Bestron
Science & Technology
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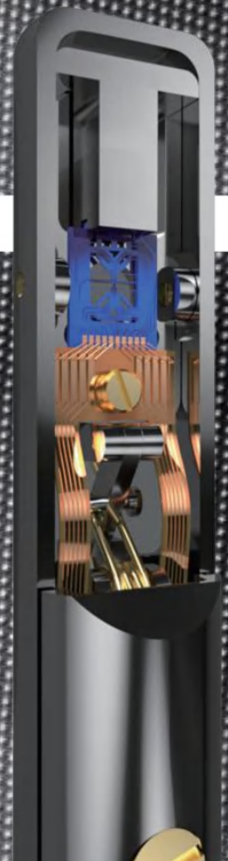


INSTEMS family

Bestron - A global leader for atomic resolution in situ scientific experiments
An Explorer and Innovator - From China, for China, to the World

ATOMIC RESOLUTION
Mechanical-Thermal-Electrical Solutions for In-Situ TEM

- In-Situ
- Atomic scale
- Double-tilt
- Straining
- Heating
- Biasing

Company Profile

BestronST Co., LTD is an advanced scientific instrument manufacturer with independent intellectual property rights.

BestronST is committed to transforming innovative, prospective technological achievements of strategic value to provide our customers with cutting-edge scientific solutions, especially in the field of electron microscopy.

These solutions aim to address key issues and are believed to bring about advancement in fields including materials science, physics, energy, biology, etc.

In line with the principle of mutual benefit and resource sharing, we look forward to communicating in-depth with experts, talents and research groups of all circles and actively pursue cooperation on transforming outstanding technological innovations. Through these endeavors, we strive to speed up the development of high-end scientific instruments and help promoting technology sharing around the world.

With the spirit of exploration, discovery, innovation and share and the philosophy of customer first, BestronST aspires to become a world-class provider of advanced scientific instruments.

Product Introduction

INSTEMS Family is a set of versatile research platforms dedicated to exploring microstructure-property evolution under harsh service conditions. The launch of INSTEMS Family will undoubtedly inject great momentum to fundamental and applied science development.

Equipped with highly integrated MEMS chips and unique double-tilt system, INSTEMS Family provides a series of TEM-based miniaturized research labs (mini-labs) that allow real-time observation of microstructure evolution at atomic scale under flexible coupling of mechanical, thermal and electrical fields. The universal adaptability, high operability, reliability and extensibility of INSTEMS Family provide users with powerful, customized, efficient in situ solutions.

INSTEMS family

Components

① Double-tilt TEM holder

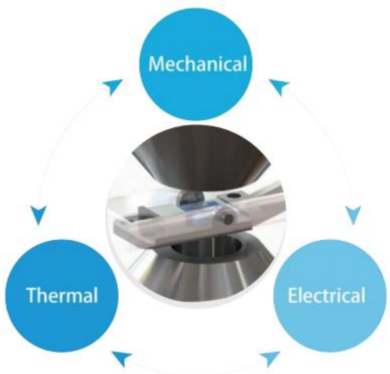
② Multifunctional mini-lab

③ Control and measurement system

④ Software (INSTEMS V2.0)

