FUSION SELECT

E-CHIPS & CONSUMABLES ORDERING GUIDE

Protochips
Creating the Connected Lab

SF-00004 5.5

Fusion E-chips

Fusion E-chips
Fusion E-chips are revolutionary products for thermal and electrical analysis of materials. Designed and manufactured using state-of-the-art semiconductor technologies, Fusion E-chips enable unprecedented performance and flexibility for *in situ* electron microscopy. They are unique, consumable, active sample supports that completely replace the traditional 3 mm copper grid.

Three Key Fusion Experiments

Thermal E-chips
Fusion Thermal E-chips provide a platform for precise temperature control, ultra-low drift, temperatures up to 1,200 ˚C and ramp rates up to 1,000 ˚C per millisecond. E-chip sample supports contain a centrally located ceramic membrane on a silicon substrate. Joule heating occurs when electrical current is forced across the conductive membrane. Micron-scale holes are patterned through the membrane to provide minimal electron beam scatter and to maximize resolution when imaging in the TEM. SEM imaging can occur anywhere in the central area of the membrane.

Fusion Thermal E-chips replace conventional TEM grids, and samples can be prepared directly upon E-chips with standard techniques including solvent dispersion, dry dip, thin film evaporation, and both *in situ* & *ex situ* FIB placement. As part of sample preparation, E-chips can be baked up to 200 ˚C or used under a heat lamp.

Electrothermal E-chips
With the Fusion heating and electrical system you can simultaneously heat and electrically bias your sample with an electrothermal E-chip. Each electrothermal E-chip utilizes the same heating technology as the thermal chip, including temperatures up to 900 ˚C with both open and closed loop calibrations. Electrothermal E-chips also feature an additional pair of tungsten electrodes patterned on an insulating layer. This design isolates the electrical stimulus, reducing current leakage and preserving signal integrity. The Clarity *in situ* software suite allows you to conveniently apply both heat and electrical bias to your sample.

Electrical E-chips
Electrical E-chips provide a platform for precise electrical biasing in current or voltage mode. The electrical stimuli are delivered to your sample via electrodes patterned directly on the E-chips. Typically platinum or tungsten deposition is used to create the electrical contact. EM imaging of samples is performed in the area around and between the electrodes. Electrical E-chips are offered with several patterns and features so that you can select the best E-chip for a particular sample and experiment. You can choose between gold and platinum for the electrode material and whether to have holes in the silicon nitride membrane. Nanowires, carbon nanotubes, graphene, patterned semiconductor or metallic thin films are compatible with all E-chip patterns.

When preparing metallic thin films on any Fusion E-chip, ensure the sample is masked so electrical shorts do not occur. E-chip part availability subject to change. Unless otherwise stated E-chip images in this document are not drawn to scale.

How to Order?

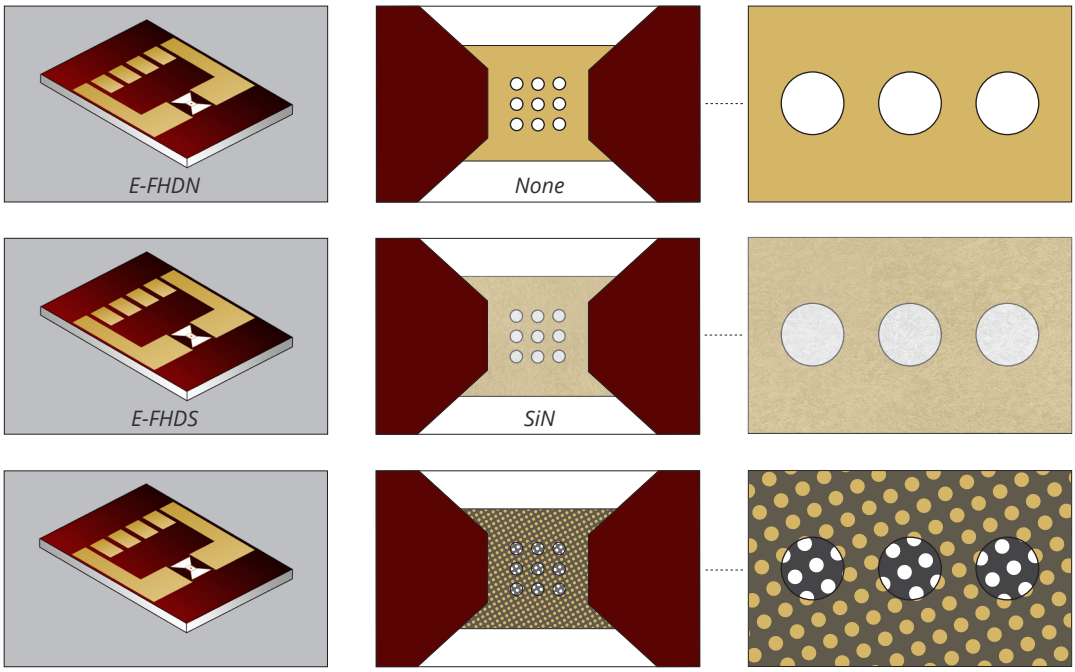
Please contact us directly at **orders@protochips.com** including part numbers and quantities (multiples of 10).

