Contribution ID: **120**

Type: **Oral Communication**

Development of high brightness ion sources with an outlook to sub 10 nm beam spot size for a compact proton beam writing system

Tuesday, 8 July 2014 10:20 (20 minutes)

In the recent past we have demonstrated the potential of proton beam writing (PBW) as a leading candidate for the next generation lithography technique [1,2]. We are now progressing towards sub-10 nm lithography in nuclear microprobe experiments. To achieve this goal, plans are being rolled out to improve the performance of existing low brightness (~15 –70 A/m^2SrV) radio frequency (RF) ion source, used for the production of proton beams at CIBA, NUS. This RF ion source has potential to deliver higher brightness [3]. An Ion Source Test Bench (ISTB) set-up has been designed and commissioned in-house to extract the full potential of the existing RF ion-source. In future the ISTB will be used to test a novel ion source design, based on electron-impact gas ionization. Currently the ISTB coupled to an RF ion source has produced nitrogen and helium ions (ion current: ~ 5 μA) and can be operated at about 1-10 kV potential. In this paper we will discuss the integration of a Wien filter and the first brightness measurements in this ISTB.
Meanwhile 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), which will eventually be coupled to ISTB [4]. The idea, with this electron-impact gas ion source, is to create ion beams with small virtual source size of about 100 nm. The first experiments with small gas ionization chambers will be performed inside a Field Emission Scanning Electron Microscope in NUS. Different gases will be introduced into the source (e.g. helium, argon, and later hydrogen). The extracted ion currents for different gases will be studied as function of gas inlet pressure and injecting electron beam energy (200 to 1000 eV). In this paper we will present the experimental results and compare it with theoretical calculations. We will also give an outlook on the feasibility of developing a table top PBW system, capable of delivering 200 keV protons with sub-10 nm beam spot size.

We acknowledge the support from the US air force, Japan office

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Session Classification: Session 1 - Nuclear Microprobe Technology 1