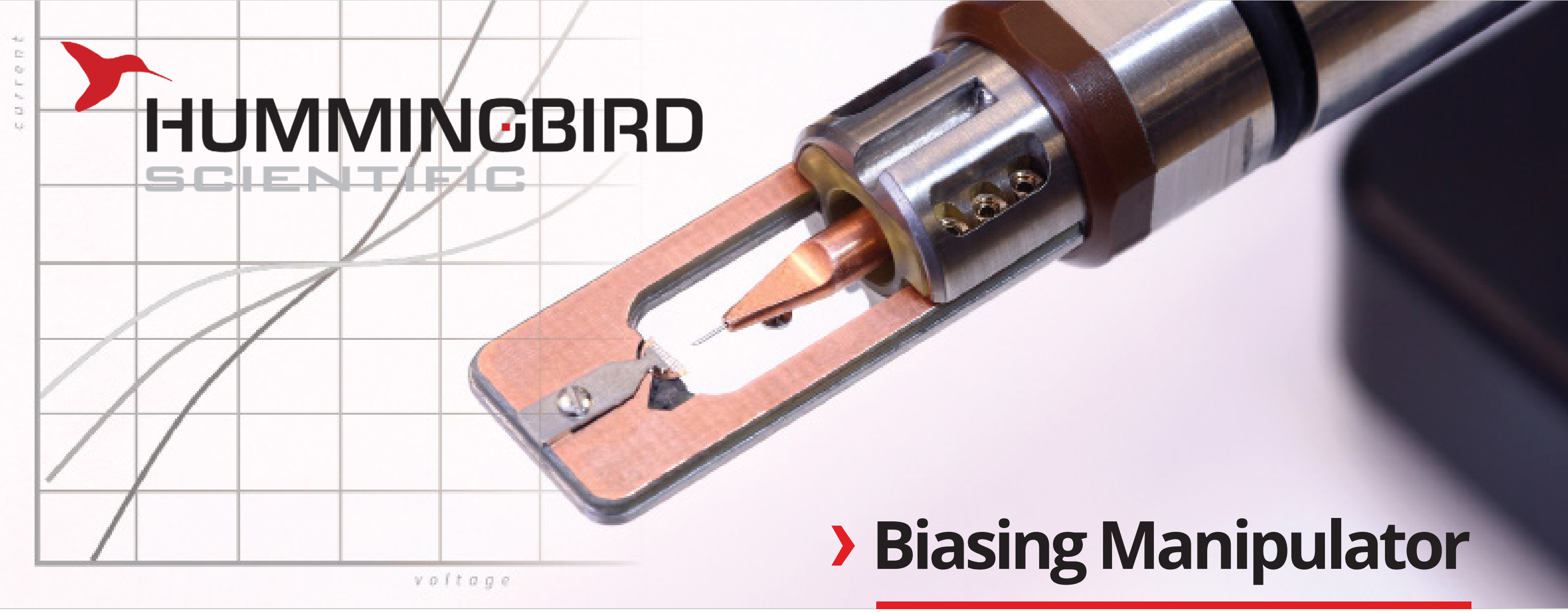


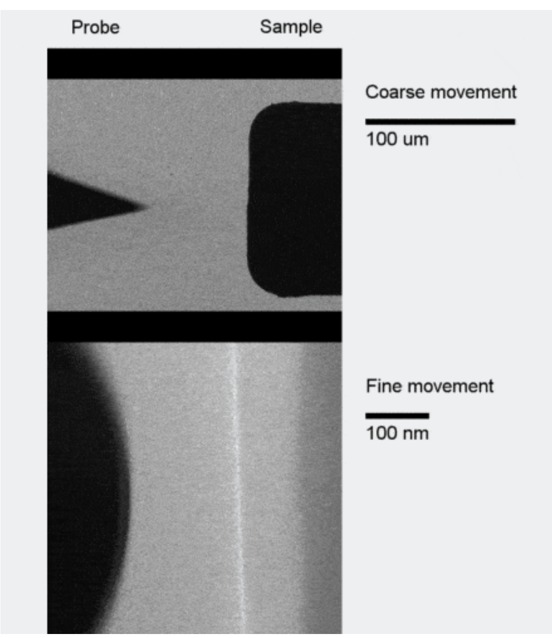
Biasing Manipulator

Technical Specs

	1800 Series
Coarse Movement Range	
***X* axis**	> 1000 µm
***Y* and *Z* axes**	500 - 1000 µm
Fine Movement Range	
***X* axis**	2 - 3 µm
***Y* and *Z* axes**	~ 40 µm
Electrical Contacts	2 standard (3 – 7)*
Current Resolution	100 pA standard (< 10 pA)*
Sample Compatibility	3 mm half grids, FIB lift-out grids, or custom*
TEM Compatibility	TFS, JEOL, Hitachi

