A LOW-TEMPERATURE ATOMIC FORCE MICROSCOPE FOR QUANTUM NANOSCIENCE

GRÜTTER RESEARCH GROUP
NANOSCIENCE & SCANNING PROBE MICROSCOPY
McGill

- Lily Williams and Sean Magnifico from the Grutter Nanoscience and SPM Group, McGill University
- JPE product used: UHV Cryogenic Connector

[1] Bustamante, José, et al. "Needle in a Haystack: Efficiently Finding Atomically Defined Quantum Dots for Electrostatic Force Microscopy." *Review of Scientific Instruments*, vol. 95, no. 8, Aug. 2024, p. 083709. *DOI.org (Crossref)*, https://doi.org/10.1063/5.0208571.

The experiment

Developing tools to probe the quantum properties of single-electron and nanoscale semiconductor devices demands instrumentation that is not only highly sensitive, but also robust and reliable under cryogenic and vacuum conditions. In our recent work, we constructed a custom Atomic Force Microscope (AFM) system capable of characterizing critical device features such as geometry, surface roughness, and electrostatic potential—with the ultimate goal of resolving energy levels in quantum dots and single-electron transistors.

A central challenge in this experiment was locating and characterizing nanometre-sized quantum dots buried in a 10×10 mm² silicon die—a task made even more complex in vacuum and at cryogenic temperatures. System stability and reliability were essential, and this is where JPE-branded cryo- and vacuum-compatible plugs made a critical difference.

These plugs provided robust electrical connections that withstood thermal cycling and mechanical strain, dramatically reducing wire breakage and electrical shorts. Their integrated strain relief helped maintain signal integrity over long scans and cooldown periods, while their ease of soldering significantly streamlined the assembly process—saving us time and reducing human error compared to our previous connector systems.

By ensuring reliable signal transmission and simplifying hardware integration, the JPE plugs played a key role in enabling a stable and functional cryogenic AFM platform. Their use allowed us to focus on the experimental challenges of quantum device characterization, rather than troubleshooting wiring failures—ultimately making this complex experiment possible.

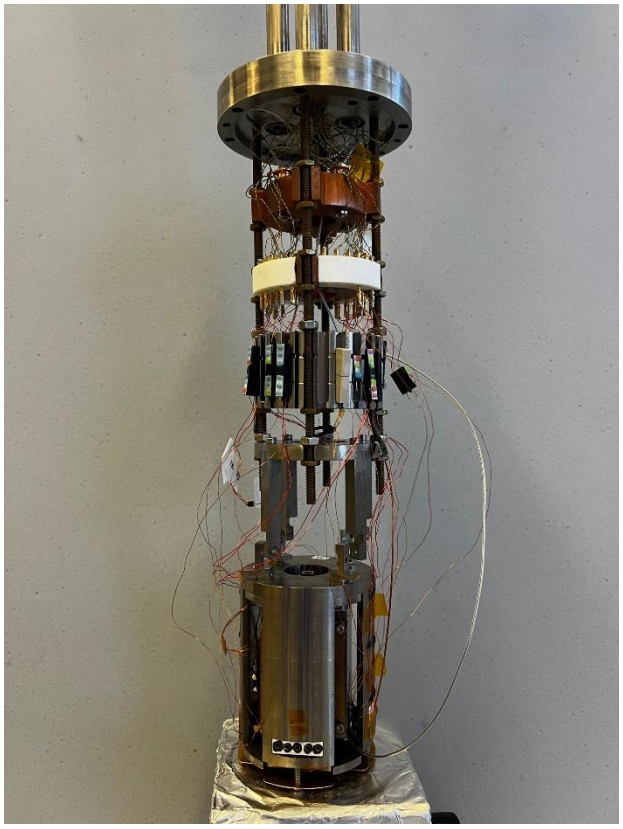


Figure 1: The low-temperature and UHV-compatible JPE plugs play a critical role in the function of the AFM. Almost all of the wires that now run the system have been converted to JPE plugs.

JPE Aziëlaan 12, 6199 AG Maastricht-Airport, The Netherlands +31 (0) 43 3585 777 www.jpe.nl

© JPE. Subject to change without notice. All data are outdated by any new release.
JPE disclaims any liability with regard to the accuracy, completeness, and timeliness of the information provided.