# Conceptual Design of Alkali Metal Ion Implanter

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## 1. Introduction

KOMAC is developing alkali ion implanters to provide alkaline ion beams such as sodium and potassium that can be used in surface physics such as research on superconductivity phenomena. As the ion source, the Bernas ion source [1], which has previously provided a metal beam such as iron or copper, is used, and only the ions having the desired mass and charge are separated by the mass separation electromagnet. The ion beams are then accelerated once again to obtain the desired energy and then irradiated to the sample. Figure 1 shows the configuration of the ion implanter.

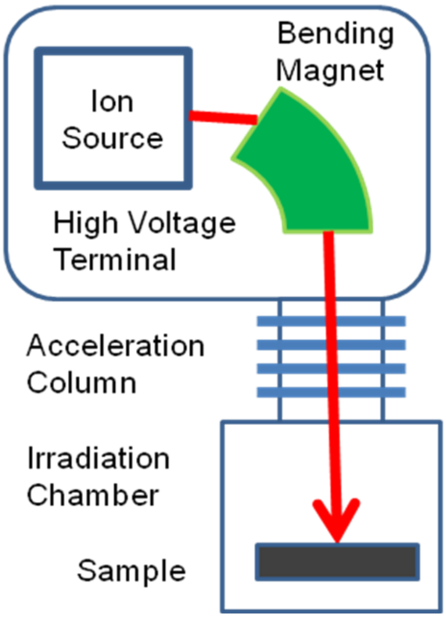


Fig. 1. Configuration of alkali metal ion implanter.

## 2. Design

### *2.1 Ionization Material*

Alkali metals such as lithium, sodium, potassium, rubidium, and cesium have low melting points and low boiling points, and are difficult to handle due to reaction with moisture in the air. Therefore, chloride is used instead of evaporating pure metal and supplying it as an ionizing material. Table 1 shows the characteristics of these chlorides.

Since the operating temperature is more than 500 ℃, the direct heating method is adopted in which a direct current is supplied to a crucible made of a conductive material to be heated instead of indirect heating by placing a heater around the crucible. The material of the crucible is stainless steel 316 which is resistant to chloride corrosion and suitable for temperatures below 1,000 ℃.

Table I: Ionization Materials [2]

| Material | Temp. for vapor pressure $10^{-2}$ torr | Typ. Op. Temp. | Melting Temp. |
|---|---|---|---|
| LiCl | 582 ℃ | 600 ℃ | 605 ℃ |
| NaCl | 658 ℃ | 675 ℃ | 801 ℃ |
| KCl | 637 ℃ | 650 ℃ | 772 ℃ |
| RbCl | 614 ℃ | 650 ℃ | 718 ℃ |
| CsCl | 570 ℃ | 600 ℃ | 583 ℃ |

### *2.2 Ion Source*

The Bernas ion source, made at the Kurchatov institute in 1991, uses a chloride as an ionization material to extract metal ion beams of relatively heavy elements such as tungsten and titanium over 5 mA. Therefore, it is estimated that more than 5 mA of alkali ion beam can be extracted from the ion source. Table 2 shows the specifications of the beam extracted from the ion source.

Table I: Ion Source Specifications

| | |
|---|---|
| Ion species | Li, K, Na, Rb, Cs |
| Ion energy | 22 keV |
| Beam current | >5 mA |
| Beam size | 60 x 1.5 mm |
| Beam divergence angle | 3° |
| Expenditure of ion material | <10 g/hour |
| Crucible temperature | 500 ~ 900 ℃ |
| Chamber pressure | <5E-5 torr |

### *2.3 Beam Optics*

The alkali beam drawn from the ion source is separated from ionic species having different charge and different charge by the 90° bending magnet with the bending radius of 350 mm. Potassium 39, the mass of which is closest to that of chlorine 37, is separated by about 10 mm from the exit of the bending magnet. A 10 mm wide slit made of graphite is installed at the entrance of the acceleration column to remove the separated chlorine ions. Since the angle between the bending magnet pole and the beam is 27 degrees, both horizontal and vertical focusing is performed, and the beam can be transmitted well. Thereafter, up to 100 kV is applied to the accelerating column to further accelerate the ion beams.

A beam optics program provided by NEC (National Electrostatics Corp., USA) was used to simulate the beam trajectory in the ion implanter. This result is shown in Fig. 2, and the beam size at the position of the sample is 10 cm in the horizontal direction, 18 cm in the vertical direction.

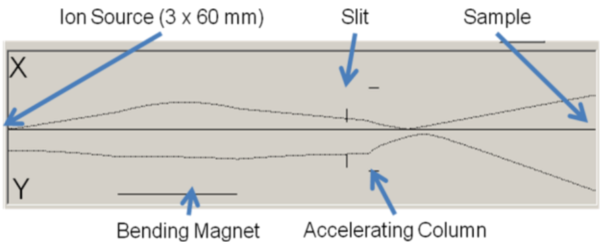


Fig. 2. Beam optics simulation of ion implanter.

*2.4 Ion Irradiation Stand*

A motor driven x-y table will be used for uniform ion beam irradiation. In this case, since the size of the ion beam reaching the sample is large, there are many beams to be lost, and the beam utilization rate may be lowered. Therefore, as the demand of alkali ion beam increases in the future, the ion implanter will be upgraded to increase the beam utilization rate by reducing the beam size by using magnetic quadrupoles.

## 3. Conclusions

The conceptual design has been carried out to provide alkali ions such as sodium and potassium by using the Bernas ion source. Chloride is used as the ionizing material, and the crucible heating is performed by direct heating in which electric current is supplied to the crucible. The ion species is separated by a 90° bending magnet and the desired ion is then accelerated to irradiate the sample.

Based on this conceptual design, the construction of the ion implanter is underway as shown in Fig. 3 and the beam irradiation test on the sample will be conducted within the year.

Fig. 3. Alkali metal ion implanter under construction.

## ACKNOWLEGEMENT

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## REFERENCES

[1] Ian G. Brown, The Physics and Technology of Ion Sources, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.
[2] Bernhard Wolf, Handbook of Ion Sources, CRC Press, New York, 1995.