DANFYSIK

High Current Ion Source System - Model 921A

- Ion currents up to 50 mA range
- High brightness ion beams
- Hot cathode multicusp/reflex type discharge
- Robust and modular mechanical design
- Integrated extraction and screening electrodes
- Optional configurations for gases, liquids, or solids
- Optional ion source power supply package

The Model 921A ion source is designed for the production of high current and high brightness ion beams for applications in particle accelerator injection, ion implantation, isotope seperation, ion beam mixing, sputtering, fusion plasma diagnostics, etc.

A magnetic multipole/reflex (“bucket”) configuration of the discharge chamber allows the creation of a quiet, cold and stable plasma of large cross section with densities suitable to form high current, high brightness ion beams. Beam currents are well reproducible and stable. The discharge can be run in continuous or pulsed mode, depending on the intended application. The discharge can be tuned to optimize the content of multiply charged ions.

The design of the extraction system is based on extensive computer simulations of ion transport under the influence of space charge forces. Standard apertures are circular, but slit apertures can be provided as an option.

The Model 921A ion source is designed modular, thus providing flexibility in the choice of suitable source components for a given charge material, preferred ionization state, and/or extraction system. Every source type can easily be adapted to new tasks by replacing individual components.

Model 921A

Gas version (G)

The basic version of the ion source system. Optimized for gaseous charges, such as noble gases, nitrogen, hydrogen and carbon dioxide. For other mono atomic gases the beam currents scale as the inverse square root of the mass number (see "Useful formulas" below).

The source operates well with different compound gases, such as carbon dioxide and hydrogen sulfide for the production of carbon or oxygen, and sulphur ions, respectively. However, if extensive use of compound gases is foreseen, we recommed use of the "hot running" vapour version, in order to minimize condensation of dissociated elements on the cold anode surface.

Vapour version (V)

This version differs from the gas version by a heat shield inside the anode. In this, elemental materials with a temperature or volatile compounds may be vaporized and introduced into the discharge chamber with a minimum of condensation in the source. The charge material is contained in a supply vessel outside the source, which may be heated to some hundred °C, if necessary. This version is well suited for elements like the halogens, phosphorus, tellurium, mercury, sulphur, and arsenic in their elementary form. By using volatile compounds, a large number of other elements may be produced with this version.

Sputter version (S)

This version is constructed as the vapour version, but with the possibility to mount a metal disk inside the discharge chamber in front of the outlet hole. The disk may be biased to a negative potential with respect to the cathode. With a gas discharge in the source, sputtered metal atoms from the disk will be ionized and mixed with the discharged plasma, causing the extracted beam to contain a large fraction of metal ions.

The sputter version is particularly well suited for producing ions of medium and high melting point materials. Elemental materials as well as alloys and sintered mixtures may be used for the sputter disks.

Options

Oven Cathode (OC)

The Model 921A may be equipped with an internal oven which makes it ideal for production of pure ion beams from elements with moderately low vapour pressure. The oven temperature is regulated independently of the other operating parameters, and condensation of charge materials is avoided by making all other internal source parts hotter than the oven itself. The charge can be introduced from the rear end, with the source mounted in operating position. Auxiliary gas (e.g. argon) may be used to stabilize the discharge; due to the higher ionization threshold of the gas ions they will only contribute a small amount to the extracted beam (typically in the order of 5%).

The oven version is suitable for materials like the alkalines and earth-alkalines, aluminium, indium, thallium, tin, lead, antimony, bismuth, and a special configuration for silver and gallium. Mass analysis of the extracted beams indicates that beam purities in the 90 to 100% range can be obtained.

Model 987

Ion source power sypply system

The power supply package is specifically designed for the Model 921A ion source system. It contains all the necessary power and control facilities to connect and operate the Model 921A ion source over its entire operating range. The system contains four individual units: Discharge supply, Cathode Heating supply, Oven supply and Sputter supply. Optional accessories for remote control are available. Only high voltage supplies for extraction and electron suppression need to be added to form a fully equipped high current ion gun.

Useful formulas

For pure, mono-isotopic gases the extracted beam current primarily depends on the effective outlet aperture, extraction voltage, and atomic weight. The beam current under matched conditions may be determined from the following formula (which contains a stafety factor):

$$I(mA) = 1.4 \cdot A^{-1/2} \cdot U(kv)^{3/2} \cdot \frac{S^2}{I+1.7\, S^2}$$

I is the ion current transported within a divergence half-angle of 30 mrad, A is the atomic mass number, U is the extraction voltage, and S the aspect ration (radius/gap) of the emitting aperture. For element mixtures the formula may be used as a guideline for each element by using its individual mass number to determine the share of the entire beam. For isotopic mixtures the share of an individual isotope ion in the beam depends on its abundance within the mixture. In the sputter mode the metal beam fraction depends on the sputtering yield of the charge material.