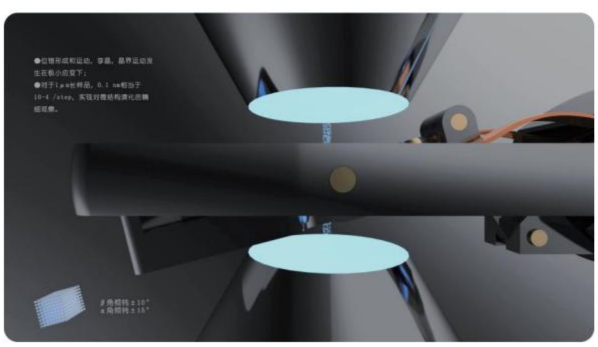
Uniqueness

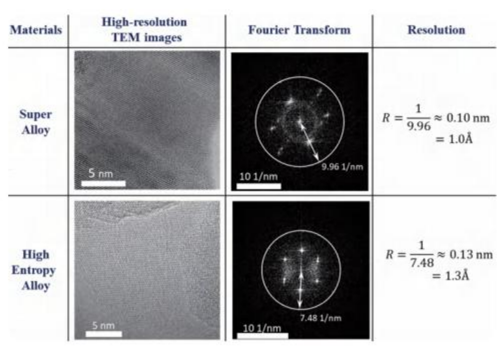
Highly integrated ALL-IN-ONE system



The highly integrated and customizable ALL-IN-ONE system can realize flexible coupling of mechanical, thermal and electrical fields by replacing varied mini-labs.

Atomic Resolution under multi-field coupling





Materials	High-resolution TEM images	Fourier Transform	Resolution
Super Alloy	5 nm	10 1/nm; 9.96 1/nm	$R=\frac{1}{9.96}\approx 0.10\ \text{nm} = 1.0\text{Å}$
High Entropy Alloy	5 nm	10 1/nm; 7.48 1/nm	$R=\frac{1}{7.48}\approx 0.13\ \text{nm} = 1.3\text{Å}$

The highly compact mini-labs and uniquely designed beta-tilt mechanism allow multi-stimuli application while preserving double-tilt function in TEM, thus providing easy access to real-time atomic scale imaging.

Uniqueness

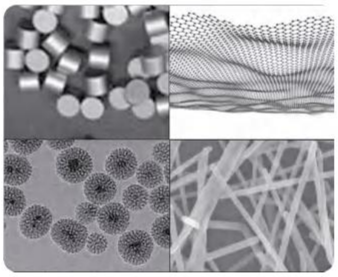
High precision multi-channel control and measurement

INSTEMS Family enjoys ultra high heating precision, pm-level driving control and pA level electrical signal measurement.

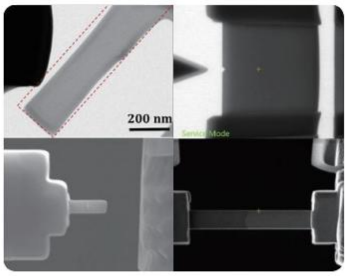
Hypersensitive miniature actuator
Stable, four-probe MEMS chips
Reliable electrical connection
Interference-free circuit layout
Powerful, high-precision multi-channel source/meter

Universal adaptability

Various fields



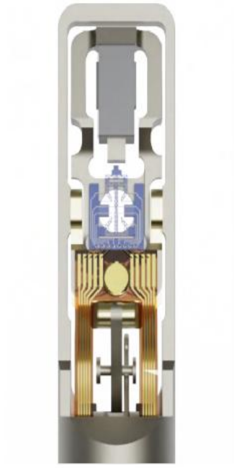
Multi-dimensional



Multi-loading methods

Benefiting from the universality and extensibility of INSTEMS-Family, multi-dimensional materials of different character can be studied by a variety of loading conditions.

INSTEMS family



INSTEMS-MET

Straining & Heating & Biasing

INSTEMS-M
Straining

INSTEMS-T
Heating

INSTEMS-E
Biasing

INSTEMS-MT
Straining & Heating

INSTEMS-TE
Heating & Biasing

INSTEMS-ME
Straining & Biasing

ATOMIC RESOLUTION
Mechanical-Thermal-Electrical Solutions for In-Situ TEM

Materials usually suffer from complex external stimuli during processing and serving. Understanding the intrinsic reason of property evolution under these harsh conditions is essential to process optimization, material modification and advanced material development, etc. Dynamic atomic scale characterization using TEM is considered a powerful research method which can better solve the problems mentioned above. In this regard, we offer researchers the INSTEMS-Family.

