excillum

# NanoTube N2


## Join the nanoscale resolution revolution

Introducing

NanoTube N2 60 kV

NanoTube N2 110 kV

## Introducing NanoTube N2

# The highest imaging resolution at more power and higher voltage

The Excillum NanoTube N2 enables industry-leading resolution in geometric- magnification X-ray imaging systems, and with an imaging speed at 60 kV that is more than 3 times faster than its predecessor, the NanoTube N1. The NanoTube N2 is also introduced at 110 kV, enabling higher penetrating power and even higher imaging speed.

The NanoTube N2 is based on advanced electron optics and the latest tungsten-diamond transmission target technology. Automatic e-beam focusing and astigmatism correction ensures that the smallest possible, truly round spot is achieved.

The NanoTube N2 also has the unique feature of internally measuring and reporting the current spot size. In addition, advanced cooling and thermal design results in extreme stability over long exposures. This enables an unprecedented true resolution of 150 nm lines and spaces.

### Features and benefits

- Superior spot quality with automatic e-beam focus of true round spot.
- Internal absolute spot size measurement.
- More than 3 times higher flux at 60 kV than the NanoTube N1. Even higher at 110 kV.
- Long-life cathode.
- Variable spot size and power setpoints with unchanged spot position.
- Cone-shaped front for excellent geometrical access to X-ray spot.

| Technical specifications NanoTube 60 kV | | | |
|---|---|---|---|
| **Voltage** | 20-60 kV[1] | **Power on target** | 0.3-2.4 W |
| **High brightness $LaB_6$ emitter** | | **Target material** | Tungsten (W) on diamond |
| **Resolution** | 150 nm-600 nm | **Target type** | Transmission |
| **Min. focus-object distance** | 100 µm | **Long term spot stability** | < 50 nm |

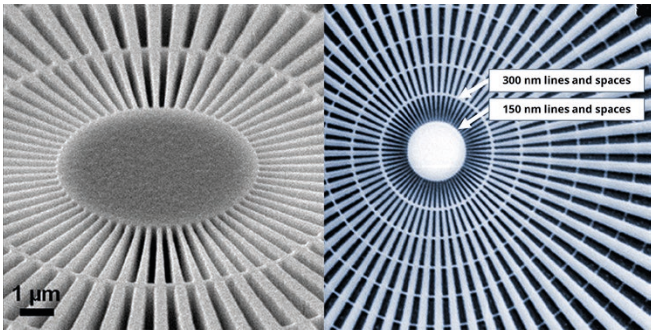
| Technical specifications NanoTube 110 kV | | | |
|---|---|---|---|
| **Voltage** | 20-110 kV[1] | **Power on target** | 1.3-6.1 W |
| **High brightness $LaB_6$ emitter** | | **Target material** | Tungsten (W) on diamond |
| **Resolution** | 150 nm-600 nm | **Target type** | Transmission |
| **Min. focus-object distance** | 100 µm | **Long term spot stability** | < 50 nm |

*1) Fully automated spot-size control at >40 kV.*

## True round spot

The true round spot of the NanoTube N2 is demonstrated by the highly symmetric images of a Siemens star resolution target. The innermost features are 150 nm.

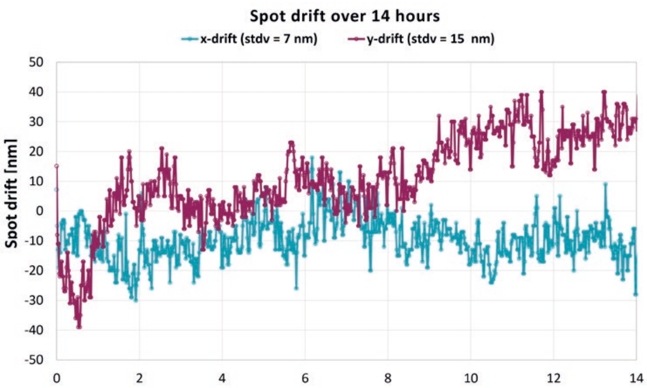
The image on the left shows a SEM micrograph of a Siemens star and a projection radiograph captured using the NanoTube N2 is shown on the right.