For additional information, please visit:
www.protochips.com
www.protochips.com/success
Call us at 919.377.0800

Guidelines for Use

1. Fusion E-chips fit all TEM systems of Thermo Fisher Scientific, JEOL, and Nion.
2. Use the provided calibration file for each heating E-chip. Download calibration files at echips.protochips.com
3. All electrical-only E-chips need a layer of photoresist removed before use. You can find this cleaning guide on the Success Community.

Thermal E-chips



E-FHDC
(Schematics not to scale)

Part Number	Thin Film Over Holes			Temperature	Calibration	
	None	SiN	2/2 Carbon	RT - 1200 °C	Open Loop	Closed Loop
E-FHDN-VO	•			•	•	
E-FHDS-VO		•		•	•	
E-FHDC-VO			•	•	•	
E-FHDN-ENV	•			•	•	•
E-FHDS-ENV		•		•	•	•
E-FHDC-ENV			•	•	•	•

Note: Fusion Select Thermal E-chips are backward compatible with Fusion and Aduro systems.

Fusion Thermal E-chips are comprised of a central ceramic membrane supported by a silicon substrate. Nine 8-micron holes are located in the center of the membrane to provide an electron transparent area for TEM imaging. These holes are arranged in a 3x3 array with 12 microns between holes. E-chips are available with three options for sample support over the holes: a carbon film with 2 micron holes, a continuous silicon nitride film, or nothing over the holes for self-supporting samples.

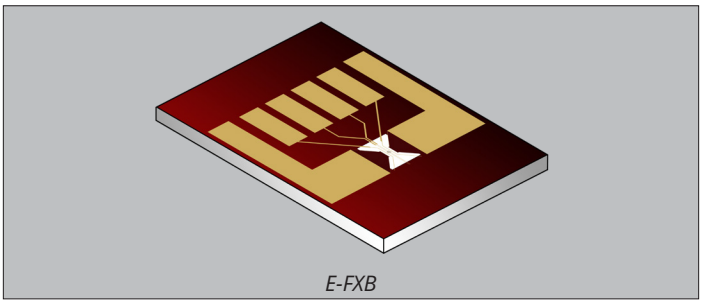
The Fusion thermal E-chips are offered in two thermal calibration configurations: "vacuum only" for standard TEM experiments and "environmental" for experiments performed in an environmental TEM (E-TEM) or ex situ on the benchtop. The "vacuum only" configuration comes with the standard open loop calibration file whereas the "environmental" configuration comes with a specialized closed loop calibration file made specifically for E-TEM or ex situ experiments. If you are not working in an E-TEM or on the benchtop, "vacuum only" thermal chips are recommended for your experiments.

Important: TEM imaging must occur through the holes due to the polycrystalline structure of the ceramic film.

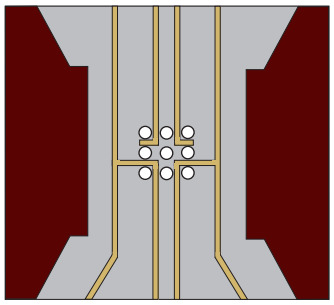
Key Features

- Chip dimensions: 4 mm x 4.65 mm
- Chip thickness: 300 µm
- Silicon nitride membrane: ~40 nm thick
- Holey carbon film: ~18 nm thick, array of 2 µm holes spaced 2 µm apart

Electrothermal E-chips



E-FXB



(Schematics not to scale)

Part Number	Electrode Spacing	Electrode Width	Electrode Material	Temperature	Calibration	
	15 µm	5 µm	Tungsten	RT - 900 °C	Open Loop	Closed Loop
E-FXB-VO	•	•	•	•	•	
E-FXB-ENV	•	•	•	•	•	•

Note: Fusion Select electrothermal E-chips are backwards compatible with Fusion and Aduro Systems.