INSTEMS-Family consists of seven in situ TEM solutions, including three single-field , three double-field and one triple-field loading platforms. The single-field platforms are INSTEMS-M (mechanical), INSTEMS-E (electrical), INSTEMS-T (thermal); the double-field platforms include INSTEMS-ME, INSTEMS-TE and INSTEMS-MT; the triple-field platform is INSTEMS-MET.

INSTEMS-Family can provide researchers comprehensive and effective approaches in a variety of fields such as aerospace, automobile, metallurgy, shipbuilding, semiconductor, energy, etc.

INSTEMS - MET

Straining & Heating & Biasing

Flexible coupling of thermal/ mechanical/electrical fields

Ultra wide temperature range (RT-1200 ºC)
pm-level driving control
Multiple load conditions
Versatile biasing procedures
pA-level measurement

Double-tilt

α tilting up to ±25° *
β tilting up to ±20° *

Stable atomic-scale imaging

Spatial resolution ≤0.1 nm*

APPLICATION

Semiconductor
Battery safety
Device failure
Thermoelectric materials
……

INSTEMS-MET is able to apply straining, heating and biasing inside TEM. It adopts unique MEMS design and innovative integration strategy to overcome many compatibility difficulties in multi-field coupling without compromising double-tilt function of TEM holder.

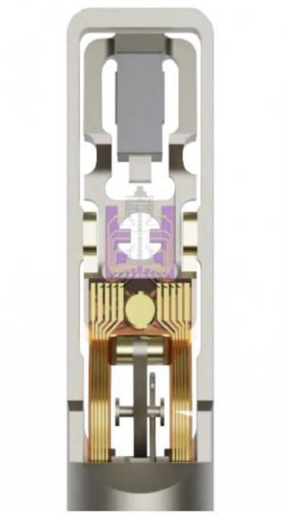
INSTEMS-MET greatly expands the scope of in situ electron microscopy and provides researchers a powerful platform to deal with problems in complex thermal/mechanical/electrical circumstances.

Mini-lab compatibility	MT/TE/ME/M/E/T
Temperature range	RT up to 1200 ºC
Heating precision	±0.1 ºC *
Max force	>2 mN
Max displacement	2 μm
Actuation accuracy	<500 pm
Max voltage	± 50 V *
Current range	0-60mA *
Spatial resolution	≤0.1 nm *
Double-tilt	α：± 25°*；β：± 20°*

* Listed specifications are dependent on mini-lab type and microscope configuration.

INSTEMS - MT

Straining & Heating



Unprecedented heating ability during straining

Ultra wide temperature range (RT-1200 ºC)
Ultra high heating precision (± 0.1 ºC*)
Programmable heating
Four-probe measurement

Multiple mechanical loading conditions

Tension/Compression/Indentation/Bending, etc.
Auto, manual, cyclic loading
pm-level driving control

Double-tilt

α tilting up to ±20° *
β tilting up to ±10° *

Stable atomic-scale imaging

Ultimate sample drift < 50 pm/s
Spatial resolution ≤ 0.1 nm*

APPLICATION

Accelerated creep deformation
High temperature phase transformation
Element diffusion
High temperature plastic deformation
Precipitation and its interaction with dislocation
Recrystallization
……

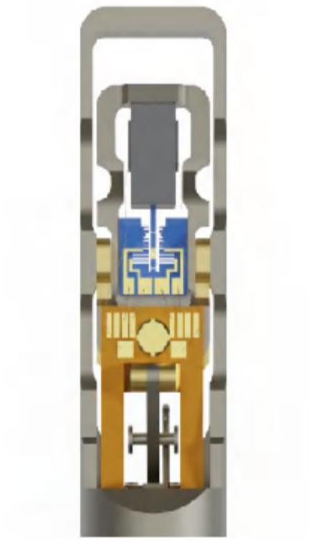
INSTEMS-MT is able to deform samples within a wide temperature range. Extremely localized heating makes possible a unprecedentedly high heating capability whilst straining. The low power required to heat the sample generates negligible sample drifting, thus ensuring, along with double-tilt ability, high-quality atomic-scale imaging in real-time. Specialized sample preparation methods allow various sample dimensions and loading conditions, making INSTEMS-MT suitable for a wide range of materials and research fields.

