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THE ARGONNE INVERTED SPUTTER SOURCE

J. L. YNTEMA and P. J. BILLQUIST

Argonne National Laboratory, Argonne, IL 60439 U.S.A.*

Abstract

The emittance of the inverted sputter source with immersion lenses was measured to be about 5 π mm mrad $MeV^{1/2}$ at the 75% level over a wide range of beam intensities. The use of the source in experiments with radioactive sputter targets and hydrogen loaded targets is described. Self contamination of the source is discussed.

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The high intensity inverted sputter source [1] has been used for several experiments with special requirements on the Argonne FN-tandem-superconducting linear accelerator system. The ion source development work associated with these experiments was carried out on the source test bench shown in fig. 1.

The test bench uses a National Electrostatic Company (NEC) general purpose accelerator tube with a built-in einzellens and changeable extraction electrodes. The 50 keV negative ion beam is analyzed with a 90° magnet, mass energy product 10 and $m/\Delta m \sim 130$. An emittance measurement device of the type developed by Billen [2] is located behind the movable Faraday cup which measures the analyzer beam current.

Experimentally obtained numbers for the emittance of C^- and Ni^- are shown in fig. 2. The emittance varies somewhat with sputter target, ion and time as well as with Cs flux. Furthermore the emittance depends on the exact geometrical parameters of the source lens system. We estimate the acceptance of the Argonne FN-tandem to be about 8 π mm mrad $MeV^{1/2}$. If the emittance of the source is much smaller than the accelerator acceptance the lifetime of the carbon stripper foils in the tandem terminal might decrease substantially. Therefore no attempt to optimize the emittance of the source has been made.

The emittance of the source in its original configuration [3,4] was about twice as large as the one measured for the new version.

Use of Source with a Radioactive Sputter Target

The source was used in a tandem-linac experiment designed to measure the concentration of ^{60}Fe in an Fe sample. The material which contained the ^{60}Fe contained substantial amounts of ^{59}Fe and ^{55}Fe. The radioactive material was mixed with normal Fe in the ratio of 1 : 100 and pressed into pellets which were mounted in the source target wheel. Pellets of normal iron without

addition of radioactive material were also inserted. In the experiment a ^{60}Ni beam is used for tuning of the accelerator-detector system but during the experiment ^{60}Ni produces an undesirable background. In experiments on the test facility it was shown that after a Ni run a substantial amount of Ni (about 0.3% of the original beam intensity) was present in the beam after the target wheel had been rotated. This Ni contamination came to a large extent from the negative ion lens A as shown in fig. 2. Replacing the target wheel assembly and lens with a clean assembly eliminated this contamination. Fairly extensive running of an Fe beam from cast iron did not appear to produce a background of more than 0.2% when the target wheel position was changed. In the experiment the target wheel assembly and lens were therefore replaced with a clean wheel-lens assembly after the experiment had been set up with the ^{60}Ni beam.

During the experiment the radioactive pellets were used for about 30 hrs. A subsequent measurement on the $^{60}Fe/^{56}Fe$ ratio from a pellet which had not been doped with radioactive material yielded a ^{60}Fe concentration about 1% of the concentration measured from the doped pellets. A measurement of the ^{60}Fe counting rate from an intermediate position of the target wheel gave a counting rate of about 0.1% of the counting rate obtained with the doped Fe pellets.

The measured activity of the doped pellets was about 5 mR/hr at 1 cm. However, there is very considerable self absorption of the radiation of ^{55}Fe, the major activity in the radioactive sample. Therefore the activity in the source when it was opened was much higher. About 85% of the active sputtered material was found on lens A with the remainder on the Pierce electrode B. The activity on lens A could nearly completely be removed by wiping. Only 90% of the activity on B could be removed by wiping. The remaining 10% required

electropolishing. The total activity observed on the ionizer was about 10% of the bonded activity found on the Pierce lens B. This amount is much smaller than the amount expected from the distribution of neutral sputtered material from the sputter target and it suggests that the ionizer cleans itself during operation.

The experiment indicates that if one uses isotopically enriched targets in the source the majority of the sputtered material can be readily retrieved from lens A.

Use of the Source with Hydrogen Loaded Targets

The source has been used in experiments requiring intense Ti beams. The new inverted source does not operate well when NH_3 is introduced in the source during operation in contrast with the original source geometry. The Ti beams were produced from Hydrogen loaded Ti in about a 1 to 1 atomic ratio. Approximately 75% of the hydride beam is a monohydride, 5% a dihydride and 20% a trihydride. The fraction of hydride formed in the Ti metal target during hydrogen loading is quite small and would be TiH_2. This suggests that the hydride beams formed from these targets are produced by reaction of the Ti and H in the Cs layer during the charge exchange collision.

