OpenSPM: A Modular Framework for Open and Smart Microscopy

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OpenSPM aims to democratize innovation in the field of scanning probe microscopy (SPM), which is currently dominated by a few proprietary, closed systems that limit user-driven development. Our platform [1-3] includes a high-speed OpenAFM head and base optimized for small cantilevers, an OpenAFM controller, a high-voltage amplifier, and interfaces compatible with several commercial AFM systems such as the Bruker Multimode, Nanosurf DriveAFM, Witec Alpha SNOM, Zeiss FIB-SEM XB550, and Nenovision Litescope, able to image using different modes (Figure 1). We have developed a fully documented, community-driven OpenSPM platform, complete with training resources, sourcing information, and hands-on workshops for building key components (AFM head, SPM controller, HV amplifier), which has already facilitated the construction of over 15 systems beyond our laboratory. The controller is integrated with open-source tools like Gwyddion, HDF5, and Pycroscopy. We have also engaged external companies, two of which are integrating our controller into their products.

We see growing interest in applying parts of the OpenSPM platform to related techniques such as correlated microscopy, nanoindentation, and scanning electron/confocal microscopy. To support this, we are developing more generic and modular software, alongside a structured development workflow. A key feature of the OpenSPM system is its Python-based API, which makes the platform fully scriptable and ideal for AI and machine learning applications. This enables, for instance, automatic control and optimization of PID parameters, setpoints, and experiment workflows. With a growing contributor base and industry involvement, OpenSPM is well positioned to become a global, open platform for next-generation SPM innovation.

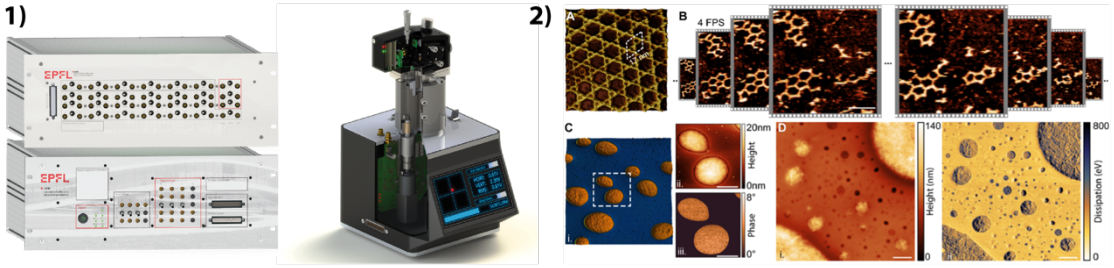

Figure 1. 1) Renders of the SPM controller, HV amplifier, and AFM base and head. 2) A) High-resolution image of p6 crystal form of annexin V. B) Dynamic assembly of hexagonal lattices formed by DNA tripods captured at 4 frames per second, scale bar 0.1 µm. C) AM-AFM image of PS/LDPE. 3D height image, color mapped with the phase image (i.), zoomed in height (ii.) and phase images (iii.), scalebars 1µm. D) ORT mode image of PS/LDPE, height (i.) and dissipation channels (ii.), scalebars 1µm.

References

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[3] A. P. Nievergelt, et al. Small Methods **3**, 1900031 (2019)