Fusion Electrothermal E-chips are Fusion Heating E-chips with four additional electrodes to support simultaneous heating and electrical characterization of samples. A thick layer of silicon nitride isolates the heating membrane from the electrodes. Samples can be placed on the membrane, over a hole and spanning the electrodes, and electrical contacts can be formed via FIB metal deposition. Fusion Select systems can use all four electrodes for a variety of electrical measurements including “4-point probe” characterization. Older Fusion and Aduro systems can use the same chips, but only the outer pair of electrodes are available for measurements. The type of Fusion system and the type of electrical measurement will determine the optimal sample configuration.

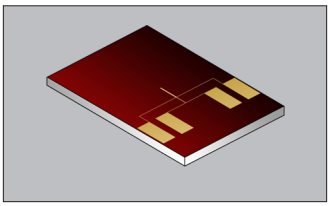
The Fusion electrothermal E-chips are offered in two thermal calibration configurations: "vacuum only" for standard TEM experiments and "environmental" for experiments performed in an environmental TEM (E-TEM) or ex situ on the benchtop. The "vacuum only" configuration comes with the standard open loop calibration file whereas the "environmental" configuration comes with a specialized closed loop calibration file made specifically for E-TEM or ex situ experiments. If you are not working in an E-TEM or on the benchtop, "vacuum only" thermal chips are recommended for your experiments.

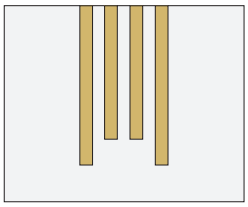
Important: TEM imaging must occur through the holes due to the polycrystalline structure of the ceramic film.

Key Features

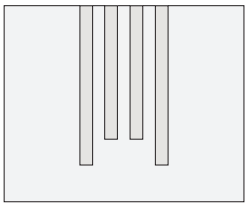
- Chip dimensions: 4 mm x 4.65 mm
- Chip thickness: 300 µm
- Sample support: ~50 nm thick silicon nitride

Finger Configuration

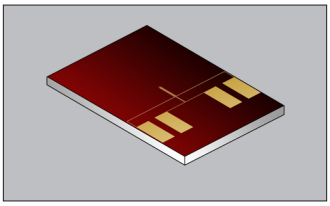


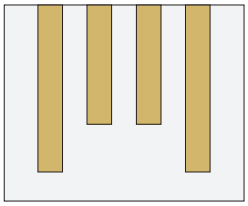


E-FED00-LN

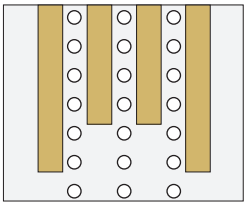


E-FED01-LN

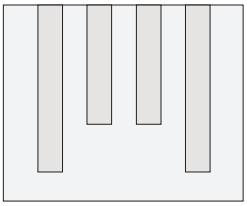




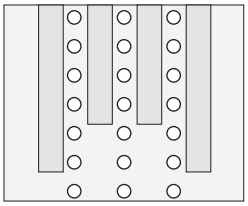
E-FEK00-LN



E-FEK10-LN



E-FEK01-LN



E-FEK11-LN

(Schematics not to scale)

Part Number	Electrode Spacing		Electrode Width		Holes	Spacing	Metal
	5 µm	10 µm	5 µm	10 µm	5 µm	15 µm	
E-FED00-LN	•		•				Gold
E-FED01-LN	•		•				Platinum
E-FEK00-LN		•		•			Gold
E-FEK10-LN		•		•	•	•	Gold
E-FEK01-LN		•		•			Platinum
E-FEK11-LN		•		•	•	•	Platinum

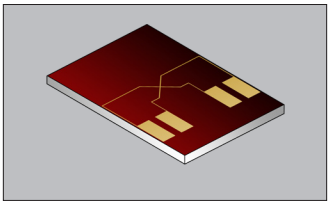
Note: Fusion Select electrical E-chips have a layer photoresist that needs to be removed before use. See cleaning guide on the Success Community for instructions.