In a number of instances (Ni, Fe) one observes hydride, carbide and oxide beams. The intensity of these beams is often much greater than could be ascribed to the sputtering of molecules from the material and a similar production process as the one used to explain the intensity of the mono and trihydride beams suggests itself. If one introduces some carbon dust on the face of a Ni target the relative intensities of C^-, NiC^- and NiC_2^- increase in the same proportion with respect to these beams from a Ni target which has not been dusted. In general contamination on the face of a sputter target remains

a problem long after the contaminating material should have been removed by sputtering. This observation would be consistent with a redeposition of part of the sputtered contamination on the sputter target by the Cs beam.

References

[1] J. L. Yntema and P. J. Billquist, Nucl. Instr. & Meth. 199 (1982) 637.

[2] J. H. Billen, Rev. Sci. Instruments 46 (1975) 1295.

[3] K. Chapman, IEEE Trans. Nucl. Sci. NS-23 (1976) 1098.

[4] P. J. Billquist and J. L. Yntema, Nucl. Instr. & Meth. 178 (1980) 9.

Figure Captions

Fig. 1. Schematic layout of test stand.

Fig. 2. Emittance of the inverted source.

Fig. 3. Inverted sputter source.

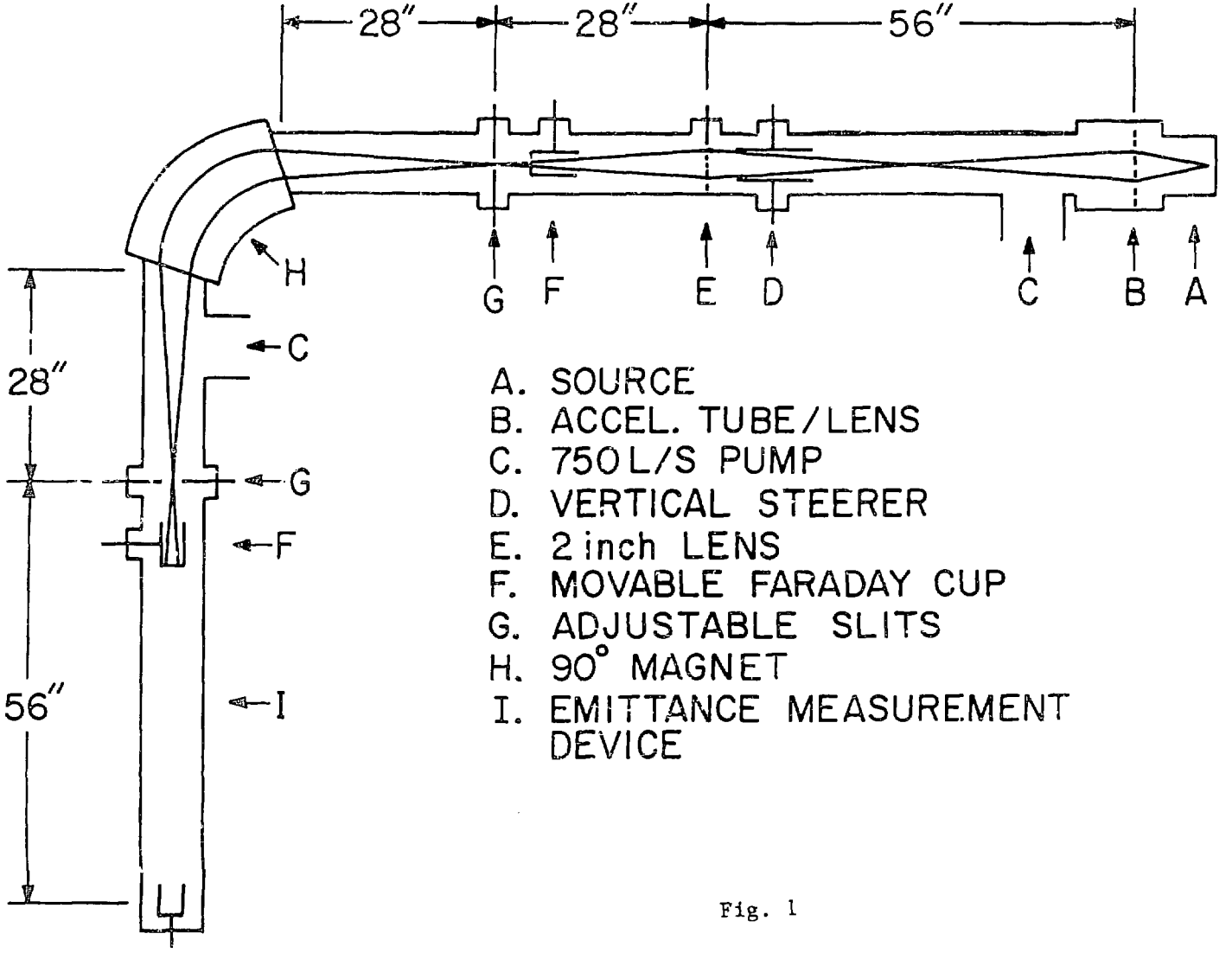
28″
28″
56″
H
G
F
E
D
C
B
A
C
28″
G
F
56″
I
A. SOURCE
B. ACCEL. TUBE/LENS
C. 750 L/S PUMP
D. VERTICAL STEERER
E. 2 inch LENS
F. MOVABLE FARADAY CUP
G. ADJUSTABLE SLITS
H. 90° MAGNET
I. EMITTANCE MEASUREMENT DEVICE