Temperature range	RT up to 1200 ºC
Heating precision	±1 ºC*
Max force	>2 mN
Max displacement	2 μm
Actuation accuracy	<500 pm
Spatial resolution	≤0.1 nm*
Double-tilt	α：± 20°* ； β：± 10°*

* Listed specifications are dependent on mini-lab type and microscope configuration.

INSTEMS - ME

Straining & Biasing



Multiple mechanical loading conditions

Tension/Compression/Indentation/Bending, etc.
Auto, manual, cyclic loading
pm-level driving control

Outstanding electrical application and measurement

Versatile biasing procedures
pA-level measurement

Double-tilt

α tilting up to ±20° *
β tilting up to ±10° *

Stable atomic-scale imaging

Spatial resolution ≤ 0.1 nm*

APPLICATION

Piezoelectric materials
Ferroelectrics
Actuator/Sensor
Photovoltaic materials
Li-ion battery
Nanodevices
Flexible electronic device
……

INSTEMS-ME is able to realize various electrical application and high precision electrical measurement. Meanwhile, several actuation modes can be chosen to meet different tilting requirement. Multiple mechanical loading modes, e.g., tension, compression, bending, etc. can be realized to satisfy varying research needs. Benefiting from an ingenious manner of mechanical-electrical coupling, INSTEMS-ME perfectly preserves the double-tilt function of TEM holder, making itself the first in the market capable of performing atomic-scale mechanical-electrical study.

Max force	> 2 mN
Max displacement	2 μm
Actuation accuracy	< 500 pm
Max voltage	± 50 V *
Current range	0-60mA*
Spatial resolution	≤0.1 nm*
Double-tilt	α：± 20°*；β：± 10°*

* Listed specifications are dependent on mini-lab type and microscope configuration.

INSTEMS - TE

Heating & Biasing

Unprecedented heating ability during biasing

Ultra wide temperature range (RT-800 ºC)
Ultra high heating precision (± 0.1 ºC*)
Programmable heating
Four-probe measurement

Outstanding electrical application and measurement

Versatile biasing procedures
pA-level measurement

Double-tilt

α tilting up to ±25° *
β tilting up to ±20° *

Stable atomic-scale imaging

Spatial resolution ≤0.1 nm*

APPLICATION

Thermoelectric materials
Semiconductor
Phase Change Memory
Battery reliability
Failure analysis
Dielectrics
……

INSTEMS-TE is able to realize various electrical application and high precision electrical measurement. On top of this, by choosing either single heating source or independent double heating source, homogeneous or gradient thermal field can be achieved. Due to this versatility, this product is suitable for not only traditional thermal and electrical researches, but also thermoelectric researches.

Temperature range	RT up to 800 ºC
Heating precision	±0.1 ºC *
Max voltage	± 50 V *
Current range	0-60mA*
Spatial resolution	≤0.1 nm*
Double-tilt	α： ± 25°* ； β： ± 20°*

* Listed specifications are dependent on mini-lab type and microscope configuration.

SPECIFICATIONS

INSTEMS-Family	INSTEMS-MET	Straining & Heating& Biasing
	INSTEMS-MT	Straining & Heating
	INSTEMS-TE	Heating & Biasing
	INSTEMS-ME	Straining & Biasing
	INSTEMS-M	Straining
	INSTEMS-T	Heating
	INSTEMS-E	Biasing
Heating	Temperature range	RT -1200 °C
	Heating precision	±0.1 °C*
	Temperature measurement	Four-electrode method
	EDS	√
Straining	Actuation accuracy	< 500 pm
	Max force	>2 mN
	Max displacement	2 μm
Biasing	Max output voltage	± 50 V *
	Current range	0-60mA *
Double-tilt	Alpha (α) tilt	±25° *
	Beta (β) tilt	±20° *
	Accuracy	＜ 0.1°
Imaging	Spatial resolution	⩽ 0.1 nm *

* Listed specifications are dependent on mini-lab type and microscope configuration.

