Wildfire
In situ TEM heating

Quantum Design EUROPE

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DENS solutions

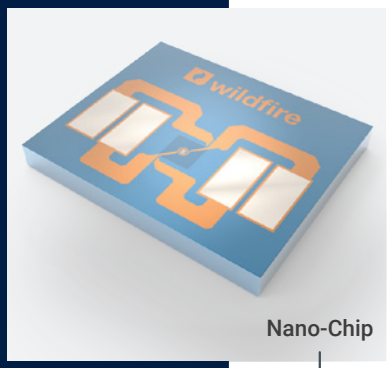
Wildfire
In situ TEM heating

Introduction

The Wildfire In Situ Heating Solution enables direct in situ TEM studies of the behavior of materials at elevated temperatures. Using Wildfire, these experiments can be conducted in a controlled and stable environment while maintaining the best performance of the TEM.

The Wildfire system offers the best imaging stability, highest tilt and highest temperature of any commercially available system.

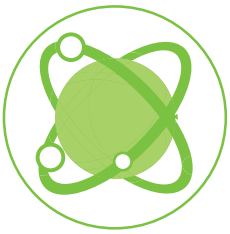
With our Wildfire system, you can heat up your sample to 1300 °C with accurate temperature control and unprecedented sample stability in all directions.



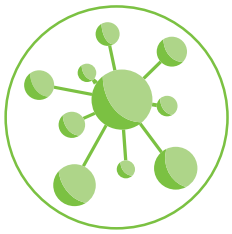
Nano-Chip

Sample holder

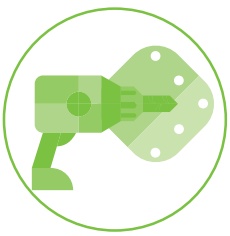
Typical applications



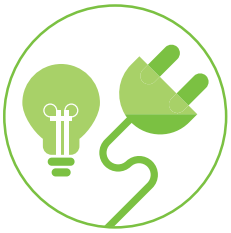
Low dimensional materials



Nanotechnology



Materials engineering



Materials for energy applications

Soft matter systems

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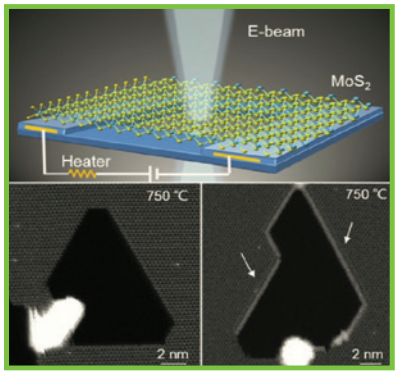
Selected Publications



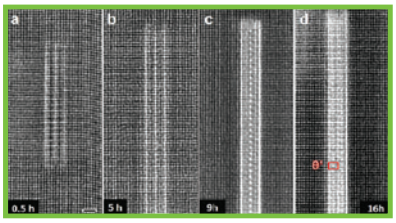
Edge structures of the etching holes in a monolayer MoS_2 achieved at 750 °C.

Low dimensional materials

Using the Wildfire H+ 3D, the researchers perform in situ e-beam sculpturing at elevated temperatures to fabricate the novel Mo_6S_6 nanowire terminated edges in monolayer molybdenum disulfide.

To confirm the detailed structure of these edges, the researchers perform an atomic-scale STEM analysis at 750 °C. They discover novel edge structures that can reveal new properties of 2D and 1D transition metal dichalcogenides (TMDs). Moreover these edge structures can open up new opportunities for the application of 2D and 1D TMDs in catalytic, spintronic and electronic devices.

Huang, Wei et al. Nano Research (2018) 1-9



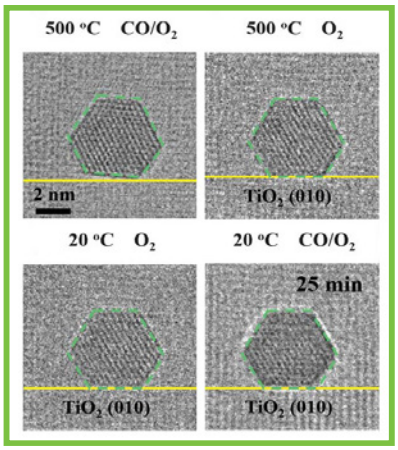
Atomic structure evolution of an individual precipitate at 160 °C.

Materials Engineering

Age-hardening in Al alloys has been used for over a century to improve its mechanical properties. However, the lack of direct observation limits our understanding of the dynamic nature of the evolution of nanoprecipitates during age-hardening. Using In Situ scanning transmission electron microscopy while heating an Al-Cu alloy, the authors were able to follow the growth of individual nanoprecipitates on the atomic scale.

A detailed knowledge of this evolution is required to reveal the formation mechanism of the strengthening precipitates, as this can be used for optimizing heat treatments in the production process.

Liu, Chunhui et al. Scientific Reports 7.1 (2017) 2184



ETEM images showing the structural evolution of the Au-TiO_2 nanocatalyst under different temperatures.

Catalysis

The interface between metal catalyst and support plays a critical role in heterogeneous catalysis. Tuning the intrinsic microstructure of an epitaxial interface with atomic precision during catalytic reactions can be challenging.

With the high stability of our Wildfire system, the authors were able to study the interface between gold nanoparticles and a titanium dioxide support. They find an unexpected dependence of the atomic structure of the Au-TiO_2 interface with the epitaxial rotation of gold nanoparticles on a TiO_2 surface during CO oxidation. Taking advantage of the reversible and controllable rotation, they achieve the in situ manipulation of the active Au-TiO_2 interface by changing gas and temperature. This suggests that real-time design of the catalytic interface in operating conditions is possible.

