

# ATMOSPHERE

*IN SITU HEATING AND GAS REACTION CELL*



# CATALYST REACTIONS

See your catalyst in action by tracking structural and chemical changes in high temperature, realistic environments.



Room Temperature up to



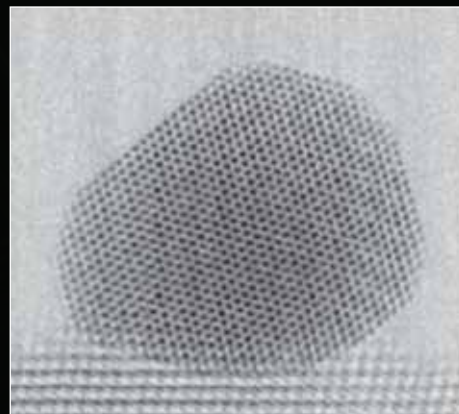
**1000 °C**

Pressure up to

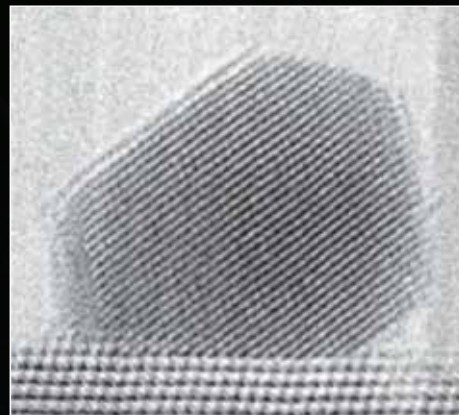


**1 ATM**

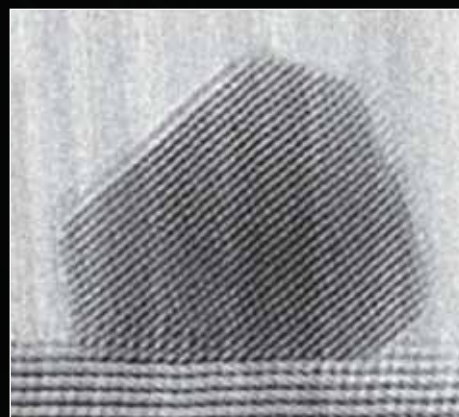
**500 °C**  
4.7% H<sub>2</sub>, 5.7% O<sub>2</sub>, balance Ar



**500 °C**  
4.9% H<sub>2</sub>, 2.0% O<sub>2</sub>, balance Ar



**500 °C**  
5.0% H<sub>2</sub>, balance Ar



**Pt Catalyst**

1 atm H<sub>2</sub>/O<sub>2</sub>/Ar

*Image courtesy University of Michigan*

# ENVIRONMENTAL CAPABILITIES IN YOUR TEM

- Set up experiments with the ease using workflow driven Clarity software.
- Take full control of the gas environment including composition, temperature, pressure and flow rate.
- Observe chemical reactions under gasses ranging from  $\text{CO}_2$  and  $\text{CH}_x$  to  $\text{H}_2$  and  $\text{H}_2\text{O}$ .