OUTSTANDING ADVANTAGES

INSTEMS-Family is a set of revolutionary scientific instruments in the field of electron microscopy. It can simultaneously achieve the following unique functions:

Wide loading ranges

Temperature: RT to 1200 °C
Force: > 2 mN
Voltage: ± 50 V *

Flexible multi-field coupling

In-situ observation of structural evolution at atomic-scale under flexible coupling of mechanical/thermal/electrical fields

Double-tilt

± 25° double-tilt under multi-field coupling. Beta tilt accuracy < 0.1°

Hypersensitive miniature actuator

The actuator can realize pm-level cyclic loading

Excellent compatibility

Independent thermal/electrical/mechanical control. Mechanical loading can be realized at any effective temperature

High success rate

The extensive universality and extensibility improve the success rate and efficiency of the experiment greatly

Flexible customizability

Multi-function mini-labs can be designed according to customers' personalized demand

Rapid & precise heating

Rapid heating & precise temperature control.

Strict quality control

Strict product standards and quality management system were established to enhance reliable and consistent performance of the products

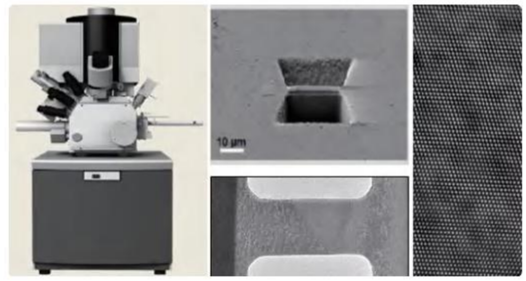
Well operability

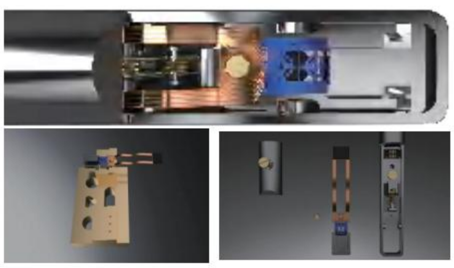
Highly integrated control system and scientific algorithm make the software interface simple and easy to use

HOW TO PERFORM IN-SITU EXPERIMENTS WITH INSTEMS-FAMILY

Sample preparation

Samples of all sizes and shapes are prepared onto a mini-lab with desired functionality using FIB and other traditional preparation methods. Mounting sites with different combinations of external stimuli are available for specific research needs.



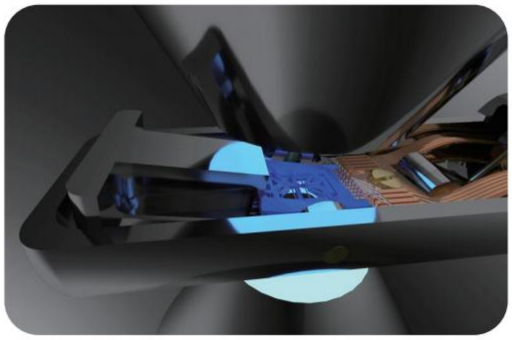


Mini-lab mounting

After sample mounting, fixate the mini-lab onto the double-tilt TEM holder via screw fastening. Connect the flexible printed circuit (FPC) with the card slot to transfer multi-channel electric signals in and out, providing precise and reliable control and monitoring of heating, straining and biasing.