*From experiment in collaboration with Fraunhofer IIS (NanoCT systems) using a Dectris PILATUS3 X CdTe 300K-W detector.*

## Long term positional stability

Thanks to the advanced e-beam system of the NanoTube N2 and the integrated thermal control, excellent long-term stability is achieved. This graph illustrates the motion of the spot relative to a fix point on the anode over 14 hours as measured internally by the source when at thermal equilibrium. Naturally, great care must be taken regarding the stability of the imaging system to maintain the same stability throughout the imaging chain.




## Excellent geometrical access

The end of the transmission target is the most protruding surface to allow for a sample to get as close as possible to the X-ray focal spot. The front is furthermore cone-shaped to allow for a sturdy cone-shaped sample holder.

## Flux increase

The NanoTube N2 achieves an impressive increase in flux. Compared to its predecessor, the NanoTube N1, the NanoTube N2 60 kV achieves 3 times higher flux. This example shows a tomographic slice from a NanoCT of an SD-card, performed with the NanoTube N1 60 kV (top image) and the NanoTube N2 60 kV (bottom image) – achieving a voxel sampling of 200nm.

The comparative NanoCT measurement was done by keeping a similar level of photon counts. With the increase in flux by the NanoTube N2 60 kV, the measurement time was reduced from 15 hours to 4 hours. At the same time, the signal-to-noise ratio gave even higher image quality, due to the reduced motion within the CT measurement.

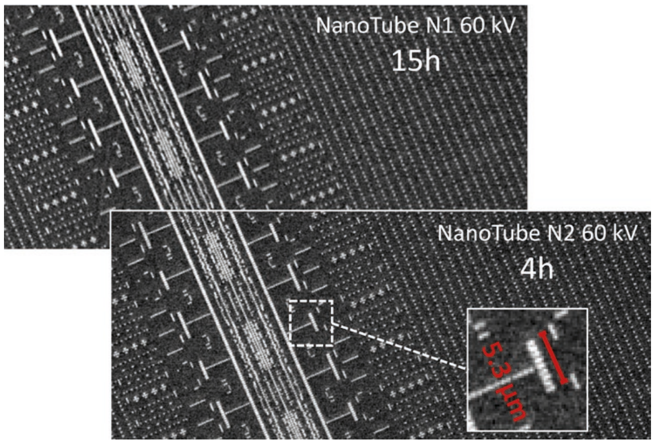
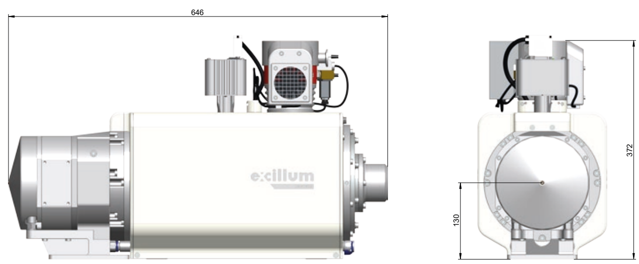
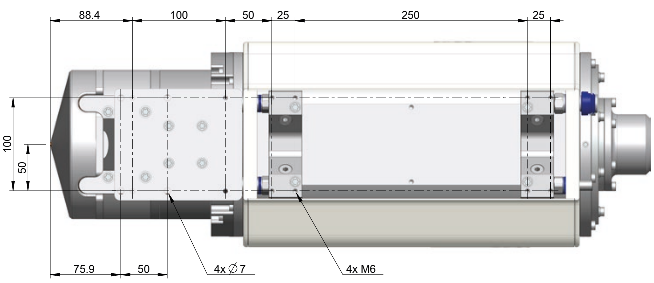



*Photo credit: Dr. Christian Fella, Fraunhofer Institute for Integrated Circuits IIS, Würzburg, Germany*

## Dimensions

646 x 220 x 372 mm (L x W x H) excluding cables.