**SAFE**

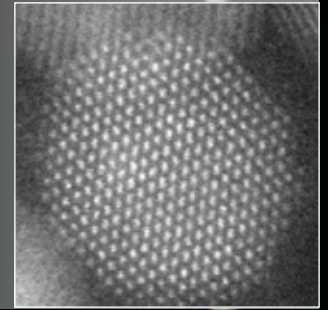
**COMPATIBLE**

**GUARANTEED**

**Ceria**

350 °C, 1 atm H<sub>2</sub>/N<sub>2</sub>

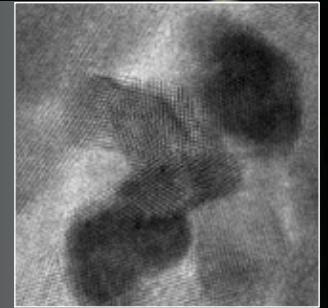
*Image courtesy University of Michigan*



**Gold on Ceria**

350 °C, 1 atm H<sub>2</sub>/N<sub>2</sub>

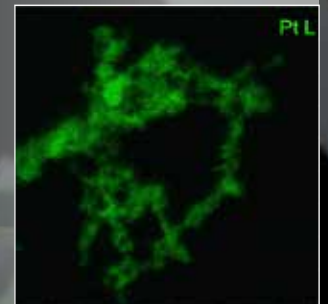
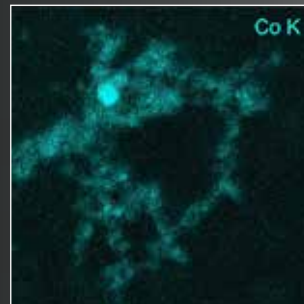
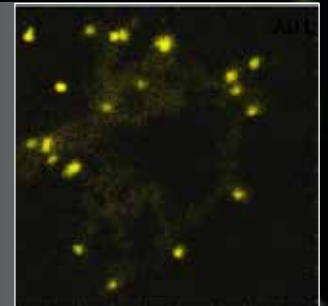
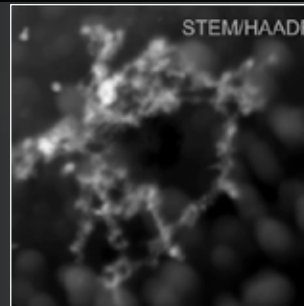
*Image courtesy Oak Ridge National Lab*



