

> Air-free Transfer

Technical Specs

	1580 Series	Biasing Transfer	3 mm Sample Transfer
High Vacuum Transfer		Yes	Yes
Inert Gas Transfer		Yes	Yes
Number of Electrical Contacts		9*	0
Contact Type		Direct Chip Contact	N/A
Settled Resolution		Up to TEM Resolution	Up to TEM Resolution
High Temperature On-Chip Sample Heating		Yes)	Yes
EELS/EDS Compatible		Yes	Yes
TEM Compatibility		Yes	Yes

* Contact us for Custom Configurations



Overview



Hummingbird Scientific's Air-Free Transfer TEM Sample Holders enable the transfer of air-sensitive samples from the preparation chamber to the TEM inside the holder, either in high vacuum or in inert gas conditions. Example applications of this holder are in-situ materials experiments with air sensitive materials for:

- > Solid-state electrolyte materials
- > Nano-scale semiconductor materials

This holder is available in two versions:

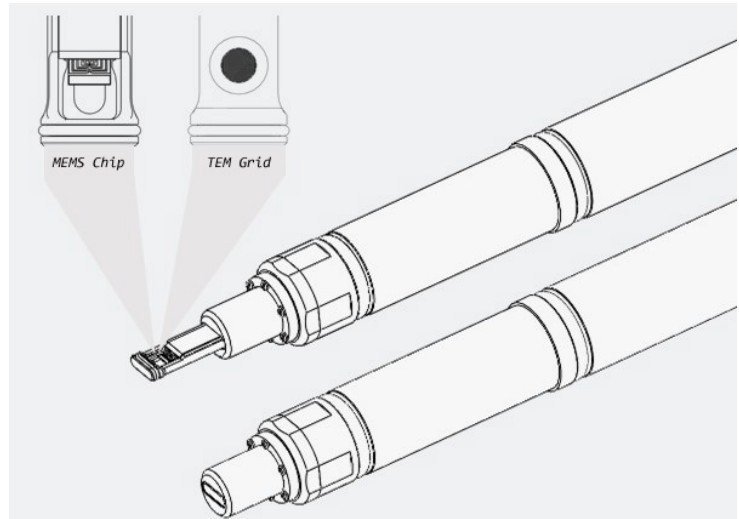
- > On-chip electrical biasing with 9 pins for in-situ biasing & imaging
- > 3mm grid samples for transfer & imaging in TEM

How it Works

Hummingbird Scientific offers air-free transfer of samples using two TEM platforms with distinct sample geometries:

- MEMS Chip with Biasing Contacts
- Standard 3mm TEM Grid

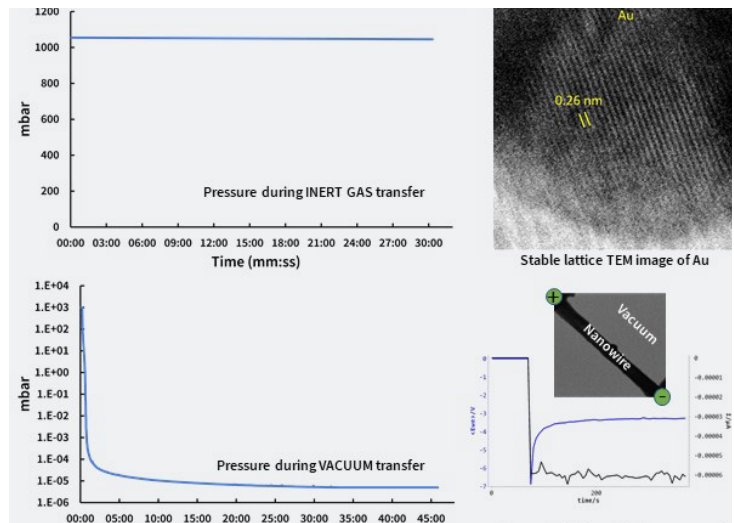
Based on the type of the transfer holder (MEMS chip vs. TEM grid), the sample is loaded onto the MEMS biasing chip or the TEM grid of the holder tip inside the preparation chamber (e.g. a glove box) for the transfer. After loading the sample, the tip is retracted into the body of the holder and hermetically sealed in either an inert gas environment or high vacuum. Once inside the TEM, the sample tip is opened to allow TEM imaging and in-situ TEM experiments.



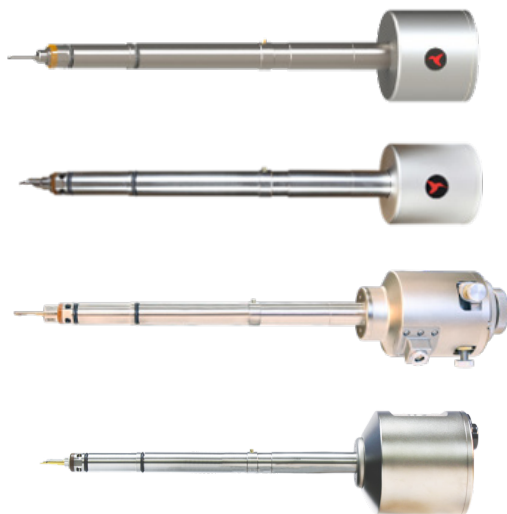
Vacuum/Inert Gas Transfer, Electrical Biasing & Imaging

To perform a successful transfer of an air-sensitive sample from a preparation chamber to the TEM, it is important to consider the best environment to keep the sample free of damage. Some air-sensitive samples transfer best under high vacuum environments, whereas others are best transferred in inert gas conditions.