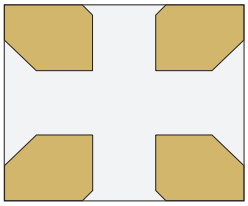
Key Features

- Chip dimensions: 4 mm x 4.65 mm or 4 mm x 5.8 mm*
- Chip thickness: 300 µm
- Sample support: ~50 nm thick silicon nitride

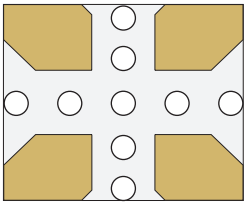
Notes: Use the E-chips with SiN membrane holes for maximum resolution. Use the E-chips without SiN membrane holes for small samples. Electrical E-chips have two possible dimension sets due to manufacturing.

Four Point

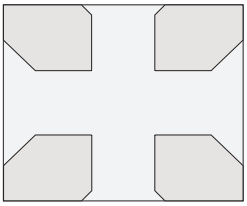




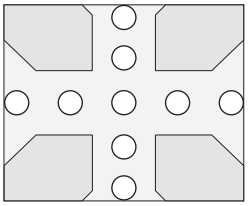
E-FEL00-LN



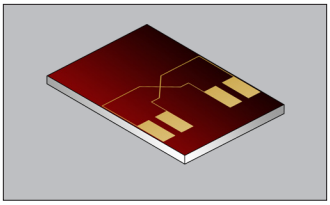
E-FEL10-LN

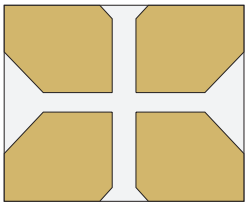


E-FEL01-LN

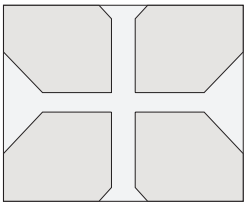


E-FEL11-LN





E-FEM00-LN



E-FEM01-LN

(Schematics not to scale)

Part Number	Electrode Spacing		Electrode Width	Holes	Spacing	Metal
	5 µm	20 µm	14 µm	5 µm	10 µm	
E-FEL00-LN		•	•			Gold
E-FEL10-LN		•	•	•	•	Gold
E-FEL01-LN		•	•			Platinum
E-FEL11-LN		•	•	•	•	Platinum
E-FEM00-LN	•		•			Gold
E-FEM01-LN	•		•			Platinum

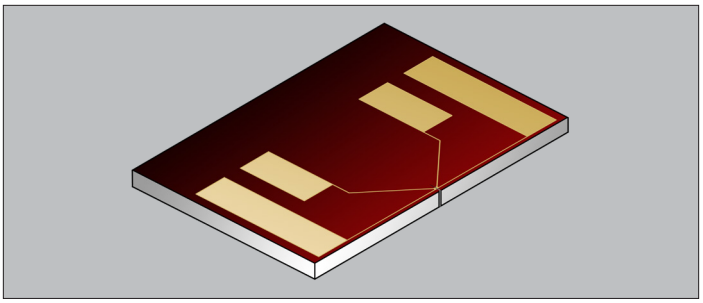
Note: Fusion Select electrical E-chips have a layer photoresist that needs to be removed before use. See cleaning guide on the Success Community for instructions.