**PtCo Catalyst**

RT, 1 atm Air

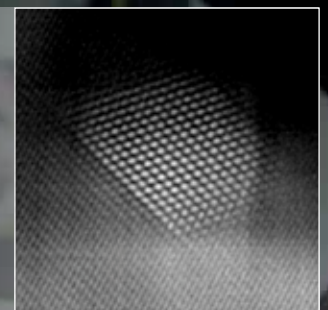
*Images courtesy Argonne Lab*



**Gold on Iron Oxide**

350 °C, 7.5 Torr N<sub>2</sub>

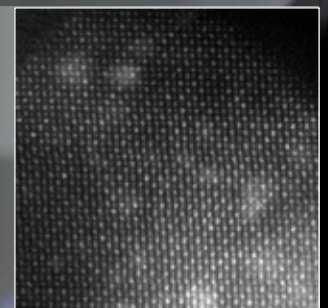
*Image courtesy JEOL Japan*

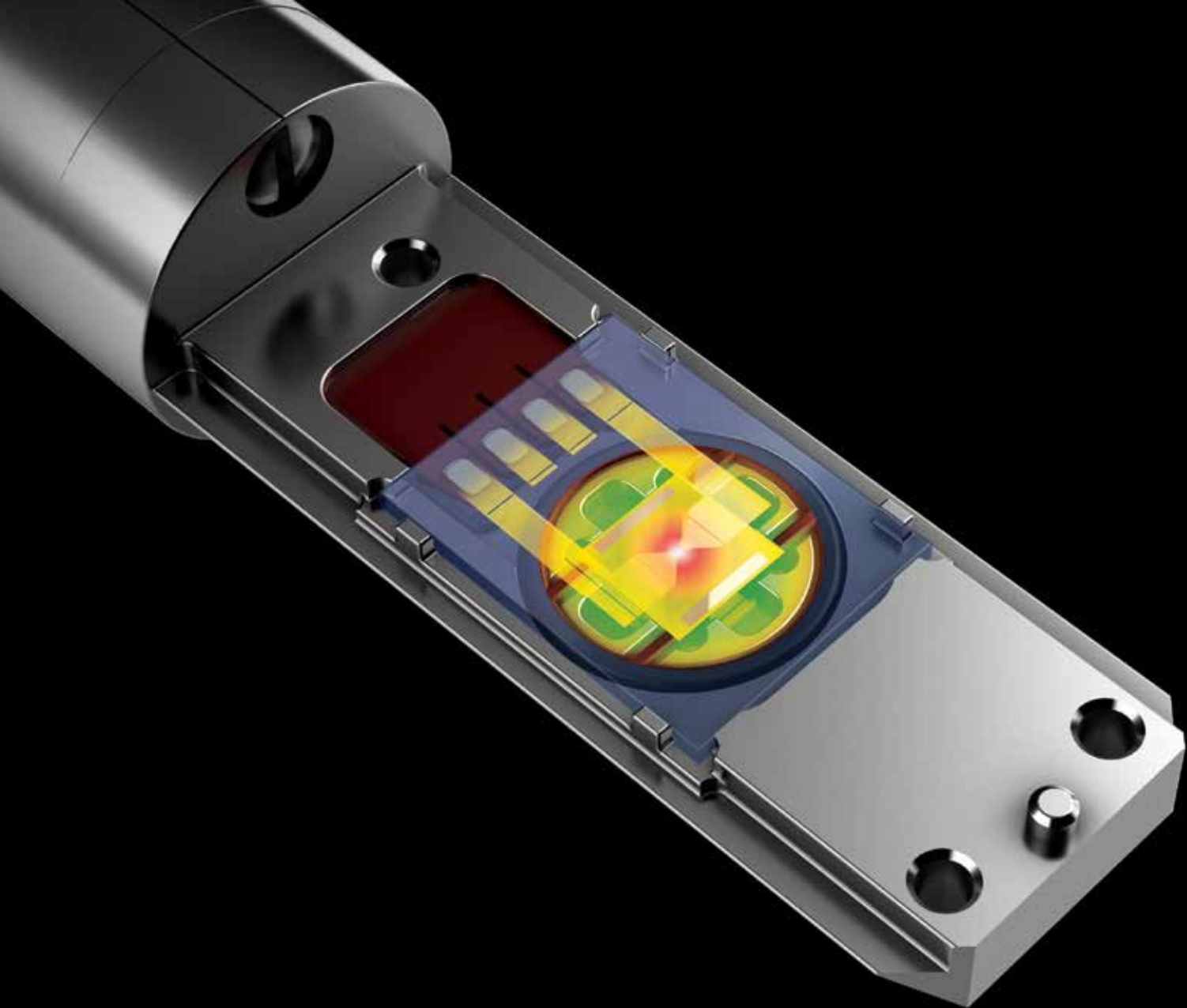


**Calcium Titanate**

350 °C, 1 atm H<sub>2</sub>/N<sub>2</sub>

*Image courtesy University of Michigan*





## ISOLATE YOUR EXPERIMENT

*The study of catalyst materials requires a chemically inert sample heater.*

Catalyst reactions occur at high temperatures, so the sample support must be thermally stable and chemically inert. Protochips developed a proprietary silicon carbide membrane heater that can quickly and accurately reach the highest temperatures without the risk of interacting with the sample or participating in catalyst reactions. The unique heating E-chips™ used with the Atmosphere system do not use coated thin-film metal coil heaters that can interfere with your experimental results.