** Contact us for custom configurations*

Overview



Hummingbird Scientific's in-situ Biasing Manipulator is the only reliable TEM holder in the market with proven capability to perform in-situ sample manipulation and site-specific electrical biasing. The holder provides accurate uncoupled movements along the X, Y, and Z axes of motion, allowing for easy point-contact with the sample and high-resolution TEM imaging. The holder is easy to use, requires little maintenance, and is available for all major TEM manufacturers (JEOL, Thermo Fisher Scientific, and Hitachi)

Key Features:

- Mobile probe for electrical contacts
- Probe's uncoupled coarse and fine movements along X, Y, and Z axes
- Easy probe exchange
- Removable sample cartridge
- Intuitive graphical user interface

Sample Applications:

- Battery Materials
- Nano-Electronic Devices
- Solar Cell
- Semiconductors

How it Works

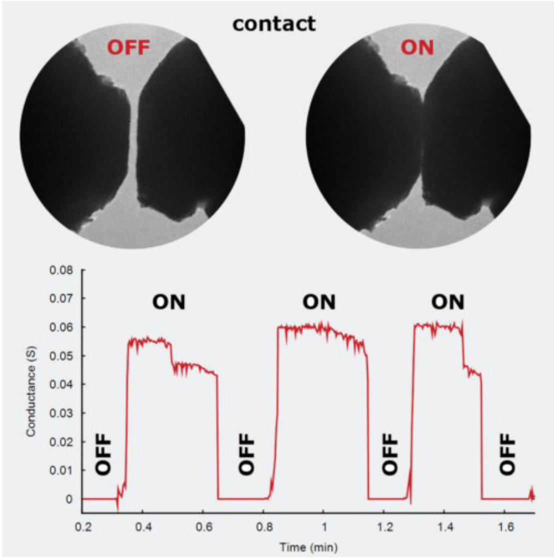
Correlate the structure and chemistry of a sample (HRTEM, electron diffraction, EELS, etc.) with its electrical properties.

Manipulate the mobile biasing probe with high spatial resolution to make electrical contacts.

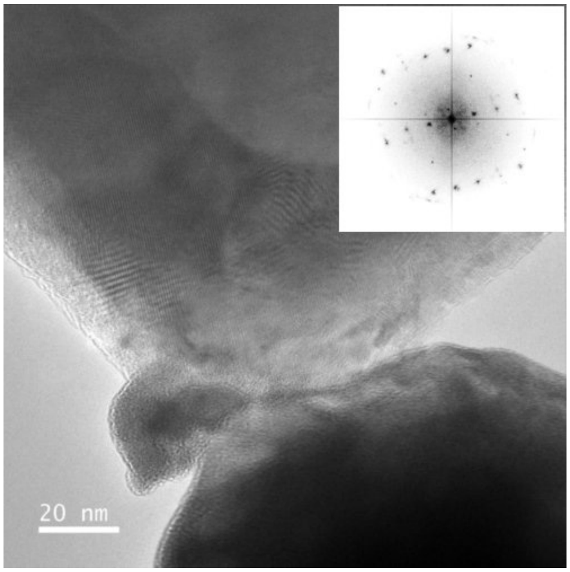
Control—uncoupled—coarse and fine movements along the X, Y, and Z axes. Coarse movements are actuated with thumb-screws. Fine movements are actuated with a piezoelectric controlled with the included controller and graphical user interface.

Take low noise electrical data with individual coax cables.

Use standard 3 mm half grid samples or FIB lift-out grids to prepare your samples.



Characterize Electrical Contacts



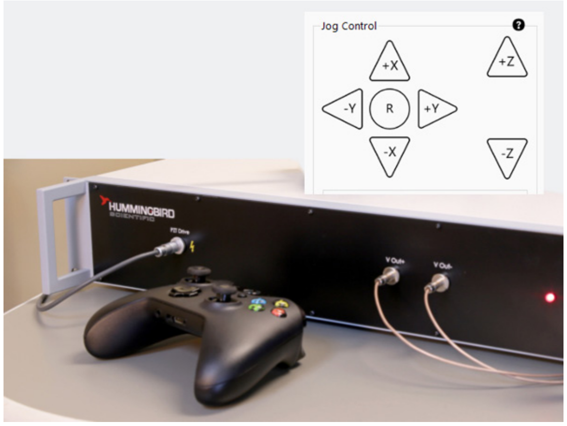
Use the full battery of TEM-based characterization techniques to record the structure and chemistry of biased electrical contacts. The wide opening area at the contact between mobile probe and sample is compatible with—and optimal for:

- High-resolution TEM imaging
- High-resolution STEM imaging
- Electron diffraction
- Energy dispersive x-ray spectroscopy (EDS)
- Electron energy loss spectroscopy (EELS)

The example shows a TEM image of a 60 nm-wide contact between the mobile biasing probe and a metal-based sample. The structure of the contact has been resolved with high spatial resolution.

Software

Hummingbird Scientific's graphical user interface features an intuitive fine movement control panel that facilitates and expedites the probe-sample contact process. Functions for varying the fine motion direction and steep size are available, and any parasitic motion in the axes can be compensated with an integrated compensation algorithm. The user can concentrate on the experiment—not on making the contact. The in-situ TEM biasing manipulator platform comes with and integrated voltage source meter supporting electrical measurements, data plotting, and data recording.