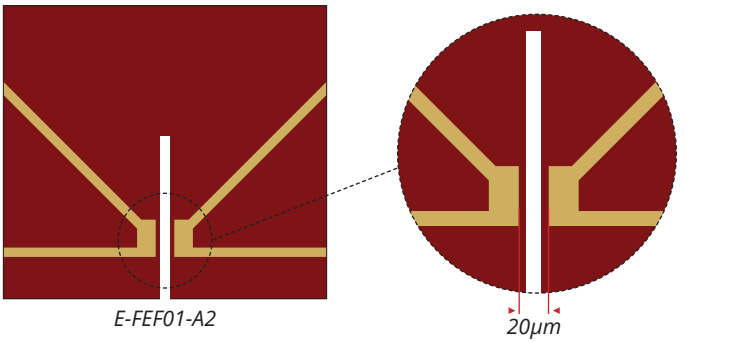
Key Features

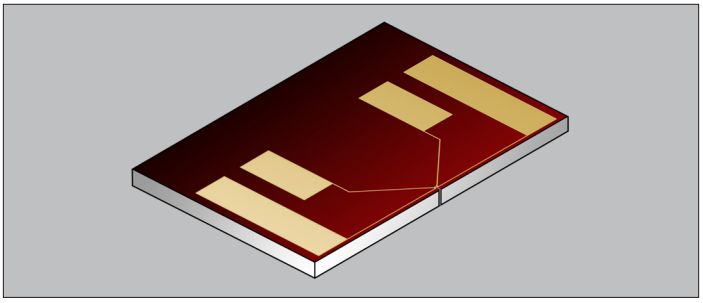
- Chip dimensions: 4 mm x 4.65 mm or 4 mm x 5.8 mm*
- Chip thickness: 300 µm
- Sample support: ~50 nm thick silicon nitride

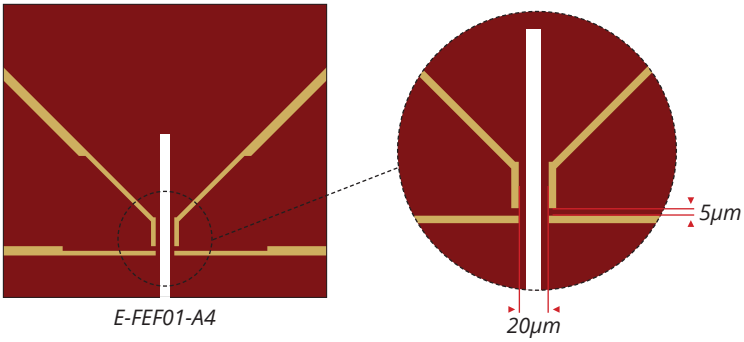
Note: Electrical E-chips have two possible dimension sets due to manufacturing.

FIB-Optimized









(Schematics not to scale)

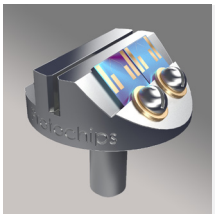
Part Number	Notch Width	Notch Length	Electrode Spacing		Metal
	10 µm	155 µm	5 µm	20 µm	
E-FEF01-A2	•	•		•	Platinum
E-FEF01-A4	•	•	•	•	Platinum

Note: Fusion Select electrical E-chips have a layer photoresist that needs to be removed before use. See cleaning guide on the Success Community for instructions.

The FIB optimized E-chips offer a workflow that reduces preparation time in half as compared to stub-mounted electrical E-chips for FIB lamellas preparation. A pass-through notch down the middle of the chip allows for easy sample deposition, while eliminating the risk of shorting out the electrical connection. Additionally, the lack of a window membrane allows for the best possible resolution in the microscope, while eliminating membrane breakage risk.

FIB E-chip Dimensions

- Dimension: 4 mm x 3.055 mm



Order our specialized FIB stub to make sample preparation even more efficient. To place an order for the FIB stub, send an e-mail to orders@protochips.com requesting part number FIB-STUB.

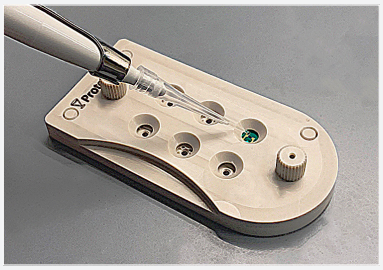
Streamline Your Workflow | Tools for Sample Preparation and Characterization

Sample preparation is an important step to your in situ experiment as it sets the foundation for every step you take thereafter. The ability to reproduce your experiment in the future can be heavily dependent on the reproducibility of the sample preparation process. Protochips has developed several tools that will help you create a highly reproducible sample preparation process that will save time and prevent wasted sample and E-chips.

Shadow Mask

Enables precise sample deposition on a targeted area of the E-chip. Compatible with Poseidon Select, Atmosphere, and Fusion Select E-chips:

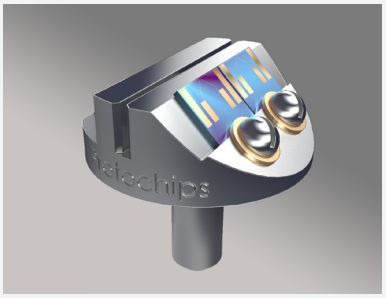
- Prevents electrical shorts
- Keeps spacers on closed-cell E-chips clean
- Compatible with common PVD instrumentation (sputter coaters, evaporators, etc.), drop casting, and dry powder depositions
- Request part number: SHW-MSK-PKG



FIB Stub

The FIB stub in combination with our step-by-step guide for FIB sample deposition onto membrane and membrane-free E-chips will help ensure your time spent at the FIB does not go to waste. Compatible with Poseidon Select, Atmosphere, and Fusion Select E-chips with a special notch for the Fusion Select FIB-optimized electrical E-chips.

