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A Combined Electron and Focused Ion Beam System*

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To micromachine or image insulating material using positively charged particles, sample charging is always a problem. The primary beam striking on the insulator will eventually charge the sample to positive potential, which will affect and broaden the incident focused beam. Conventionally, there are two ways to neutralize the sample. An electron beam can be aimed and hit on the sample to compensate the positive potential. Or, adding a gas cell on the path of positive charge particles can partially neutralize the beam before it reaches the sample. Either way is very complicated. To form electron beams with an extra source and column is needed. In addition, precise alignment is inevitable. The gas cell solution requires long working distance, depending on the cross-section of neutralization for different ion species. The new approach we are developing is to use a double-chamber source and a single column to form a beam containing both ions and electrons. It can be applied to various applications, such as ion beam inspection, ion beam milling, and secondary ion mass spectroscopy etc.

As shown in Figure 1a, the new system consists of two identical alumina plasma chambers, which are separated by a stack of electrodes. The inner diameter of these two chambers is approximately 1.5 cm. The chamber on the left is the electron source, and the one on the right is the ion source. Double layer of copper wires are wound out-side the chambers as external antenna. Gases, such as argon, are introduced into both chambers to generate plasma by RF induction discharge.

The potentials applied on the electrodes are arranged in such a way (Figure 1b) that only electrons are extracted from the left chamber, and positive ions are extracted from the right one. Electrode No.2 acts as a suppressor, which is biased at higher potential than the third electrode, to prevent the ions drifting into the left chamber. The potential on Electrode No.1 is more negative than No.3. Therefore, the electrons in the right chamber cannot reach the left side either.

Electrons extracted from the left chamber will drift through the right chamber. Since its beam energy is higher than the positive ion extraction voltage, electrons together with the positive ion beam are extracted from the column attached to the right chamber. Therefore, a beam consisting of both electrons and positive ions is formed. A beam separator (Figure 2a) is installed after the column so that electron and ion beam can be detected separately. Preliminary results shown in Table 1 confirm the co-existence of both electrons and ions in the beam.

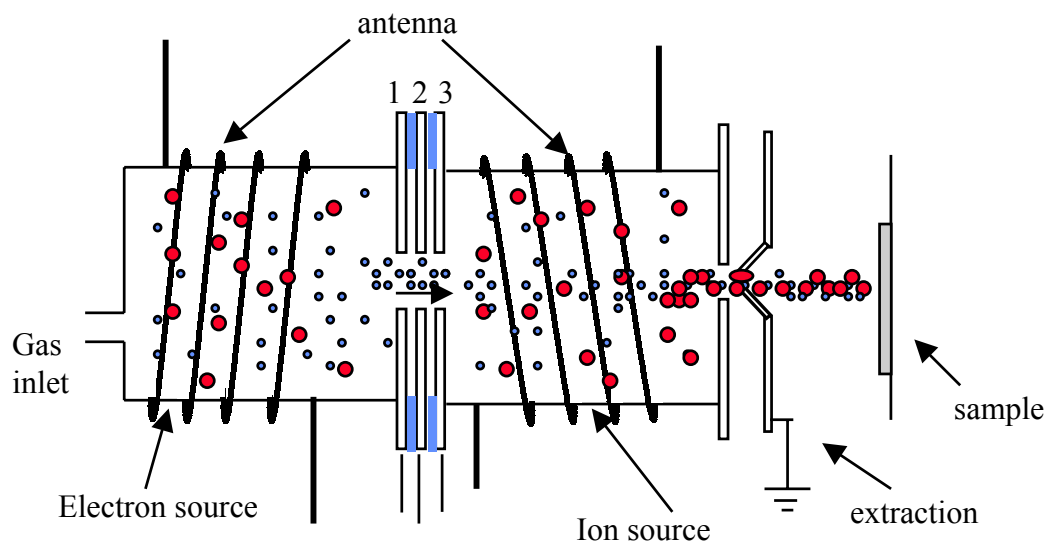
Using the set up described above, we have achieved a self-aligned dual beam, which can easily neutralize the charged insulator sample. In applications such as SIMS, one can also adjust the incident electron energy to control the secondary ion emission coefficient, thus enhancing the signal. More improvement can be made to optimize the system: the two chambers can be controlled to work at different power and gas pressure to get different ion and electron current ratio, the stack of electrodes can be carefully designed for better electron beam extraction.

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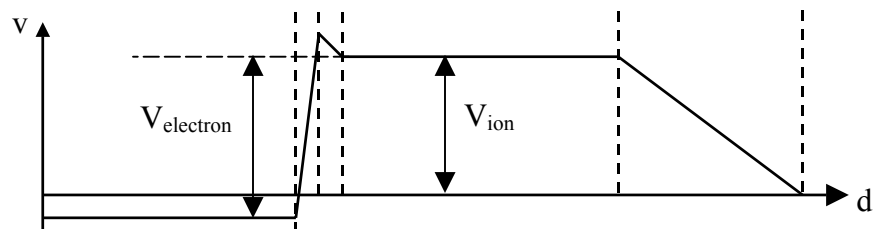
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(a)



(b)

Figure 1 (a) Schematic diagram of a double-chamber source. A beam consisting of electrons and positive ions can be formed using a single column. Larger dots represent positive ions, while smaller dots represent electrons. (b) Axial potential distribution of the setup.

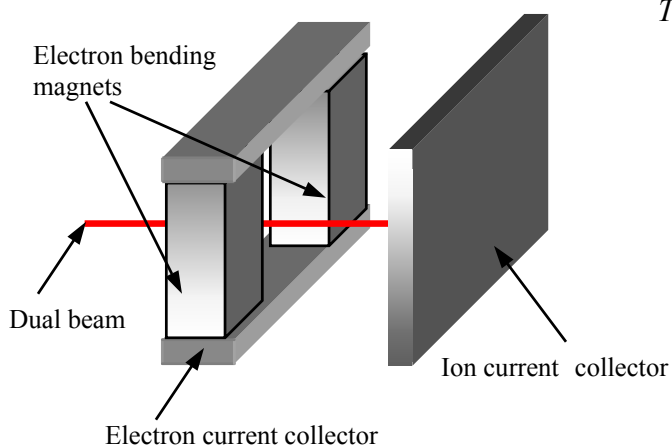


Table 1 Electron and ion beam current detected by the beam separator.

V_{electron} (V)	V_{ion} (V)	Beam current (nA)	
		Electron	Ion
600	0	-260	0
0	200	0	567
600	200	-260	1520

Figure 2 Schematic diagram of the beam separator used for dual beam detection.