Featured Research

In-situ TEM probing of lithium interfaces for solid-state batteries

Using Hummingbird Scientific's in-situ TEM Biasing Manipulator holder, researchers at Toyota Research Institute of North America and the University of Pennsylvania devised an experiment in which air-sensitive lithium metal is brought in contact with novel solid-state electrolytes to observe the degradation mechanism during the lithium charge and discharge cycles. They observed dendrites and delamination of lithium metal upon reaction with lithium thiophosphate (LPS) electrolyte. However, when the same electrolyte is doped with lithium iodide, the dopant plays a protective role and prevents such degradation. This improves the lithium cycling capacity. The in-situ TEM manipulation and biasing capabilities can accelerate the fundamental understanding and microstructural evolution of nanostructured battery materials to develop better batteries.

Reference: Singh et al. Chem. Mater. 2020, 32, 17, 7150–7158. DOI: 10.1021/acs.

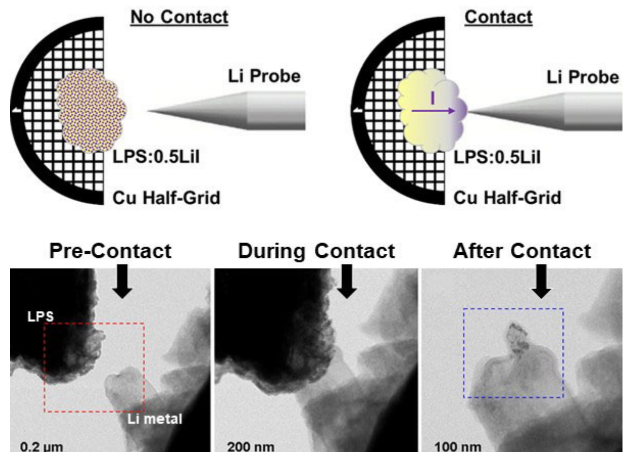
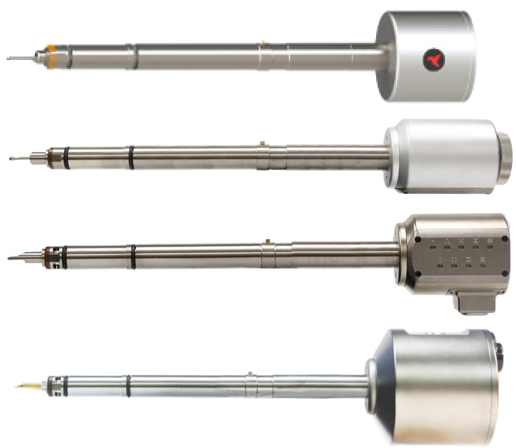


Figure: In-situ probing of solid LPS electrolyte against lithium metal showing lithium dendritic growth and delamination during charge and discharge cycle.

Related Products



- **Biasing Holder**
  Wire-bonded samples to investigate working devices
- **Air-Free Transfer Biasing Holder**
  Air-Free sample transfer to the TEM
- **MEMS Heating + Biasing**
  Transport measurements at different temperatures
- **Cryo-Biasing Holder**
  Exploring quantum and advanced energy materials

Selected Publications

Zeyang Zhang, Jean E. Calderon, Saisaban Fahad, Licheng Ju, Dennis-Xavier Antony, Yang Yang, Akihiro Kushima, and Lei Zhai. **"Polymer-Derived Ceramic Nanoparticle/Edge-Functionalized Graphene Oxide Composites for Lithium-Ion Storage,"** *ACS Applied Materials & Interfaces* (2021)

Jung Ho Yoon, Jiaming Zhang, Peng Lin, Navnidhi Upadhyay, Peng Yan, Yuzi Liu, Qiangfei Xia, J. Joshua Yang, **"A Low-Current and Analog Memristor with Ru as Mobile Species,"** *Advanced Materials* (2020)

Nikhilendra Singh, James P. Horwath, Patrick Bonnick, Koji Suto, Eric A. Stach, Tomoya Matsunaga, John Muldoon, and Timothy S. Arthur. "**Role of Lithium Iodide Addition to Lithium Thiophosphate: Implications beyond Conductivity**." *Chemistry of Materials* (2020)

Nikhilendra Singh, James Horwath, Timothy Arthur, Daan Hein Alsem, Eric Stach. **"Using Operando Electrochemical TEM as Part of a Correlative Approach to Characterize Failure Modes in Solid-State Energy Storage Devices."** *Microscopy & Microanalysis* (2020)

Eric Stach, James Horwath, Nikhilendra Singh, Timothy Arthur, Daan Hein Alsem, Norman Salmon. **"Understanding the Relationship Between Air Exposure, Electron Dose and Beam Damage in Solid Electrolyte Materials."** *Microscopy & Microanalysis* (2020)

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