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Development and SEM integration of the Nano Aperture Ion Source

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The Nano-Aperture Ion Source (NAIS) is a new type of ion source, researched by L. van Kouwen, which should enable several ion species (Ga^+, He^+, Ne^+, Xe^+) without compromising brightness[1] $\geq 1 \cdot 10^5 A/(m^2 srV)$, or energy spread. An electron beam from a Schottky source is focused on a hole in a nano gas channel. Gas flowing through this channel is ionized due to electron impact ionization, after which it is extracted from the source by an extraction potential (*Fig.1*).[2] L. van Kouwen identified problems with chip design and experimental setup. The production yield of the NAIS chips, created by MEMS technology, was low because two membranes needed a voltage difference while maintaining a 1-micron separation. Therefore, the chip design has been altered. These changes have considerably improved production yield and the maximum pressure the chip can withstand, up to 3 bar. This alteration does negatively affect the possibility to extract the ions from the chip, since an extraction field can only be applied outside the chip.

Instead of an electric field within the chip, a structure can be used to guide the gas towards the extractor, which can be created using Electron Beam Induced Deposition (EBID) (*Fig.2*). To optimize this structure, several simulations are performed in the Rarefied Gas Regime using Python and SPARTA. Together with an electric field and ion trace simulations in GPT, a theoretical brightness can be acquired and optimized by changing the structural design. An experimental setup is being used to test chip life time and perform brightness measurements (*Fig.3*). This setup is modified by applying a new extractor with a 6D-aligner directly onto the chip and by decoupling the chip position and the electrostatic components. However, if the NAIS chip is to be used for FIB applications, a large demagnification of the source is required to reduce the ion beam spot size. Therefore, an additional setup is being developed by combining a commercially available SEM and FIB columns in one device on the same beamline (NiCole and Tomahawk columns provided by Thermo Fisher Scientific). This setup is scheduled to be ready in 2023 and should produce a usable prototype.

[1] Leon van Kouwen, Pieter Kruit; Brightness measurements of the nano-aperture ion source; Journal of Vacuum Science & Technology B (2018).

[2] Leon van Kouwen; Introduction to focused ion beams, ion sources, and the nano-aperture ion source; Advances in Imaging and Electron Physics Including Proceedings CPO-10 (2019), Start Page 181.

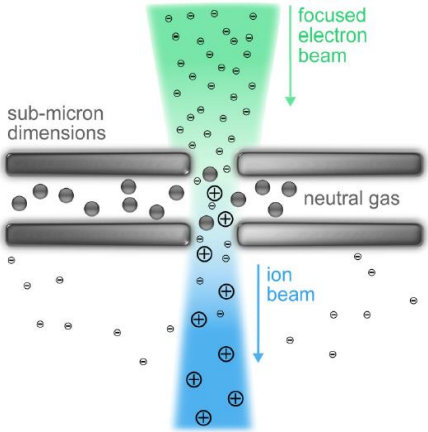

Fig.1 principle of the NAIS: gas is ionized by a focused electron beam and extracted by a strong electric field.

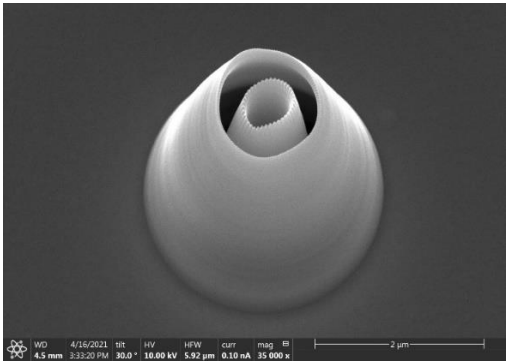

Fig.2 produced microstructure (EBID) to enhance ion beam performance.

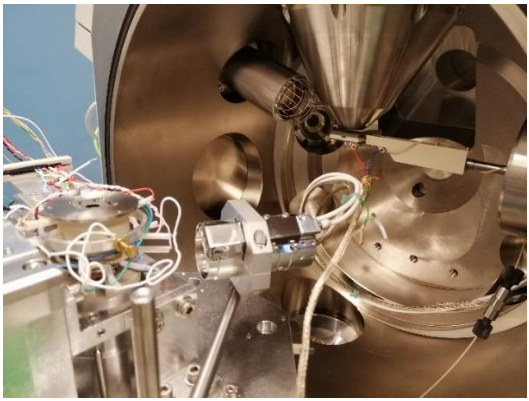

Fig.3 current experimental setup in SEM chamber.