HUMMINGBIRD SCIENTIFIC

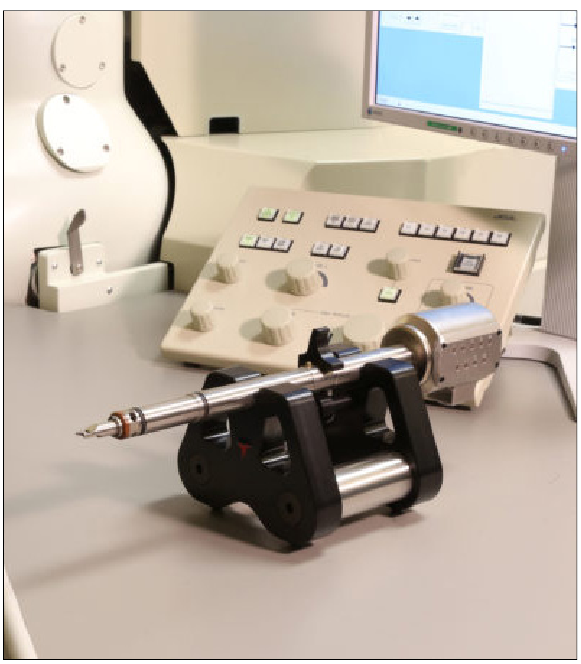
MEMS Heating + Biasing

Technical Specs

1550 Series	Single-Tilt	Double-Tilt
Tilt Range	Up to ± 45° depending on objective pole	Up to ± 20° (alpha and beta) depending on objective pole
Beta-tilt accuracy	N/A	< 0.01 degrees
Electrical Contacts	9*	9*
Contact Type	Direct Chip Contact	Direct Chip Contact
Max Operating Temperature	> 1000°C	> 1000°C
Settled Resolution at 1000°C	Up to TEM resolution	Up to TEM resolution
Temperature Stability	+ 100 hours	+ 100 hours
Temperature Measurement	4-point resistance sensing	4-point resistance sensing
EELS / EDS Compatible	Yes (full temp range)	Yes (full temp range)
TEM Compatibility	TFS, JEOL, Hitachi	TFS, JEOL, Hitachi

** Contact us for Custom Configurations*

Overview



Hummingbird Scientific's in-situ TEM MEMS Biasing/Heating Sample Holder allows users to heat and/or electrically bias their sample inside the TEM. Heating can be performed to > 1000°C in closed loop control with an on-chip sensor.

The system features:

- Direct chip contact insertion mechanism—no fragile probes that make inconsistent contact involved, so easy to use.
- Standard MEMS chip biasing/heating with 9 contacts
- Single and double tilt configurations
- 4-point temperature sensing method
- Shielded electrical cables for low current measurements
- Integrated heating and voltage source meter controller
- Intuitive graphical user interface for system control
- EDS compatible over the full temperature range

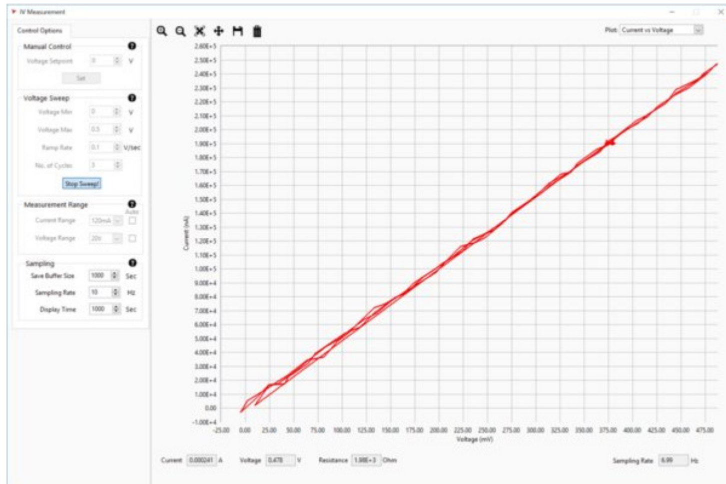
The system is available as a single-tilt and double-tilt version. The double-tilt holder features a high-accuracy (<0.01 degree) beta-tilt mechanism and no tilt-backlash when changing tilt direction, making it the most stable and usable double-tilt holder available.

