DENS solutions

INNOVATIONS THAT MATTER

In Situ HEATING solution for TEM platforms

wildfire

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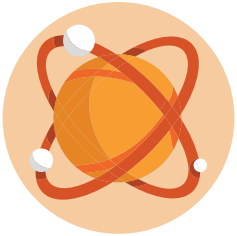
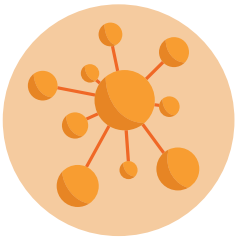
The Wildfire In Situ Heating Solution enables the direct in situ TEM studies of the behavior of materials at elevated temperatures. More importantly, these experiments can be conducted in a controlled and stable environment while maintaining the best performance of the TEM.

Wildfire holder

Typical applications



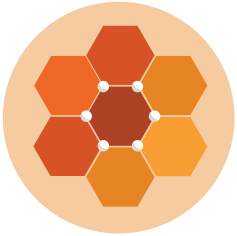
Low Dimensional Materials



Nanotechnology

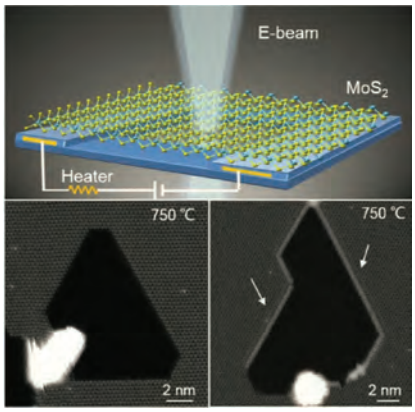
Materials Engineering

Materials for Energy Applications



Soft Matter Systems

Selected publications

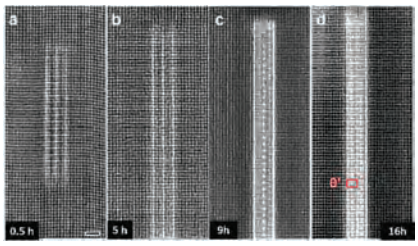


Edge structures of the etching holes in a monolayer MoS_2 achieved at 750 °C.

Low dimensional materials

Using the Wildfire H+ 3D, researches from the Zhejiang University performed in situ e-beam sculpturing at elevated temperature to fabricate the novel Mo_6S_6 nanowire terminated edges in monolayer molybdenum disulfide. To confirm the detailed structure of these edges, an atomic-scale STEM analysis has been performed at 750 °C. These edge structures may impart novel properties to the 2D and 1D materials and provide new opportunities for their applications in catalytic, spintronic and electronic devices.

Huang, Wei, et al. "In-situ fabrication of Mo_6S_6-nanowire-terminated edges in monolayer molybdenum disulphide." Nano Research: 1-9.

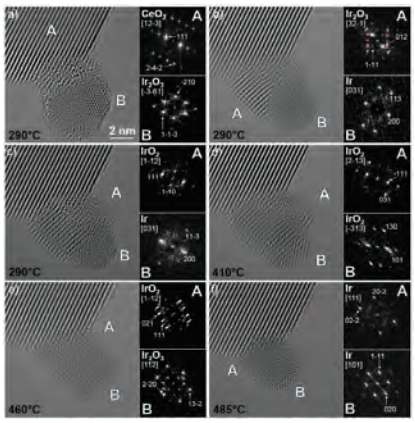


Atomic structure evolution of an individual precipitate at 160 °C.

Materials Engineering

Age-hardening in Al alloys has been used for over a century to improve it's 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, authors were able to follow the growth of individual nanoprecipitates at 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. "In-situ STEM imaging of growth and phase change of individual CuAlx precipitates in Al alloy." Scientific Reports 7.1 (2017): 2184.