- Designed specifically to securely hold E-chips
- Step-by-step guides give specific angles and instructions for successful deposition and thinning on the E-chip (guides are located on the Success Community)
- Top notch is designed to hold our Fusion Select FIB-optimized electrical E-chip vertically so the deposition process mimics using a typical half-grid for a familiar feel.
- Request part number: FIB-STUB



If you have a question or would like to place an order for any of the above workflow items, please email ordes@protochips.com. For supporting documentation and troubleshooting guides for all in situ systems, please visit **success.protochips.com** or email **support@protochips.com**.

Miscellaneous Supplies:

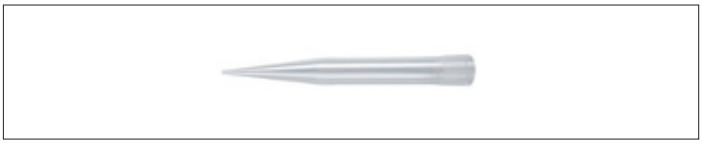
Many accessory items that work well with the Fusion Select system are available as part of the Poseidon Select Toolkit, which is available from our partner, Electron Microscopy Sciences (EMS).

Orders may be placed directly through EMS:

https://www.emsdiasum.com/microscopy/products/tem/holder.aspx

Small Volume Pipette 0.1-2µl - Autoclavable. Small volume allows for precise deposition of sample onto the Poseidon E-chip. Requires compatible pipette tips

Pipette Tips - 10 ul disposable pipette tips, required for the small volume pipette.

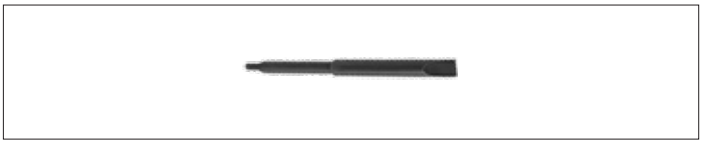


PTFE Dish - 60mm diameter 25 ml capacity. Used to clean photoresist off E-chips. Two are required, one for acetone to dissolve the resist and one for methanol to ensure there is no acetone residue.

Watch Glass - 75 mm diameter. Used to plasma clean E-chips to ensure they are clean and hydrophilic. Curved watch glass makes placing and picking up E-chips easier.

Torque Screw Driver - for tightening lid screws.

Torque Driver Bit - for Torque Screw Driver



Torque Driver Adapter - Insert Bit 1/4" Dr Hex Adapters. Adapter holds the torque driver bit, so it can be inserted into the torque driver

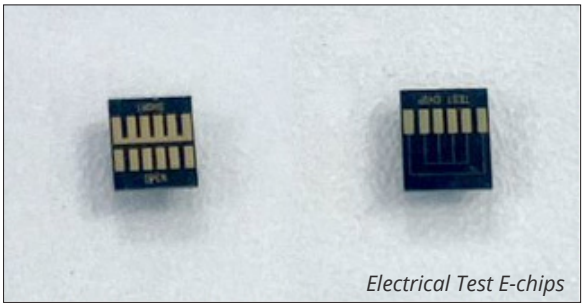
Style 2A Straight-Tip PVDF Tweezers - Carbon tip tweezers help to avoid chipping the E-chip silicon

Style 7 Curved-Tip PVDF Tweezers - Carbon tip tweezers help to avoid chipping the E-chip silicon

Special Purpose E-chips

Electrical Test E-chips

Test E-chips for checking the electrical connections of the Fusion TEM holder. Do not use for experiments.