Mode and parameter setting

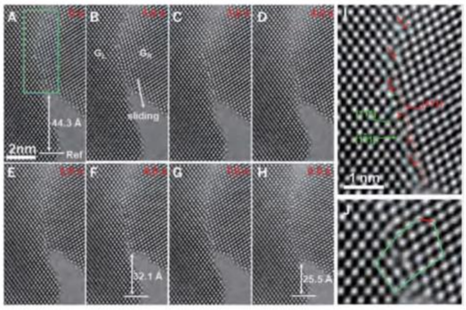
After inserting the holder into TEM chamber and connecting the entire system, loading patterns can be programmed to cater to specific experiment design. Sample parameters can be put into the software to directly acquire the data of interest.



In situ experiment

Apply external stimulus (stimuli) to the sample and record atomic scale structural evolution and property change, so as to establish structure-property correlation under complex external environment.

APPLICATION CASE



Science

REPORT

METALLURGY

Tracking the sliding of grain boundaries at the atomic scale

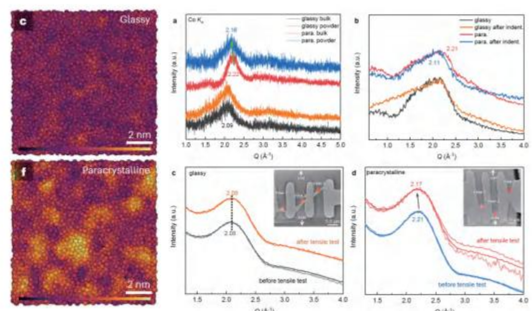
Science 375(2022)1261-1265.

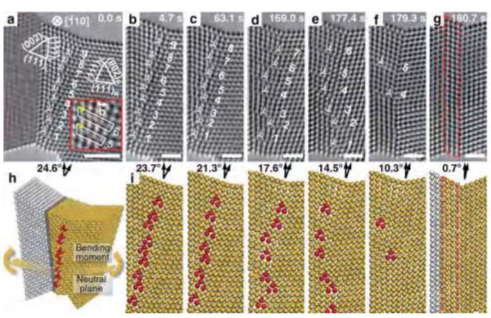
For the first time, either direct atomic-scale sliding along the GB or sliding with atom transfer across the boundary plane was observed.

nature materials

Nature Materials (2023): 1-7.

That stress-induced inverse transition from the paracrystalline to amorphous states leading to exceptional toughening in oxide glasses.





nature COMMUNICATIONS

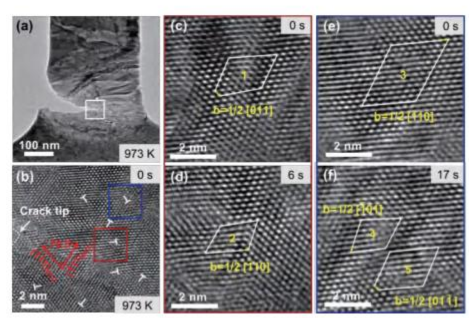
Nature Communications, 2022, 13(1):4151.

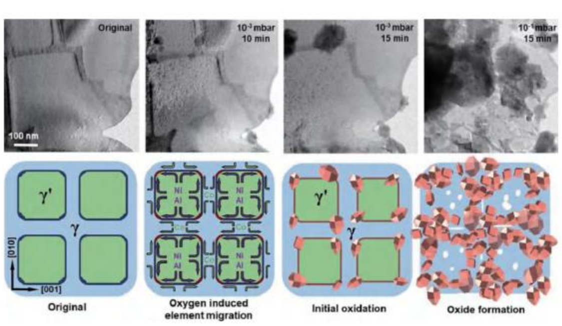
Atomic-scale observations of grain boundary (GB) dislocation climb in nanostructured Au during in situ straining at room temperature.

nature COMMUNICATIONS

Nature Communications, 2021, 12(1): 2218.

First uncovered that tungsten fractures at 973 K in a ductile manner via a straininduced multi-step BCC to FCC transformation and dislocation activities within the strain-induced FCC phase.