The beam emittance depends on the chosen extraction geometry (maximum current or maximum brightness) and the actual operation conditions. As a guideline the following formula may be used:

ε (π mm mrad) = 4.5 · d (mm)

where ε is the beam emittance and d is the aperture diameter. In ion optics terms the extracted beam may be represented approximately by a beam waist of half the diameter of extraction aperture, and with a divergence of approx. 22 mrad.

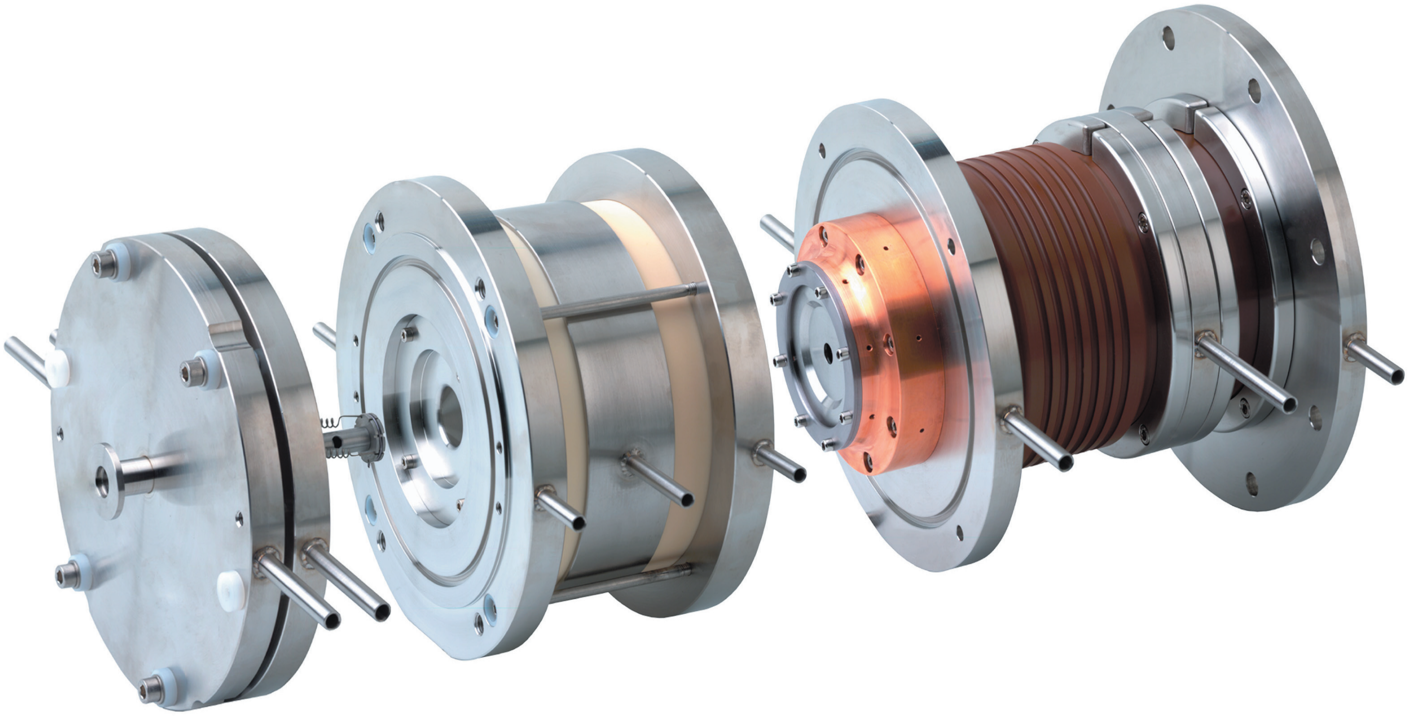
Detailed discriptions of various versions are given in Refs. 1 and 2, and a detailed discussion of emittance and brightness scaling rules for high current ion sources in general may be found in Ref. 3. The sputter version is described in Refs. 4 and 5.