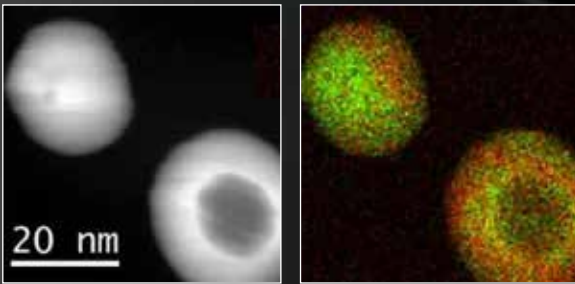
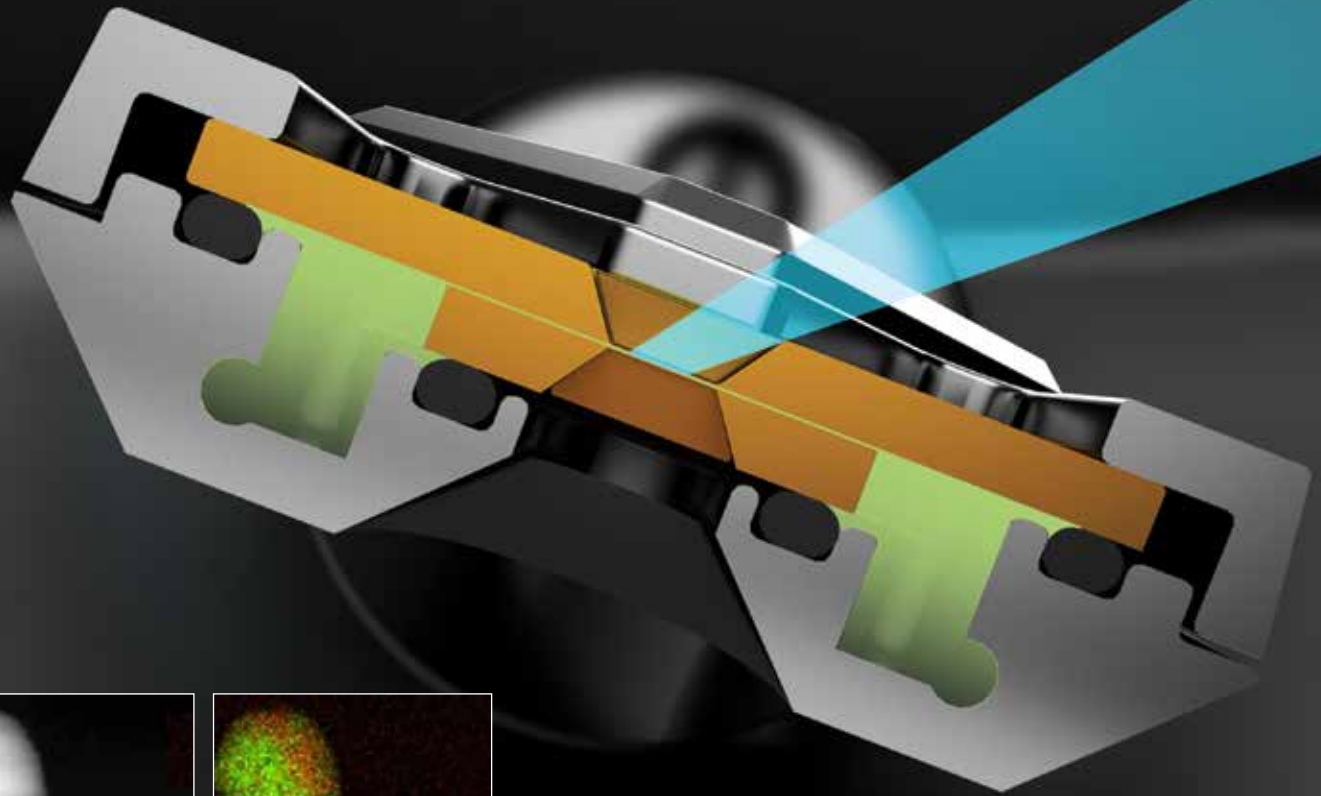


Image courtesy University of Manchester

## IMAGE YOUR SAMPLE CHEMISTRY

*EDS capabilities enable real-time chemical analysis.*

The design of the Atmosphere holder enables, for the first time, true in situ closed-cell EDS elemental analysis in the TEM. The holder design provides a large line-of-sight solid angle from the sample to the EDS detector, minimizing tilt and maximizing count rate. The Atmosphere holder is even compatible with multiple detectors within the TEM, including high angle EDS Detectors. And, it works at high temperatures.

