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NanoMi: Progress on an Open-Source Electron Microscope

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NanoMi [1,2] is a public license platform we are developing for building low-cost electron microscopy hardware as-well-as Python-based control software. A key design consideration for the NanoMi was the affordability and ease with which the components could be manufactured. This allows the NanoMi to be used as the basis for low-cost, hands-on educational lab practicals on electron microscope design, construction, and operation. Additionally, as all parts are ultra-high vacuum compatible, independent of the vacuum envelope, and modular, the platform may allow for electron-optical capabilities to be added to existing vacuum systems. All parts have been designed for sub-50 keV operation with electrostatic optics to avoid the need for water-cooling.

At present, the core components for an electron microscope including electrostatic lenses, deflectors, stigmators, sample/aperture holders and movers, and the vacuum chamber have been designed; as have the control electronics and software (Figure 1) to control the components. With the current parts, we have assembled a working electron microscope – the NanoMi V1 – which is capable of obtaining transmission (TEM), scanning (SEM), and scanning transmission (STEM) images at modest resolution as well as transmission diffraction patterns. Transmission images are captured using an off-the-shelf optical camera pointed at a scintillator screen mounted at the end of the vacuum envelope. Image data can be fed into the Panta-Rhei Image Viewer by CEOS GmbH for real-time display and processing.

Here, we demonstrate the progress which has been achieved in the optical configuration and control interface of the first fully assembled and functional instrument. We present example images that have been currently achieved (Figure 2) and explain how the electron-optical components are interfaced with electronic and software controllers. We detail the challenges encountered and overcome with the assembly and operation of the first V1 instrument.

Nanomi.org and <https://github.com/NRC-NANOMi/NanoMi> provide further information and downloadable Python software code.

References

- [1] M. Malac et. al, NanoMi: An open source electron microscope hardware and software platform, Micron 163 (2022) 103362.
- [2] Support for the project was provided by NRC-NANO and by NSERC RGPIN-2021-02539

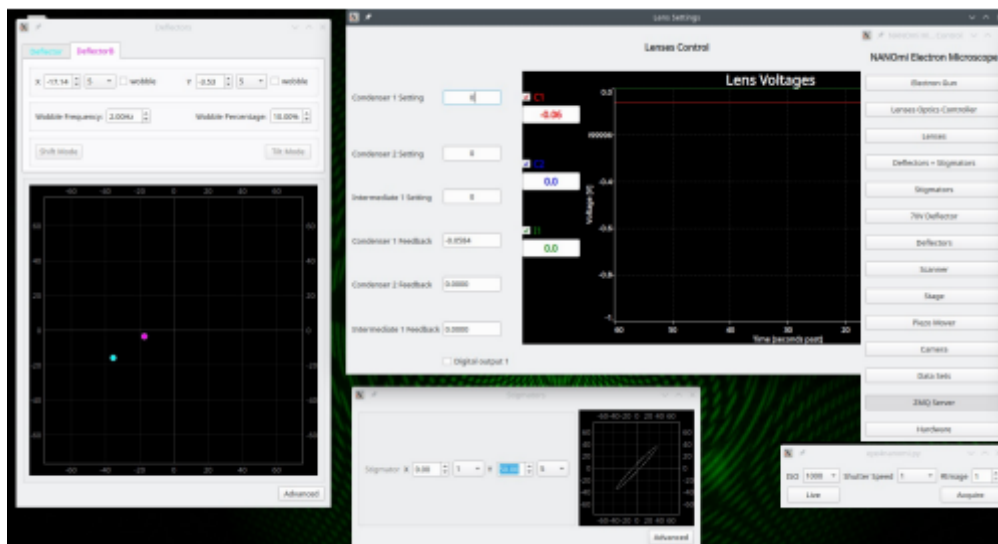


Figure 1. Example of the software control interface. The panel on the far right opens windows for various control interfaces. The other displayed windows are the controllers for the deflectors, stigmators, lenses, and camera.

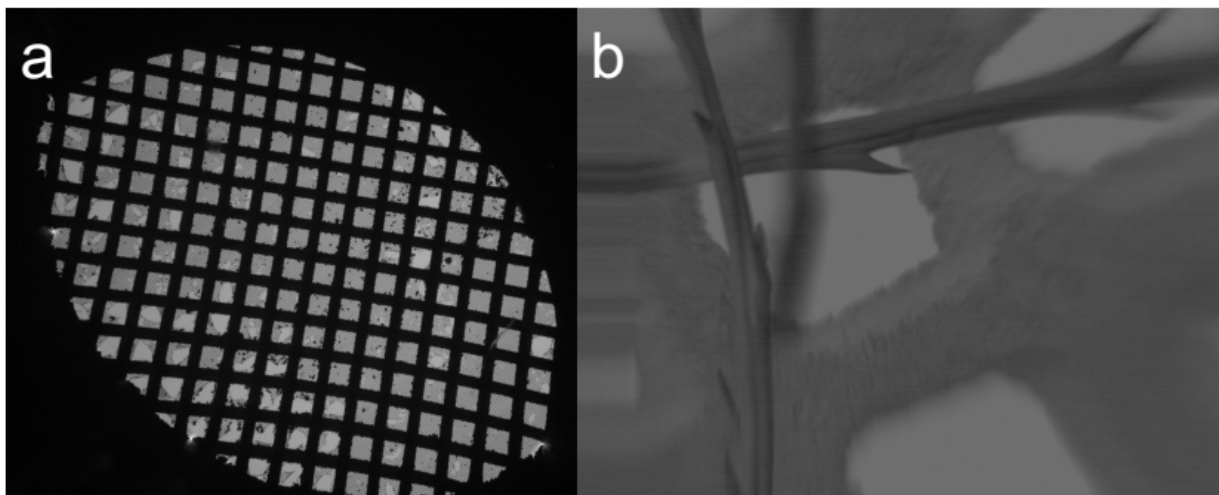


Figure 2. Examples of images acquired on NanoMi V1. a) TEM image of a Quantifoil carbon mesh with $7\mu\text{m}$ square holes and $2\mu\text{m}$ thick grid bars. b) SEM image of a carbon-coated dandelion parachute on a 2000 mesh copper grid.