Ion beam currents

Typical DC beam currents (mA) from Model 921A ion source

Element	30 keV Aperture, 1 cm²	Version
H1,2,3	15	G,V,OC
He	9	G,V,OC
Li	10	OC
B	3.5	V,OC
C	2	G,V,OC
N1,2	8	G,V,OC
O	1	G,V,OC
Ne	8	G,V,OC
Na	5	OC
Mg	5	OC
Al	1.5	V,OC
P	4.5	V,OC
S	4.5	G,V,OC

Element	30 keV Aperture, 1 cm²	Version
Ar	(M) 5.5	G,V,OC
K	4	OC
Ca	4	OC
Ti	1	V,OC
Cr	1	V,OC
Ni	0.75	V,OC
Cu	0.75	V,OC
As	3	V,OC
Kr	3.5	G,V,OC
J	2	V,OC
Xe	3	G,V,OC
Cs	2	OC
Bi	2.5	OC



Model 921A Vapour Version, showing the three main parts of the ion source: Cathode, Discharge Chamber, and Extraction System.

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Installation specifications

Dimensions	Length	410 mm
	Diameter	365 mm
	Weight	40 kg
Vacuum	Pumping requirements	300 l/s diffusion or turbo pump
Cooling	Type	Water or organic media
	Pressure drop	5 bar
	Flow	15 l/min. (4USgpm)
Power	Cathode	160A/10V dc, max. 1% ripple
	Discharge	40A/125V dc, max. 1% ripple
	Oven	250A/10V dc or ac, max. 1% ripple
	Sputter	6A/500V dc, max 1 % ripple
	Mains stabilizer	10kVA, stability 1% pp
	(All power supplies must be operated on HV potential; this implies the use of an adequate isolation transformer or motor generator).	
HV-Supplies	Extraction	25-40 kV/20-50 mA depending on application
	Electron suppression	-10 kV/5 mA
Gas feed	Needle valve or regulated gas dosing valve.	

References

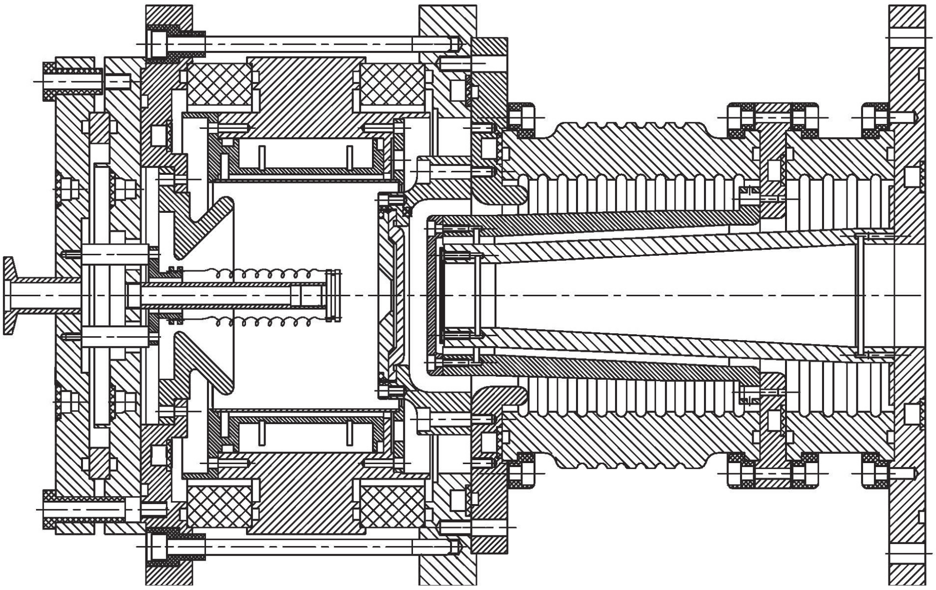
1. R. Keller, P. Spädtke, and F. Nöhmayerm Proc. Int. Ion Engineering Conf., Kyoto, p. 25-30 (1983): "A High-Current Ion Source System for Gases and Non Volatile Elements".

2. R. Keller, P. Spädtke, and H. Emig, Proc. 4th Int. Conf. on Low Energy Ion Beams, LEIB-4 Brighton, Vacuum, 36, 833-835 (1986): "Recent Results with a High Current, Heavy-Ion Source System".

3. R. Keller, Proc. of NATO Advanced Study Institute in High-Brightness Accelerators, Pitlochry, Scotland (1986), to be published in Plemum Physics Series: "Brightness Limits for Ion Sources".

4. R. Keller, B.R. Nielsen, and B. Torp, NIM B37/38, 74-77 (1989): "Metal Beam Production Using a High Current Ion Source".

5. B. Torp, B.R. Nielsen, D.M. Rück, H. Emig, P. Spädtke, and B.H. Wolf, Rev. Sci. Instrum. 61, 595-597 (1990): "High Current Ion Beams of Metallic Elements".



Model 921A Gas Version