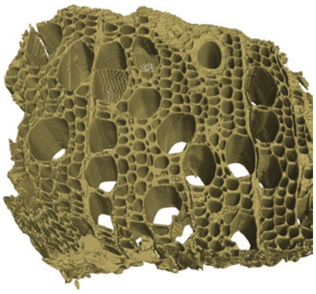
# See nano structures with unprecedented precision

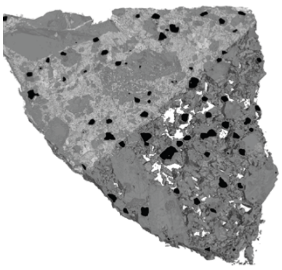
## NanoCT for materials characterization

A NanoCT system with the new Excillum NanoTube N2 was designed, developed and commissioned at Fraunhofer IIS, Würzburg, Germany. Together with an EIGER2 CdTe detector, the system is optimized for materials characterization and NDT applications.

## Geological and raw materials

The image shows a 3D rendering of the phase-contrast NanoCT of an alder wood sample, revealing the inner microstructure of the wood in high resolution. Voxel sampling 300 nm.

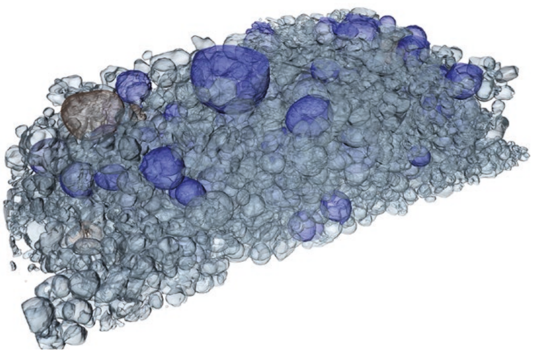




A 3D rendering of the phase-contrast Nano-CT of a basalt sample, revealing the different phases, elements and structures help geologists to further understand this sample. Voxel sampling 350 nm.

## Battery research

A 3D rendering of the NanoCT of a lithium ion battery cathode (NCA/LCO-E), showing particles of different sizes. Voxel sampling 140 nm.



## NanoCT for NDT, metrology and inspection

A 3D rendering of an SD card, showing the full reconstruction of the internal features and structures. Voxel sampling 200 nm.

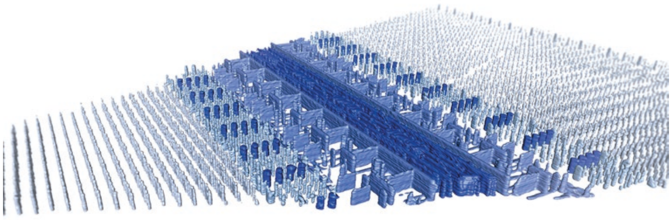
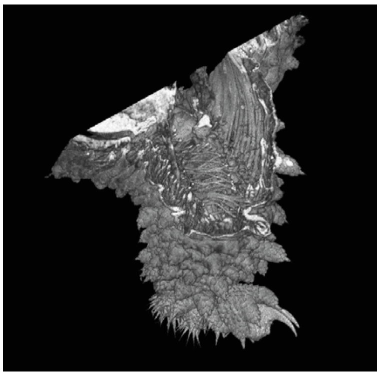


*Photo credit if not stated otherwise: Dr. Christian Fella, Fraunhofer Institute for Integrated Circuits IIS, Würzburg, Germany*

## NanoCT for life sciences

A NanoCT device comprising of a NanoTube and a photon counting detector provides the ability of tomography with very high resolution. At the Technical University of Munich, Germany, the device has achieved a state-of-art ~100 nm spatial resolution and capability of investigating phase-contrast imaging.

A NanoCT image of the leg of a velvet worm (0.4 mm long). The surface morphology can be visualized with an image quality similar to scanning electron microscopy, and simultaneously the visualization of internal musculature at a resolution higher than confocal laser scanning microscopy.



*M. Müller, et al., "Myoanatomy of the velvet worm leg revealed by laboratory-based nanofocus X-ray source tomography", PNAS (2017).*

## Safety and compliance

*For information about the safety and compliance of all Excillum X-ray sources, please visit our website: excillum.com/compliance*

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