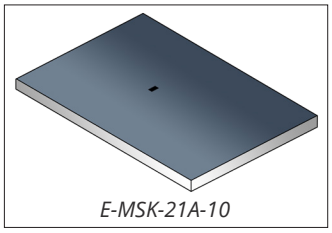


Electrical Test E-chips

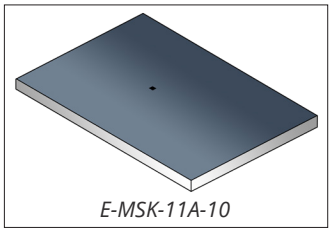
Part Number	Includes	Quantity	Description
E-F-TOF	Open / Short Test E-chips	1 Kit	Replacement Fusion Select Test E-chip kit used to test the Fusion Select TEM holder's electrical connections. Not for Imaging

Mask E-chips (Not for TEM Imaging)

Special purpose E-chips used with the shadow mask, designed to mask off areas on the Fusion E-chip for sample deposition. Not designed for imaging. See Product Description for more information.



E-MSK-21A-10



E-MSK-11A-10

Part Number	Includes	Quantity	Description	Specifications
E-MSK-21A-10	Shadow Mask E-chip: Narrow Opening	10	E-chip mask for depositing sample with the mask jig. Not for use in the TEM.	240 x 120 Micron Deposit Area
E-MSK-11A-10	Shadow Mask E-chip: Square Opening	10	E-chip mask for depositing sample with the mask jig. Not for use in the TEM.	120 x 120 Micron Deposit Area

Additional Replacement Parts

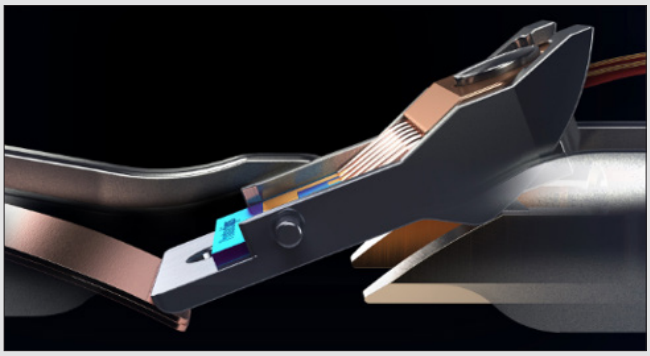
Did something not listed above get lost or damaged? Replacement o-rings, holder stands, cables, etc are available. Contact orders@Protochips.com with a description of the part you need and holder serial number for a quote

Add More Capability to your Existing System

Upgrade for increased workflow efficiency that add more capability to your Fusion system.
Please contact sales@Protochips.com for a personalized quote.

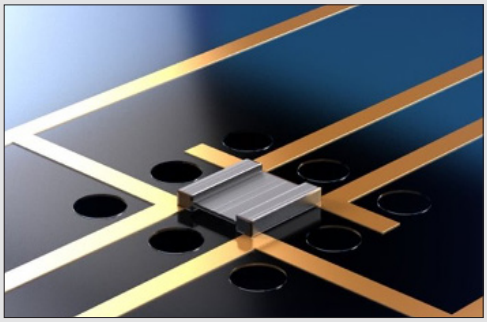
Beta Tilt
Add beta-tilt capability to your existing Fusion Select holder.

- Friction-free tilt for superior temperature and electrical-measurement accuracy
- Beta-tilt capability can be installed remotely and does not require any TEM holder modification or downtime
- Add up to ±20° tilt (pole piece dependent)
- **Contact sales@Protochips.com for quote**



Electrical & Electrothermal Capability
Perform electrical characterization of samples over a wide temperature range with accuracy. With more electrical contacts and newly designed E-chips, Fusion Select delivers the flexibility and sensitivity required for electrothermal experiments.

- Electrical probes located directly over heater for temperature accuracy
- Heating & Simultaneous 4-point probe measurements
- No Fusion Select TEM Holder modification or downtime required
- **Contact sales@Protochips.com for quote**



AXON Machine Vision Software Platform
Redefine your *in situ* experience by linking the transmission electron microscopy detectors and *in situ* systems together with a revolutionary new tool.

- Improves data quality, enhances and extends your current microscope capabilities and makes in situ experiments easier for the novice to most advanced users.
- The AXON platform is a module-based software solution. Easily plug in new modules as they are released, and your system will stay up to date with the latest features.
- Contact your local Protochips' representative for a quote optimized for your setup.
- **Contact sales@Protochips.com for quote**

Support

Not sure which E-chip or tool you need? Our applications scientists are always happy to help you find the right configuration for your experiment.

Contact support@Protochips.com and we'll connect you with one of our highly-skilled applications scientists.

WE'RE HERE TO HELP!