Fig. 1

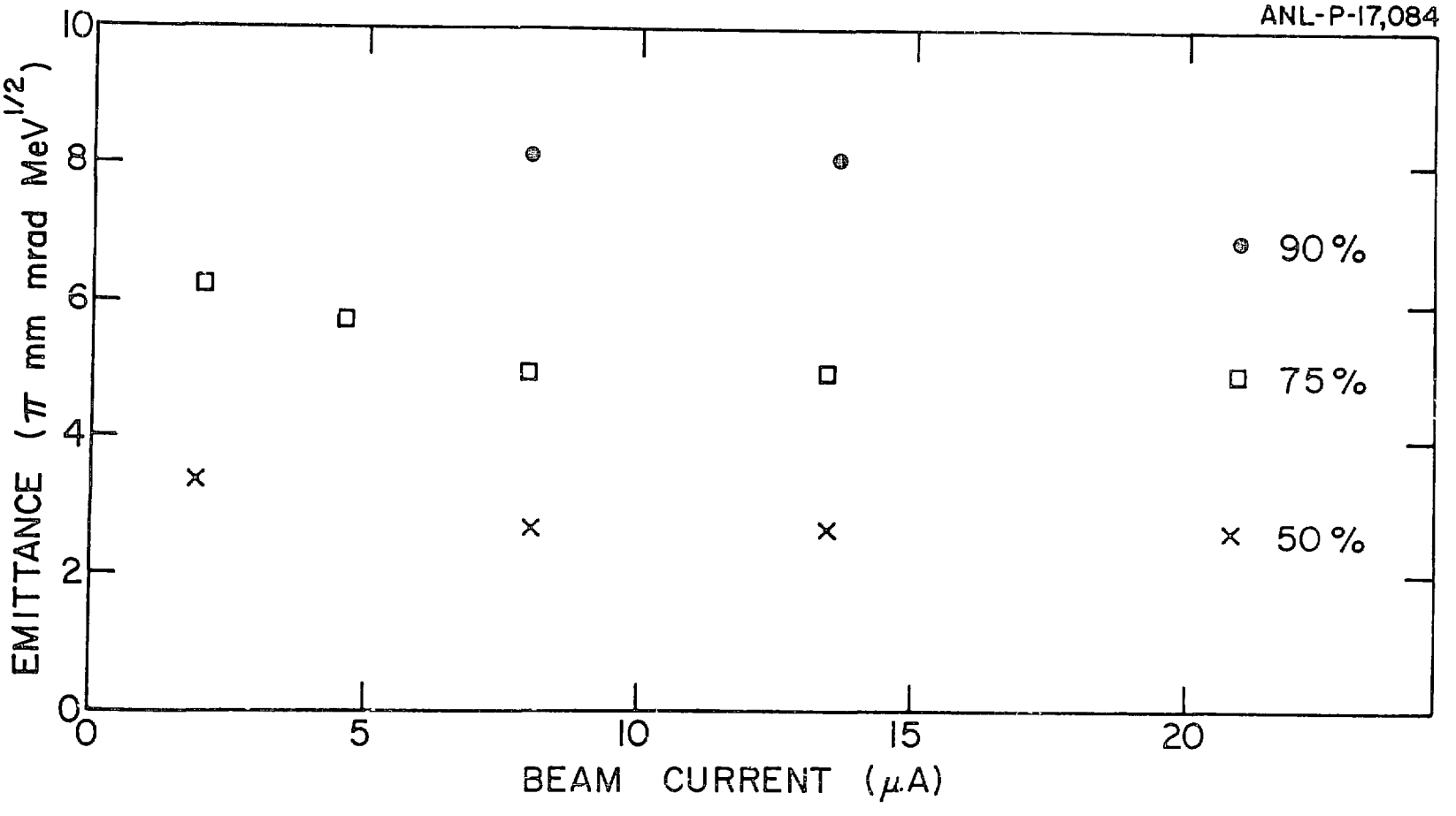
ANL-P-17,084
EMITTANCE (π mm mrad MeV^1/2)
BEAM CURRENT (μA)
90 %
75 %
50 %
0
2
4
6
8
10
0
5
10
15
20