Hummingbird Scientific's Air Free TEM Transfer Holders are designed to hold both a positive pressure over the atmosphere for an inert gas transfer (Figure Top Left) or hold a high vacuum during a transfer (Figure Bottom Left). The holder's biasing version has up to 9 electrical biasing contacts for on-chip electrical biasing and heating. The holder's 3 mm grid version of the holder similarly allows TEM characterization of air-sensitive samples.



Related Products



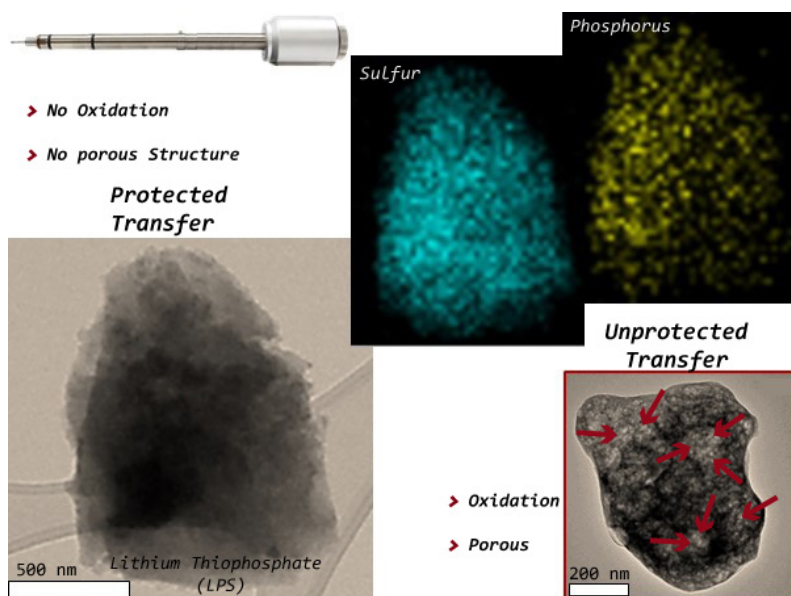
- **Biasing Holder**
Wire-bonded samples to investigate working devices
- **MEMS Biasing + Heating Holder**
High temperature transport measurements—phase changes
- **Biasing Manipulator Holder**
In-situ electrical contacts with mobile probe
- **Cryo-Biasing Holder**
Exploring quantum and advanced energy materials

Featured Research

Air-free transfer of air-sensitive solid-state battery electrolyte material

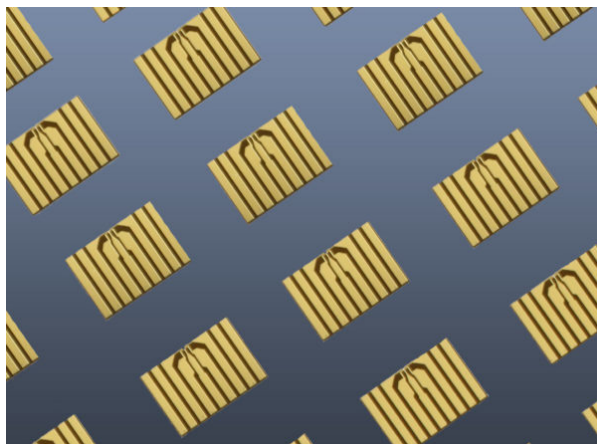
Solid-state batteries are generally non-flammable and studied for use in future electric vehicles. However, solid electrolytes are known to be highly sensitive to air and moisture.

Researchers at Toyota Research Institute of North America and the University of Pennsylvania successfully transferred air-sensitive solid-state electrolyte material (Lithium Thiophosphate – LPS) inside the TEM using Hummingbird Air-free Transfer holder. There are clear differences between samples transferred with and without the TEM transfer holder (Figure – Right). The LPS particle transferred using the Air-Free Transfer TEM holder shows no sign of surface oxidation and degradation. The electron dispersive spectroscopy (EDS) data confirms no significant level of oxygen on the surface. The same LPS material transferred to the TEM in a standard holder without a protective mechanism (Figure – Bottom Right) undergoes surface oxidation resulting in a porous microstructure.



Data Courtesy: Dr. Nikhilendra (Nik) Singh, Toyota Research Institute of North America, James Horwath and Dr. Eric Stach, University of Pennsylvania

Accessories



Accessories available for your Air-free Transfer holder include:

- > Specialized Heating/Biasing and Biasing MEMS Chips
- > MEMS Heating/Biasing Controller
- > Specialized Sample Biasing Substrate (e.g., FIB Prep)
- > Biasing Power Supplies – Contact Us for Configurations
- > Vacuum Tip Cover

Selected Publications

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

For the most up-to-date Selected Publications please visit: <https://hummingbirdscientific.com/products/air-free-transfer/>



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