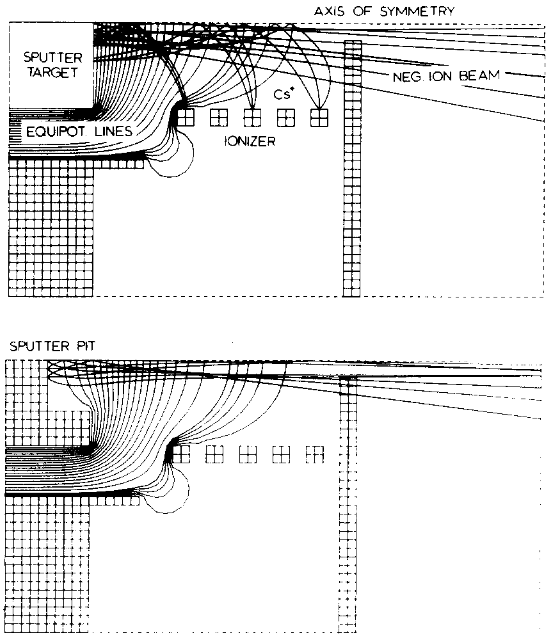

Fig. 2. (a) Plotted equipotential lines and trajectories of the negative ions for a flat sputter target. (b) The same for a sputter target with a pit.

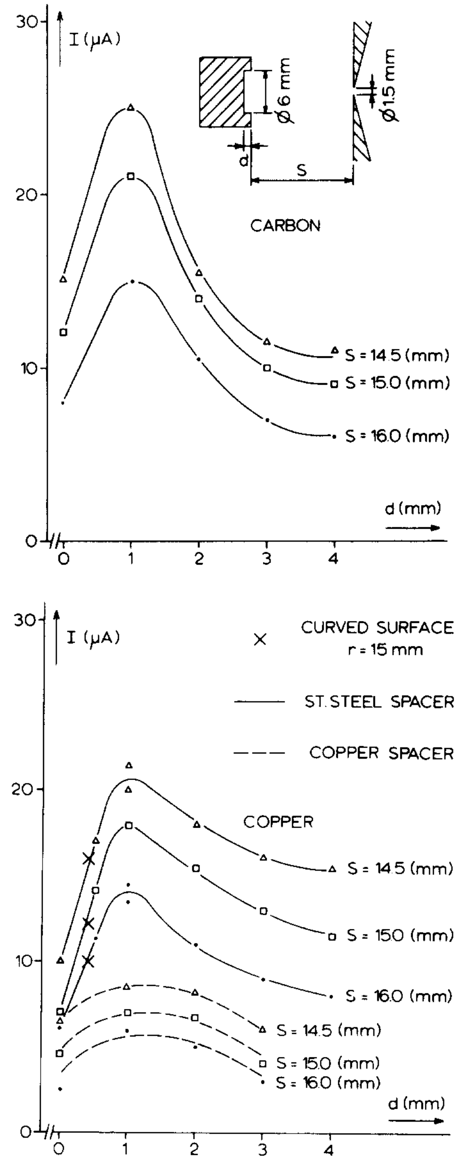

Fig. 3. (a) Variation of C^- current as a function of the depth d of the pit with different spacings S. (b) The same for Cu^-. Solid lines: high surface temperature, dotted lines: low surface temperature. Crosses: curved sputter surface (see text).

target and the extraction aperture are given. To study the temperature effect of the sputter surface the spacer between the cooled probe holder and the sputter target was changed. Instead of a stainless steel spacer a copper spacer was used. These measurements show a strong influence of the target temperature (fig. 3b). It seems that for a copper spacer the temperature becomes too low, as a result of which the target surface is covered with too thick a cesium layer. To compare the output current of the ANIS with the source just described, a target with a curved surface ($r = 15$ mm,) was put into our source. In fig. 3b the results are plotted on the curves for the different spacings S (see crosses) and they show that output currents are about halved. In table 1 a survey is presented of the different negative ion currents obtained with this modified ANIS source.

Table 1

Sputter cathode	Ion	Current (μA)
TiH_2	H^-	32
AlB_2 (powder)	$^{11}B^-$	0.7
C	$^{12}C^-$	21
CaF_2 + Cu (powder)	$^{19}F^-$	33
Al	$^{27}Al^-$	0.7
Si (crystal)	$^{28}Si^-$	27
P/Cu (alloy [a])	$^{31}P^-$	5
FeS	$^{32}S^-$	12
Ni	Ni^-	6.5
Cu	Cu^-	8
Ag	Ag^-	2.5
Au	^{197}Au	15

[a] 15% P/Cu alloy available from Ventron Corporation, Alfa Products, 152 Andover St., Danvers, MA 01923, USA.

3. The inverted sputter source

In Utrecht the inverted sputter source is used for carbon dating research. This source proved to have a

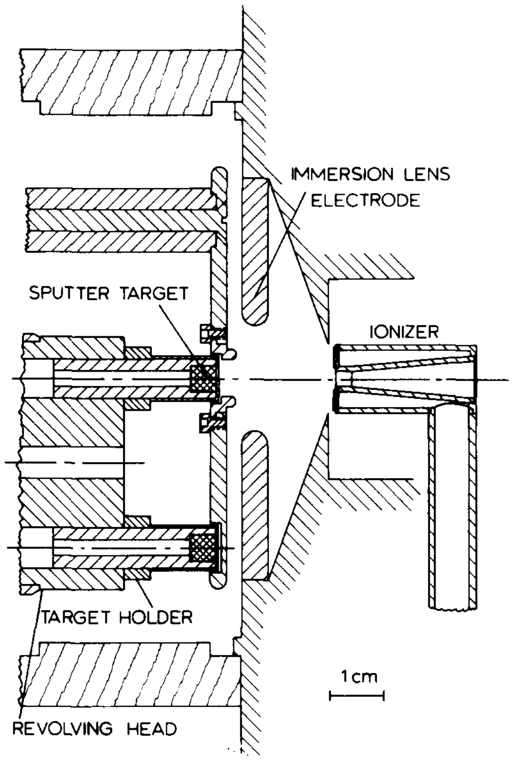

Fig. 4. The modified inverted sputter source.

very good stability and a low background. To obtain higher carbon currents this source was improved, following the design of White [6], and Yntema and Billquist [7]. An immersion lens which focuses the positive ions on the sputter target and the negative ions through the hole in the ionizer was placed between the ionizer and the target (see fig. 4). The geometry of the electrode configuration was optimized with a computer program [5]. The modified source is very reliable and stable; the erosion spot on the sputter target is smaller than 1 mm and appears to be very well centered. The output current for carbon is about 90 μA, at an extraction voltage of 15 kV and a power supply current of about 3 mA.

On the revolving head eight cylindrical targets can be mounted, which are oil cooled. By using an air-lock valve, the sputtering targets can be changed without breaking the vacuum. The targets not in use are located in small chambers in the cathode flange to prevent these targets from becoming contaminated (see fig. 4).

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