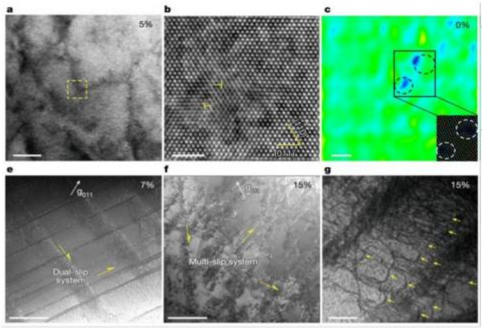


Acta MATERIALIA

Acta Materialia 215 (2021): 116991.

Initial oxidation in Ni-based superalloy by in situ visualizations and investigations of the nano- and atomic-scale dynamic processes from room temperature to 900 °C

APPLICATION CASE



nature

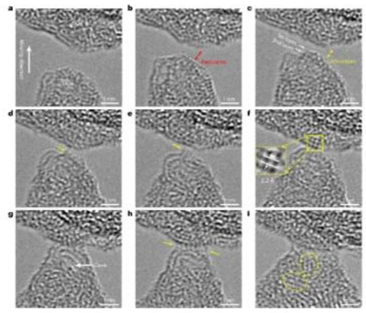
Nature. 2024 Jan;625(7996):697-702.

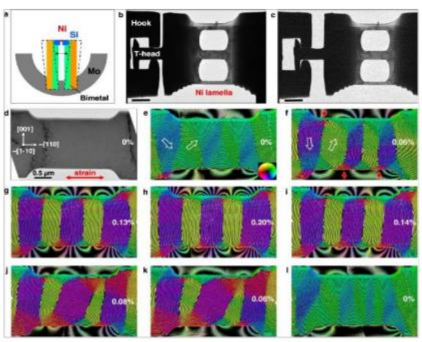
Hierarchical chemical fluctuations (HCFs) spanning from submicrometre to atomic scale create a high density of diffusive boundaries that effectively impede dislocation motion.

nature materials

Nature Materials 22.11 (2023): 1317-1323.

This article conducted a quantitative evaluation of the room-temperature self-healing behaviour of a fractured nanotwinned diamond composite.





nature COMMUNICATIONS

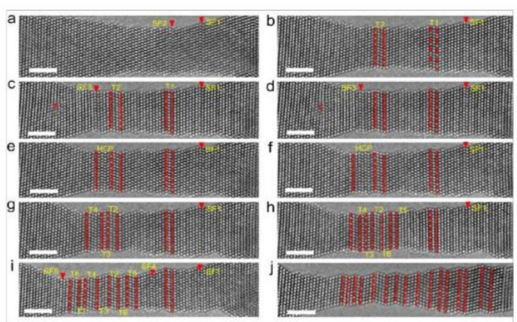
Nature Communications 14.1 (2023): 3963.

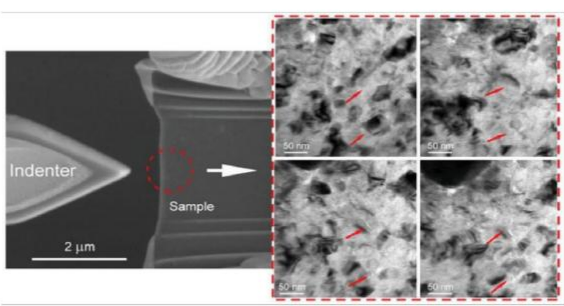
Direct nanoscale observations reveal how tensile strain modifies magnetic domains in a ferromagnetic Ni thin plate using in situ Fresnel defocus imaging.

nature COMMUNICATIONS

Nature Communications 14.1 (2023): 5705.

In situ observation of AuCu nanowire tensile processes reveals how chemical inhomogeneity enables superplasticity and ultrahigh strength.





ADVANCED FUNCTIONAL MATERIALS

Atomistic simulations are combined with experiment to demonstrate a strengthening strategy for the sintered NPD by introducing thin amorphous grain boundary.

ABOUT US

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