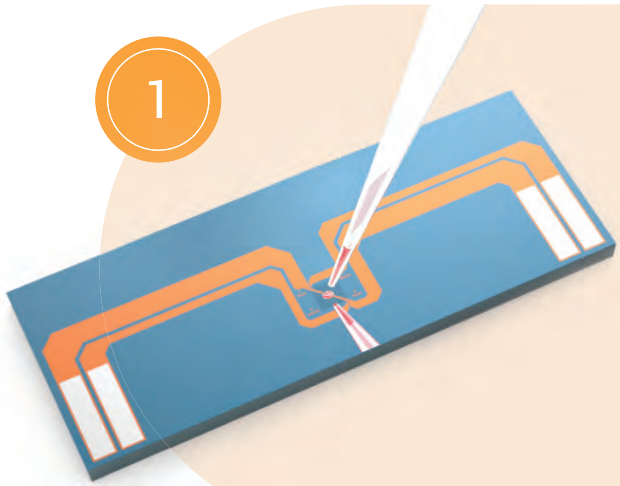
HRTEM images extracted from video sequences recorded under a mixture of CH4:H_2O at pressures equal to 10-2 mbar and 1.2 mbar respectively in a-b) and c-f). Initial Ir + Ir_2O_3 composite nanoparticle at 290°C (a- b) is gradually further oxidized (c-d) before and almost complete homogenization as Ir_2O_3 at 460°C (e) and its final complete reduction into metallic Ir at 485°C (f).

Materials for energy application

Solid Oxide Fuel Cells are clearly one of the possible routes for renewable energy cogeneration with the advantage of reducing our dependence to fossil energy sources. One main drawback of the current technologies is the reduced lifetime of the cell, therefore, research of new and better catalysts is needed. In current experiments the $Ir/Ce_{0.9}Gd_{0.1}O_{2-x}$ catalyst was exposed to a mixture of methane and water in an environmental TEM and heated up between 290 and 550°C using a Widlfire H+ 3D heating system. The competitive reducing and oxidizing actions of methane and water lead to oscillations between the metallic phase of Ir and the expected oxidized IrO_2 structure. Surprisingly, a new intermediate crystalline structure appears when heating a partially oxidized particle up to its complete oxidation before a final reduction under the predominant action of methane above 480°C.

Epicier, Thierry, et al. "Experimental Evidence for the Existence of an Iridium Sesquioxide Metastable Phase during ETEM Studies of Methane Steam Reforming on an $Ir/Ce_{0.9}Gd_{0.9}O_{2-x}$ Catalyst." Microscopy and Microanalysis 24.S1 (2018): 1648-1649.

Why Wildfire?

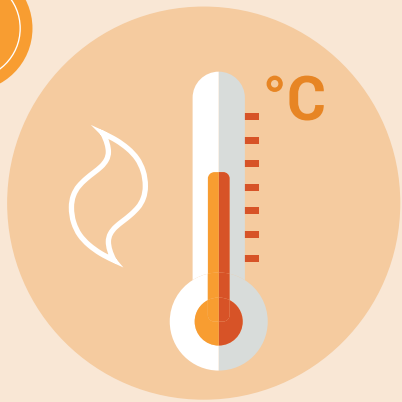


Simplified sample preparation

1. Easy and Fast thin film transfer
No topography over large area

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

3. Best quality FIB lamellae
Final thinning can be performed directly on the chip without affecting heating performance

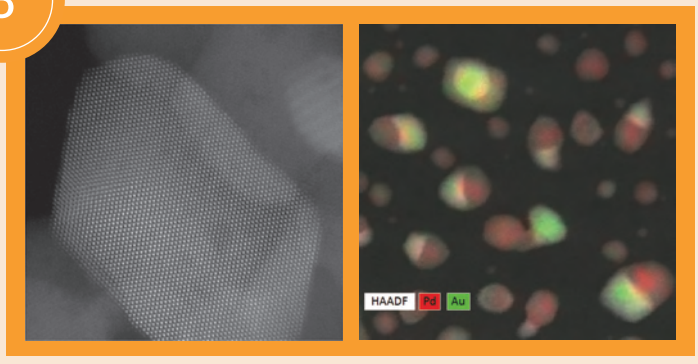


Reliable heating control

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 over 850 um²

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



High impact results

1. High stability
Less than 200 nm displacement and short settling time even for 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 heater allows to perform EDS analysis up to 1000 °C