Fig. 2

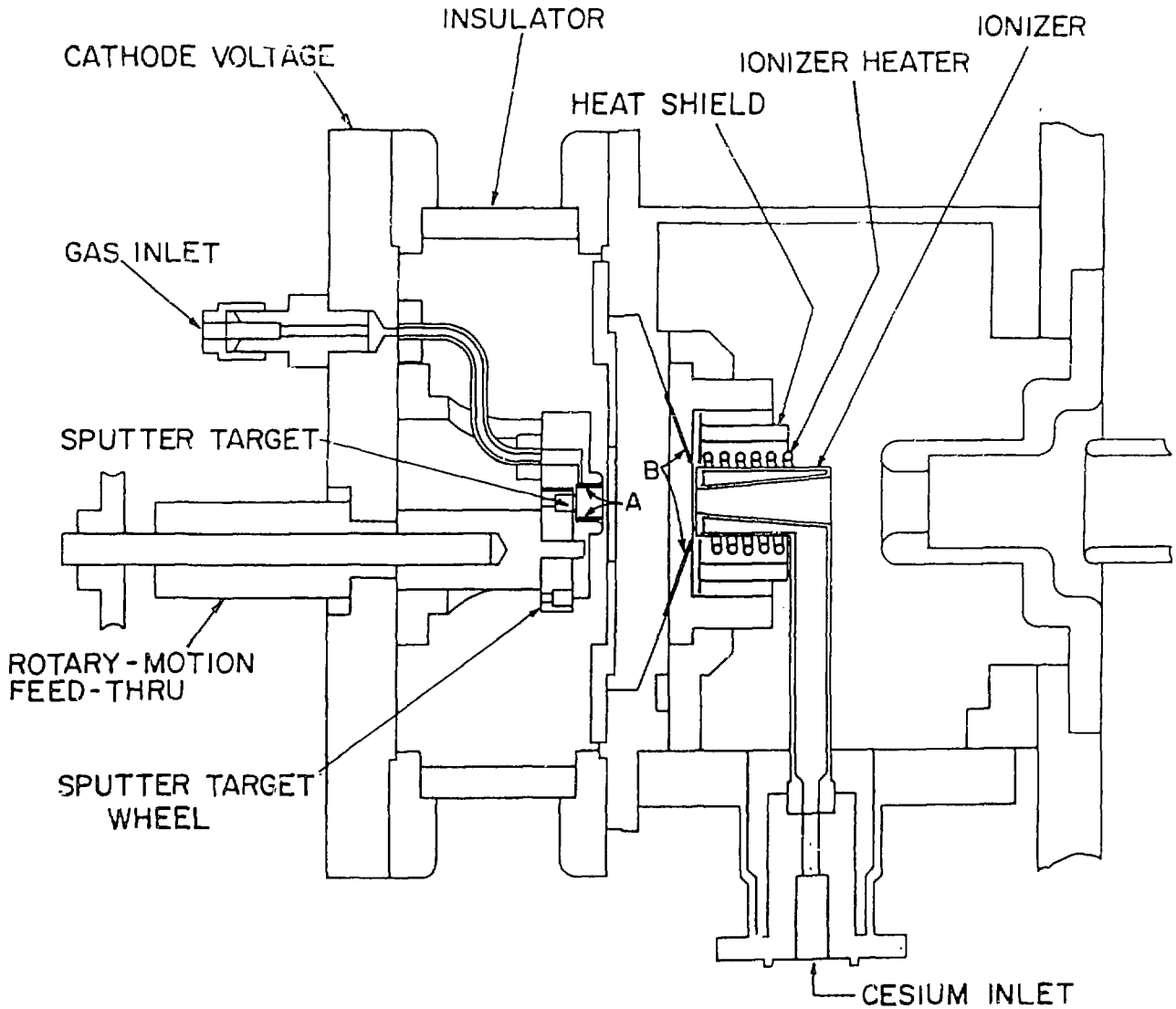
INSULATOR
IONIZER
CATHODE VOLTAGE
IONIZER HEATER
HEAT SHIELD
GAS INLET
SPUTTER TARGET
B
A
ROTARY-MOTION
FEED-THRU
SPUTTER TARGET
WHEEL
CESIUM INLET

Fig. 3