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High-resolution X-ray source with advanced e-beam technology: pushing the resolution limitation for lab-scale NanoCT

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Since more than ten years, MetalJet sources, based on liquid-metal-jet technology, are successfully operated in many labs over the world. By using a high-speed jet of liquid metal, instead of the traditional solid- or rotating anode, it has been demonstrated that a much higher power can be applied to the anode. Since melting of the anode is thereby no longer a problem as it is already molten, MetalJet has achieved an at least 10x significantly higher brightness than the conventional solid-anode microfocus tube with the X-ray spot size range of 5- 40 μm. Key applications include X-ray diffraction and scattering, but several publications have also shown very impressive imaging results using liquid-metal-jet technology, especially in phase-contrast imaging and X-ray microscopy.

Driven by needs from scientific research, healthcare and industrial applications, X-ray microscopy has been successfully transferred from synchrotron to laboratory and the spatial resolution has been pushed to sub-micrometer. One way to further improve the resolution is to use the X-ray source with small focal spot. Based on advanced electron beam and target technologies, a state-of-art nanofocus x-ray tube has been developed by Excillum. The NanoTube N2 reaches an isotropic resolution of 150 nm lines and spaces.

Further unique features include high stability for long-time imaging investigations, continuous switching among different voltage and spot size without change in X-ray spot position, internal electron-beam size measurement and user-defined electron-beam deflection. Furthermore, the front surface of the NanoTube is cone shaped, so that the sample could be mounted as close as possible to the focal spot with standard a CT sample holder.

Typical nanofocus X-ray tubes normally have rather limited flux, which leads to long acquisition times of nanoCT in lab. The NanoTube N2 was launched in 2020 and is currently available at 60 kVp, and 110 kVp. The newly released NanoTube N2 60 kV achieves at least 3x higher flux than its predecessor (NanoTube N1) at 60 kV, which means a 3x faster image acquisition. NanoTube N2 110 kV offers further increase in flux at small spot sizes and a higher emission voltage, enabling larger and/or higher absorbing samples, covering most materials science applications.

Until now the NanoTube has been integrated into different Nano-CT systems for applications of biomedical [1][2][3] and materials science [4], as well as non-destructive testing and industrial inspection. Particularly, the Nano-CT system developed at Fraunhofer IIS, has turned into a commercialized system through ProCon X-ray GmbH.

References

[1] M. Müller et al., (2017). PNAS 114 (47), 12378-12383 (2017)
[2] S. Ferstl et al., IEEE Transactions on Medical Imaging, 1-1 (2019)
[43] J. Romell et al., Proc. of SPIE 11112, X-ray Nanoimaging: Instruments and Methods IV (2019)
[4] C. Fella et al., Microscopy and Microanalysis, 24(S2), 234-235 (2018)