Software for accurate temperature control

Impulse Software

Advanced control and data analysis

Full integration

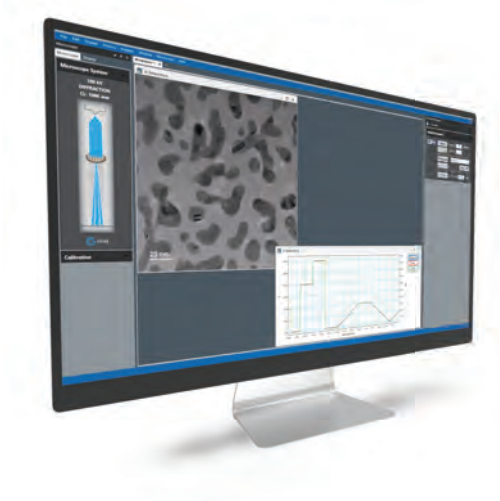
- Sleek interface to execute and monitor the experiment
- Complete control over your sample environment
- Access to calorimetry measurements

Automate your experiments

- Designed for ease of use
- Drag and drop profile builder with a wide choice of parameters
- Graphical visualization of the profile during creation and execution

Flexible graph interface

- Large canvas area for graphs
- Monitor in real-time only the parameters you are interested in
- Add new graphs, drag and drop to re-arrange them



Camera integration

True experimental integration

Easy & Fast experiments

- One SW to control in situ parameters & imaging

No mistakes or misinterpretation

- In situ data synchronized with images at any frame rate

Save your time for analysis

- Analyze images as a function of in situ parameters

System specifications

JEOL	Wildfire H (H+)	Wildfire H+ DT
Heating control	Four point probe resistive feedback	
Temperature range	RT - 600 °C (1300 °C)	RT - 1300 °C
Polepiece compatibility	URP, FHP,HRP, WGP	URP, FHP,HRP, WGP
Alpha tilt range	URP, FHP ±15 deg HRP,WGP ±20 deg	URP, FHP ±15 deg HRP,WGP ±20 deg
Beta tilt range	NA	± 15 deg
Attainable resolution	≤ 60 pA*	≤ 60 pA*
Drift rate	≤ 0.3 nm/min*	≤ 0.3 nm/min*
Temperature accuracy	≥ 95 %	≥ 95 %
Temperature Homogeneity	≥ 99.5 %	≥ 99.5 %
Viewable area	> 850 μm^2	> 850 μm^2

Thermo Fisher Scientific	Wildfire H (H+)	Wildfire H+ DT	Wildfire H+ 3D
Heating control	Four point probe resistive feedback		
Temperature range	RT - 600 °C (1300 °C)	RT - 1300 °C	RT - 1300 °C
Polepiece compatibility	Bio-TWIN, C-TWIN, TWIN, S-TWIN, X-TWIN	Bio-TWIN, C-TWIN, TWIN, S-TWIN, X-TWIN	Bio-TWIN, C-TWIN, TWIN, S-TWIN, X-TWIN
Alpha tilt range	± 30 deg	± 25 deg	± 70 deg
Beta tilt range	X	± 25 deg	X
Attainable resolution	≤ 60 pA*	≤ 60 pA*	≤ 60 pA*
Drift rate	≤ 0.3 nm/min*	≤ 0.3 nm/min*	≤ 0.3 nm/min*
Temperature accuracy	≥ 95 %	≥ 95 %	≥ 95 %
Temperature Homogeneity	≥ 99.5 %	≥ 99.5 %	≥ 99.5 %
Viewable area	> 850 μm^2	> 850 μm^2	> 850 μm^2

*Listed specifications are dependent on microscope configuration

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. Supporting tools

Optional for Wildfire H+ DT: biasing expansion kit

Service and Support:

Product Warranty	24 months* with a possibility of extension
Product Liability Insurance	Every system includes product liability insurance to cover unlikely damages to the TEM or operators
Regulatory compliance	CE, RoHS, FCC
Mechanical compatibility	Approved by TEM manufacturers
Radiation safety	According to TEM manufacturers compliance regulations
Service	Dedicated Field Service Engineer

*Depending on configuration

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