

Dual HCD Ion Source

for high current metal ion beams

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From the plasma of a **Hollow Cathode Discharge** high current beams of positively charged metal ions have been extracted. Up to mass 100 ion beams with currents beyond 10 mA have been delivered in long time operation (50 to 100 hours). Ion source economy with respect to sputter material consumption is at least one order of magnitude better compared to conventional sputter PIG ion sources [1].

Ion sources for low charged Ions (Z/A) = 0.017 became interesting for the GSI Intensity Enhancement Project since the UNILAC Prestripper accepts now for example 4+ Uranium ions from the injector. This gave reason to think about ion generators covering well this (Z/A) range. The suitably modified hollow cathode discharge was found as a device fulfilling some of the demands at least for metal ions below Mass 100. The mechanical set up was derived from existing GSI PIG Ion Source structures [2] to fit advantageously the necessary infrastructure as were magnets, vacuum chambers and manifolds. Ions from PIG discharge are usually extracted out of the hollow anode. This ion source geometry is modified by introducing an additional coaxial electrode. The electrode sequence: "heated Cathode - Anode - SE - Anode - cold Cathode" can be seen as a symmetrical or **Dual Hollow Cathode Discharge** geometry. Ions are extracted in the same manner as formerly from the PIG Source but now out of the hollow cathode sputter electrode SE.

Ions in the vicinity of the slit window going to leave the plasma are accelerated in the cathode fall before entering the strong electric extraction field of the outer ion beam forming area. The acceleration of the positive ions in the steep cathode fall prior to extraction is perhaps the reason for the surprisingly good beam quality.

Up to now most work was directed on the production of high current ion beams from lighter ions up to mass 100. The **Dual HCD** was operated in the non-homogenous "magnetic bottle" field of the Compact - PIG - Ion Source [3] as well as in the homogenous magnetic field of the GSI PIG Ion source magnet. Results for selected ion species are shown in Table 1. Enhanced ion beam yields from the Compact Ion Source Set up are due to the higher extraction Voltages available in this arrangement.

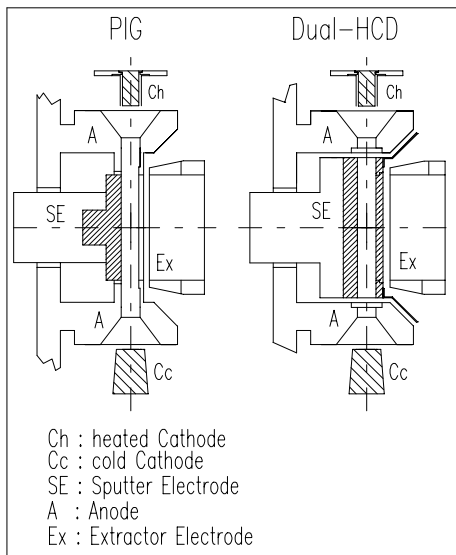


Fig.1: **Dual HCD and PIG Ion Source**

Sputtered particles from the inner wall of the hollow cathode, mostly of atomic nature, travel through the plasma column to become ionised in collision processes or to leave the plasma again hitting the cathode-wall. Ionised particles may contribute to the Sputtering by Self-Sputtering and / or being re-implanted into the surface, anyway staying available for further ion beam production.

Element		Discharge				Ion Beam	
Ion	Mass	U	I	B-Field		Curr	Extr
	amu	V	A	Tesla	Form	mA	kV
Mg1+	24	500	16	0.54	H	20	14
Al 1+	27	500	12	0.5	B	20	16
Al 1+	27	750	16	0.15	B	45	23
Ti 1+	48	500	6	0.77	H	6	13
Ti 1+	48	1000	22	0.15	B	24	25
Ti 2+	48	2400	6	0.53	H	8	13
Ti 2+	48	600	23	0.15	B	15	24
V 2+	51	750	8	0.55	H	4	14
V 1+	51	1100	13	0.15	B	13	21
Fe 1+	56	1650	18	0.8	H	5	12
Ni 1+	58	2000	15	0.84	H	11	13
Cu 1+	63	1000	4	0.14	B	16	18
Mo 2+	98	500	15	0.15	B	10	22
Zr 2+	90	400	18	0.75	H	3	13
Ta 3+	181	500	7	0.86	H	1.5	13
Ta 4+	181	500	6	0.86	H	2	17
Pb 1+	208	200	4	0.14	B	1	6
Pb 2+	208	200	4	0.15	B	2	12
U 1+	238	550	16	0.84	H	0.4	3.2
U 2+					H	1.2	6.4
U 3+					H	2.5	9.6
U 4+					H	1.6	12.8

Table 1: **Ion Yields from Dual HCD Ion source**

Values for 1% duty cycle operation (10/s;1 ms)

H : homogenous magnetic. Field (PIG)

B : magnetic bottle field (CPIG)

Ref :

[1] P.M. Morozow , B.N. Makov and M. S. Joffe,

Atomnaya Energiya 3, 272, (1957)

[2] "Handbook of Ion Sources" by B. Wolf, GSI Darmstadt, Germany, Crc Press Boca Raton New York London Tokyo, 1995, P 69).

[3] M. Müller, IEEE Trans. Nucl. Sci. NS-30 (1983) 1499