# ASSEMBLE IN 10 MINUTES OR LESS

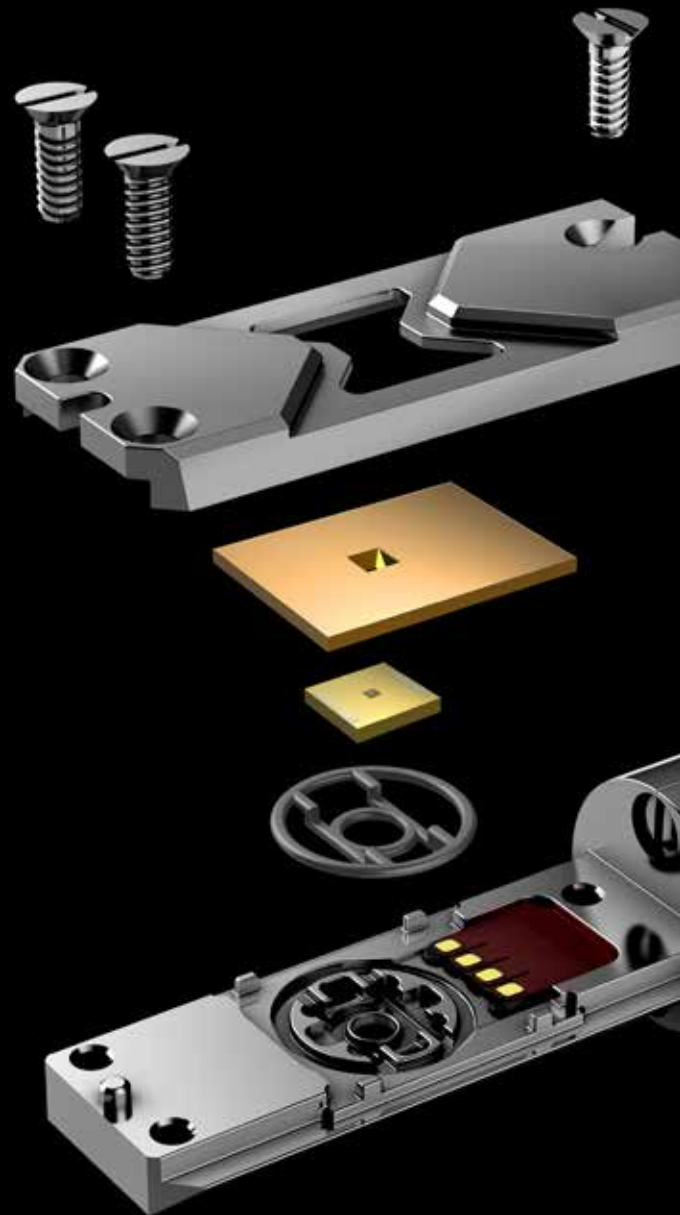
Our patented sealing and lid designs enables:

- **Easy assembly:** Samples can be loaded quickly with self-aligning E-chips
- **Safety:** With only 1 gasket, the sealing surface within the tip is minimized, greatly enhancing the safety of the TEM.
- **EDS analysis:** Material is minimized on top of the E-chip, providing direct line-of-sight to the sample

# MEASURE TEMPERATURE WITH ACCURACY

Gases are efficient at removing heat from materials via convection. The amount of heat removed is a function of the gas pressure and composition, which can change throughout an experiment.