Biasing

Hummingbird's Scientific Heating + Biasing sample holder has an industry leading 9 contacts (standard). All electrical contacts are available for non-heating biasing experiments with our biasing MEMS chips. While using the heating + biasing capability with our Heating-Biasing MEMS chips, four contacts are used for heating and sensing; the remaining five contacts are available for biasing the sample.

Hummingbird Scientific's graphical user interface features intuitive controls for heating and biasing functions, including temperature-set point and voltage sweeps. Custom camera integration options are available.

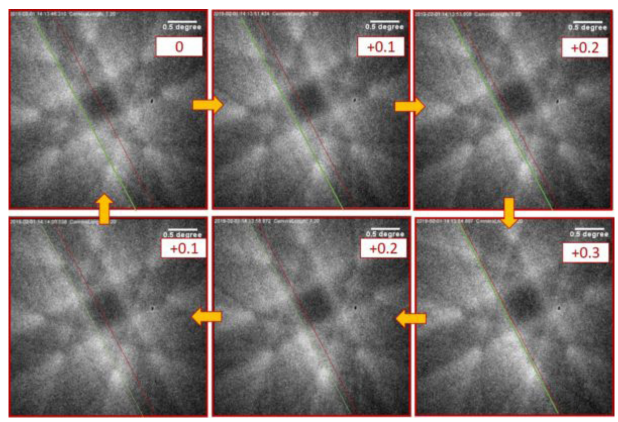
All our MEMS chips are designed, fabricated, and tested in-house, and are available in our web store for our customers.



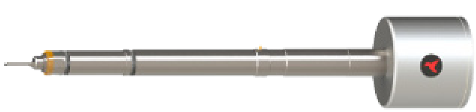
Accurate and repeatable beta-tilt

The beta-tilting resolution and accuracy of this double-tilt Heating + Biasing TEM holder are <0.01 degree. The negligible backlash one gets when reversing tilt direction that often makes other double-tilt TEM holders difficult to use is in the same order of magnitude.

The figure on the left shows beta-tilt from 0 to 0.3 to 0 degree with an exact return to 0.0 after tilting the same amount of steps in both directions.



Related Products

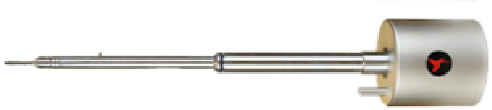


- **Biasing Holder**
  Wire-bonded samples to investigate working devices

- **Air-Free Transfer Biasing Holder**
  Air-Free sample transfer to the TEM

- **Biasing Manipulator Holder**
  In-situ electrical contacts with mobile probe

- **Cryo-Biasing Holder**
  Exploring quantum and advanced energy materials



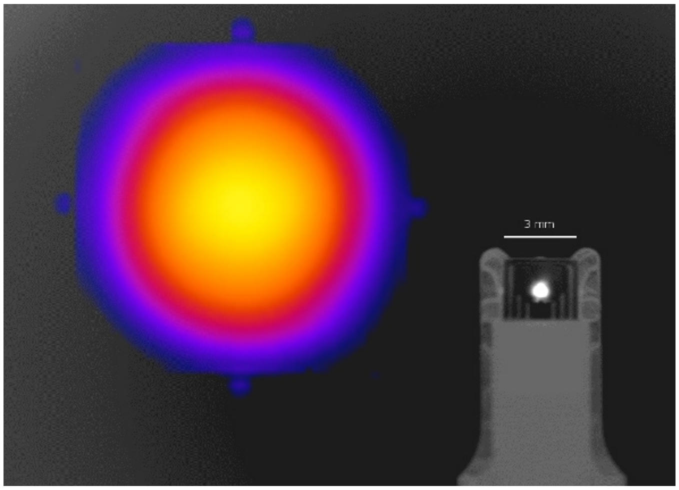
- **Furnace Holder**
  Standard bulk TEM samples at high temperatures

