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Development and brightness measurement of an electron impact gas ion source for proton beam writing applications

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In the recent past we have demonstrated the potential of proton beam writing (PBW) as a leading candidate for next generation lithographic technique 1. We are now progressing towards sub-10 nm lithography in nuclear microprobe experiments, but the beam resolution and writing time are limited by the low brightness radio frequency (RF) ion source currently used. We are developing a high brightness electron impact gas ion source, with expected brightness of about 4 to 5 orders of magnitude higher than RF ion source 3.

The idea of this electron impact gas ion source is to create ion beams, with small virtual source size of about 100 nm diameter, from a miniature chamber, by ionizing the gas molecules with electrons 3. The experiments are performed inside an environmental scanning electron microscope (ESEM). The extracted total ion beam current and ion source brightness were studied as function of gas inlet pressure (helium or argon gas), electron beam energy (500 to 2000 eV) and ion extraction voltage. With an electron beam current of 7 nA, this ion source produces 300-500 pA of Ar ions. The ion source reduced brightness is measured to be more than 100 A/m^2SrV, being one tenth of the electron beam brightness (measured as 10^3 A/m^2SrV) for 700 eV electrons. The results are limited by the poor brightness of the existing ESEM, but if used with a standard SEM our ion source brightness is expected to be 10^5 A/m^2SrV.

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