Yuan, Wentao et al. Science 371 (2021) 517-521

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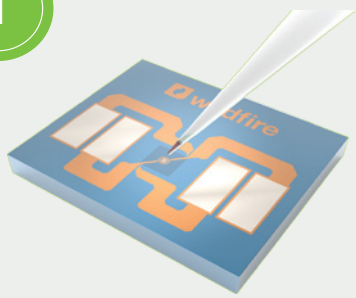
Why Wildfire?

1



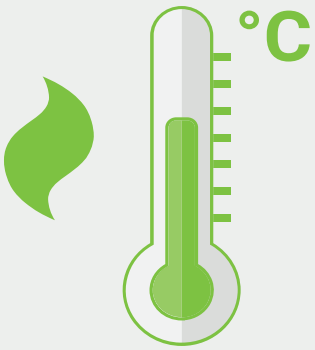
Simplified sample preparation

1. Easy and fast thin film transfer
No topography over large areas.

2. Drop-casted particles are in the field of view
The capillary effect is greatly reduced.

3. Best quality FIB lamellae
Easily prepare the lamellae using our dedicated FIB Stub, and perform final thinning directly on the chip without affecting heating performance.

2



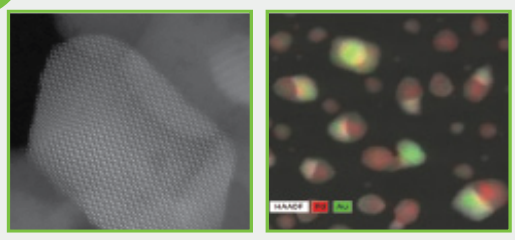
Reliable heating control

1. Accurate temperature
4-point probe heating provides accurate temperature control across the whole range with 0.005 °C stability.

2. High homogeneity over the largest viewable area
Less than 0.5% deviation in temperature uniformity.

3. Accuracy and homogeneity proven by customers
Temperature verified directly in TEM using EELS and SAED techniques.

3



High impact results

1. High stability
Less than 200 nm displacement and short stabilization time even if ΔT = 1000 °C.

2. Unaffected S/TEM performance
Minor Z-displacement (bulging) preserves the ultimate resolution without tedious stage movements.

3. Improved analytical capabilities
Reduced infrared radiation from the microheater allows to perform EDS analysis up to 1000 °C.

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Software for accurate heating control

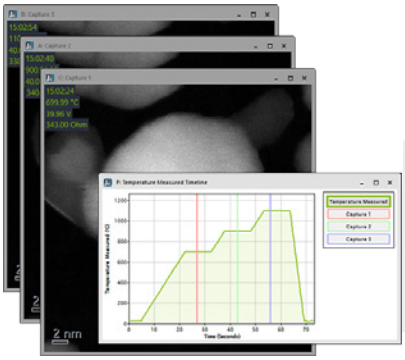
Impulse 1.1

Intuitive In Situ experiment control and automation software

Impulse 1.1 grants you complete control over your stimuli. It offers an integrated control interface that is flexible to adapt to your experiment. You can even design your In Situ experiment from your desk. Decide which sample conditions you want to be met at which time and Impulse will do the rest.

Smart automation

- Easily design your experiment with the drag-and-drop profile builder.
- Smart automation keeps track of measurements and ensure that your sample conditions are met.
- Accurately reproduce your experiments.

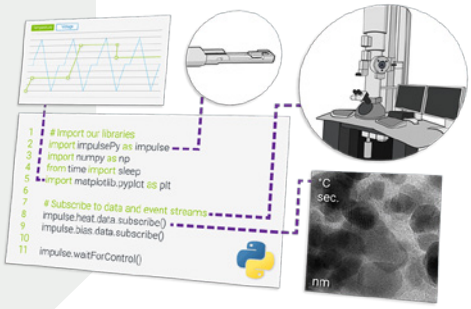


Data integration

- Synchronize your stimuli data with other data from your experiment.
- Provide your camera and detector images with stimuli annotations in seconds.

Experimental freedom

- The Impulse application programming interface (API) and Python module lets you control your system using Python scripts. This offers unbound freedom in experiment control.
- Automate and synchronize data collection of cameras and detectors with the control of the stimuli.



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System specifications

	Wildfire H+ DT	
	JEOL	Thermo Fisher Scientific
Heating control	Closed 4-point probe feedback loop	Closed 4-point probe feedback loop
Temperature range	RT - 1,300 °C	RT - 1,300 °C
Polepiece compatibility	All	Bio-TWIN, C-TWIN, TWIN, X-TWIN, S-TWIN
Alpha tilt range	URP, FHP ≥ ± 15 deg HRP,WGP ≥ ± 20 deg	≥ ± 25 deg
Beta tilt range	URP, FHP ≥ ± 15 deg HRP,WGP ≥ ± 25 deg	≥ ± 25 deg
Attainable resolution*	≤ 60 pm	≤ 60 pm
Drift rate*	≤ 0.5 nm/min	≤ 0.5 nm/min
Temperature accuracy	≥ 95 %	≥ 95 %
Temperature Homogeneity	≥ 99.5 %	≥ 99.5 %
Viewable area	850 µm²	850 µm²

** Listed specifications are dependent on microscope configuration*

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Complete ‘plug & play’ package

1. Wildfire heating TEM specimen holder
2. Nano-Chips starter pack
3. Heating control unit
4. Laptop with Impulse software
5. FIB stub 3.0

Service and Support

Product warranty	24 months with optional extension
Regulatory compliance	CE, RoHS, FCC
Radiation safety	According to TEM manufacturers compliance regulations

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Wildfire
In situ TEM heating

Wildfire
Heating

Lightning
Heating + Biasing

Climate
Gas + Heating

Stream
Liquid + Biasing or Heating

Version 3.0

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