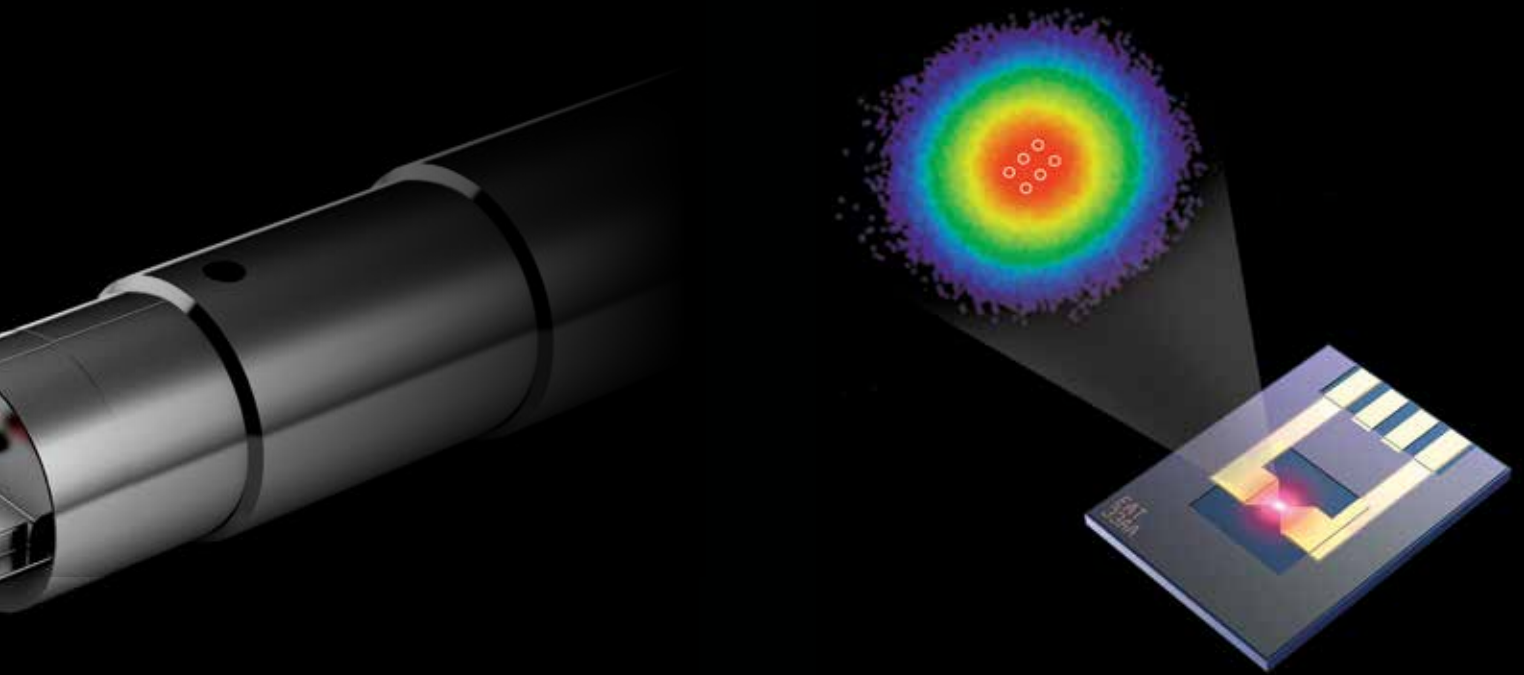
Clarity software sets the sample temperature and responds to changes in pressure and composition using closed-loop feedback control, providing accurate sample temperature under all experimental conditions.





# MAXIMIZE IMAGE QUALITY

Sample location in the holder can affect resolution differently in TEM and STEM. Atmosphere features a unique double E-chip design that allows for optimum sample placement, maximizing resolution without compromising usability.



# ENSURE EXPERIMENT REPEATABILITY

Closed-loop operation is critical, but you also need thermal uniformity. The entire sample area must be at the same temperature to ensure experimental validity. The Atmosphere heating E-chips provide superior thermal uniformity for accurate results.