Heating

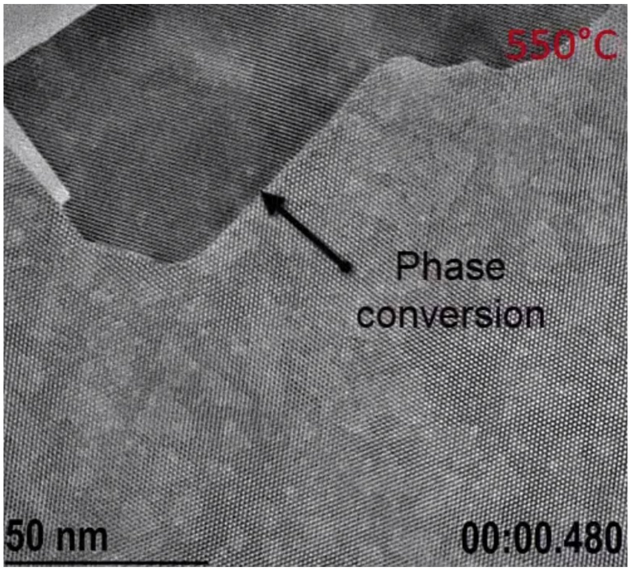
Hummingbird Scientific's Heating + Biasing TEM holder platform is supported by our microfabrication team. All our MEMS chips are designed, fabricated, and tested in-house to assure optimal performance and quality.

Our fabricated MEMS chips-based microheaters provide:

- Temperatures > 1000°C
- 4-point resistance sensing
- > 100 hours of temperature stability
- Large field of view
- Compatibility with electron-based spectroscopy (EELS and EDS)



Featured Research



Phase transformation of 2D transition metal (TM) dichalcogenides during the in-situ high-temperature heating

Two-dimensional (2D) TM dichalcogenides demonstrate exceptional electronic and optical properties. A previous study by researchers from the University of Pennsylvania on a few layers of 2D MoS2 has shown multiple phases with atoms occupying orientations within single/multiple layers (see npj 2D Materials and Applications here).

Here, the same group study different thin 2D dichalcogenide material and observe a unique conversion of phases from the parent crystalline substrate. The conversion is initiated when the temperature of the sample reaches around 500°C. The diffusion velocity of the new phase is dependent upon the stimulus applied to the sample.

Data provided by Pawan Kumar, Eric Stach and Deep Jariwala from the University of Pennsylvania.

Selected Publications

Pawan Kumar, James P. Horwath, Alexandre C. Foucher, Christopher C. Price, Natalia Acero, Vivek B. Shenoy, Eric A. Stach, and Deep Jariwala. **"Direct visualization of out-of-equilibrium structural transformations in atomically thin chalcogenides,"** *npj 2D Materials and Applications* (2020)

Pawan Kumar, James Horwath, Alexandre Foucher, Christopher Price, Natalia Acero, Vivek Shenoy, Deep Jariwala, Eric Stach, Daan Hein Alsem. **"Non-equilibrium Structural Phase Transformations in Atomically Thin Transition Metal Dichalcogenides,"** *Microscopy & Microanalysis* (2020)

Jules Gardener, Austin Akey, Daan Hein Alsem, and David Bell. **"Focused Ion Beam Sample Preparation for High Temperature In-situ Transmission Electron Microscope Experiments: Use Carbon for Now,"** *Microscopy & Microanalysis* (2020)

Alexander B. Bard, Matthew B. Lim, Xuezhe Zhou, Julio A. Rodriguez Manzo, Daan Hein Alsem, and Peter J. Pauzauskie. **"Observation of Void Formation in Cubic NaYF4 Nanocrystals Using In Situ Heating Transmission Electron Microscopy,"** *Microscopy & Microanalysis* (2019)

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HUMMINGBIRD SCIENTIFIC
2610 Willamette Dr NE
Lacey WA 98516
t: 360.252.2737 - f: 360.252.6474
www.hummingbirdscientific.com