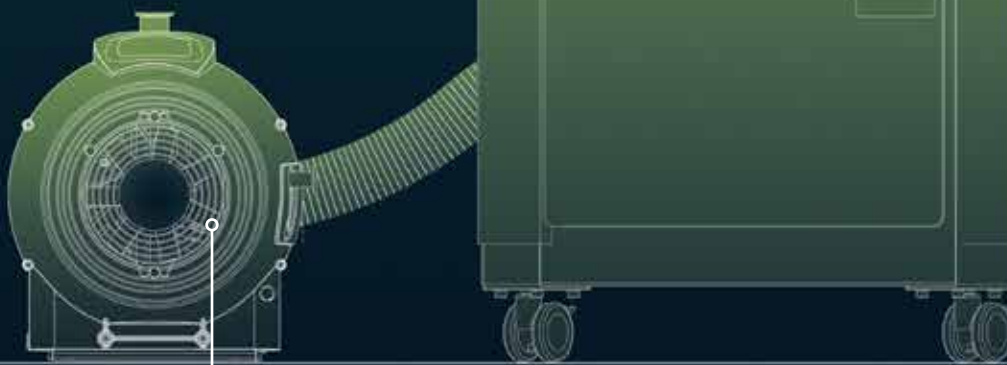
# ATMOSPHERE SYSTEM COMPONENTS

## GAS MANIFOLD

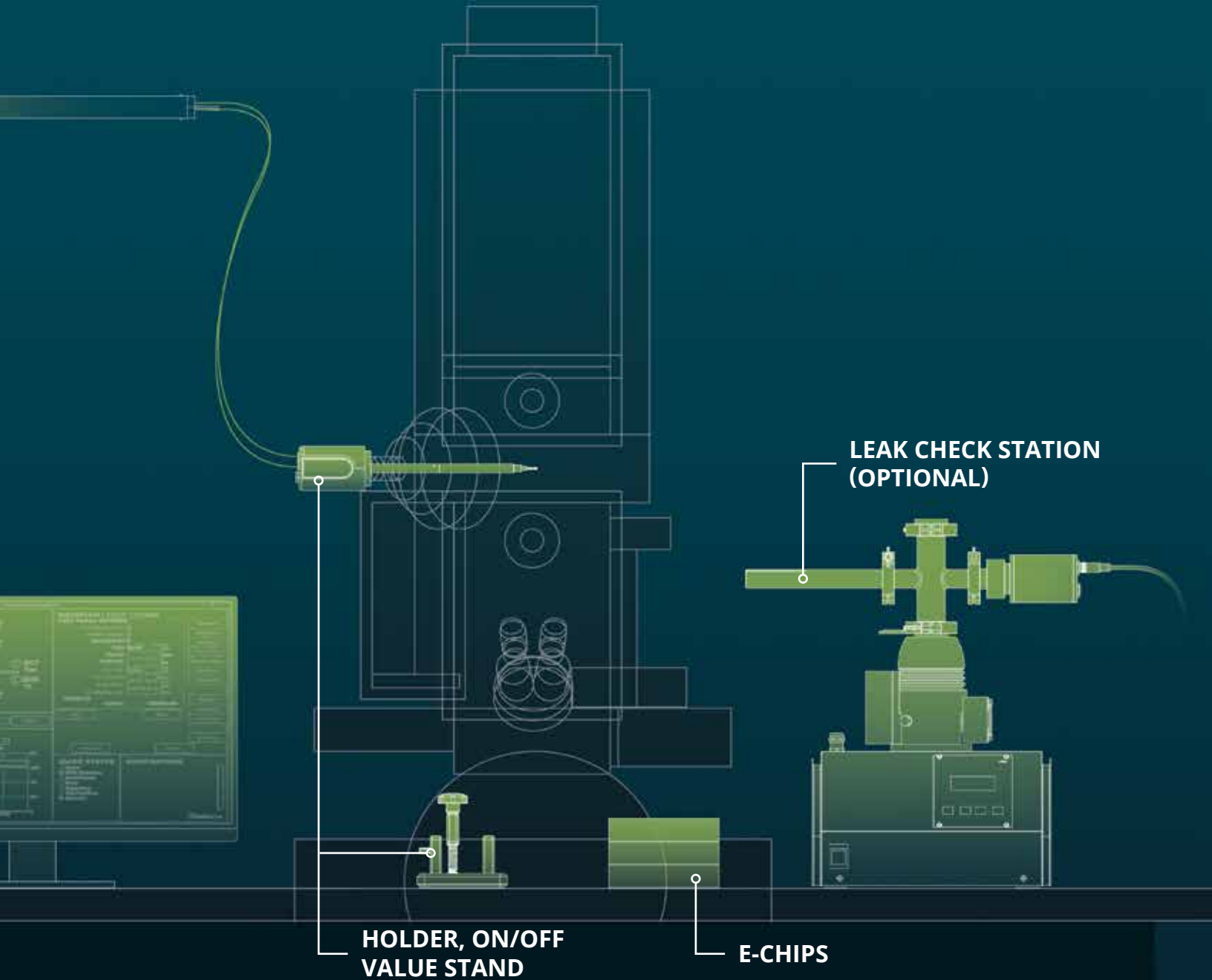
- Automatic gas mixing and pump/purge sequences through Clarity software
- Inert 316 Stainless Steel Construction
- Mix any gas without calibration, including H<sub>2</sub>O vapor
- Connections for mixing up to 3 different gasses
- Integrated flow and pressure sensors for precise gas delivery

## CLARITY SOFTWARE

- Simple, workflow-driven interface
- Shuts down system if leak is detected
- Monitors experiment and logs data in the background
- Synchronizes data with images and videos through Clarity Echo



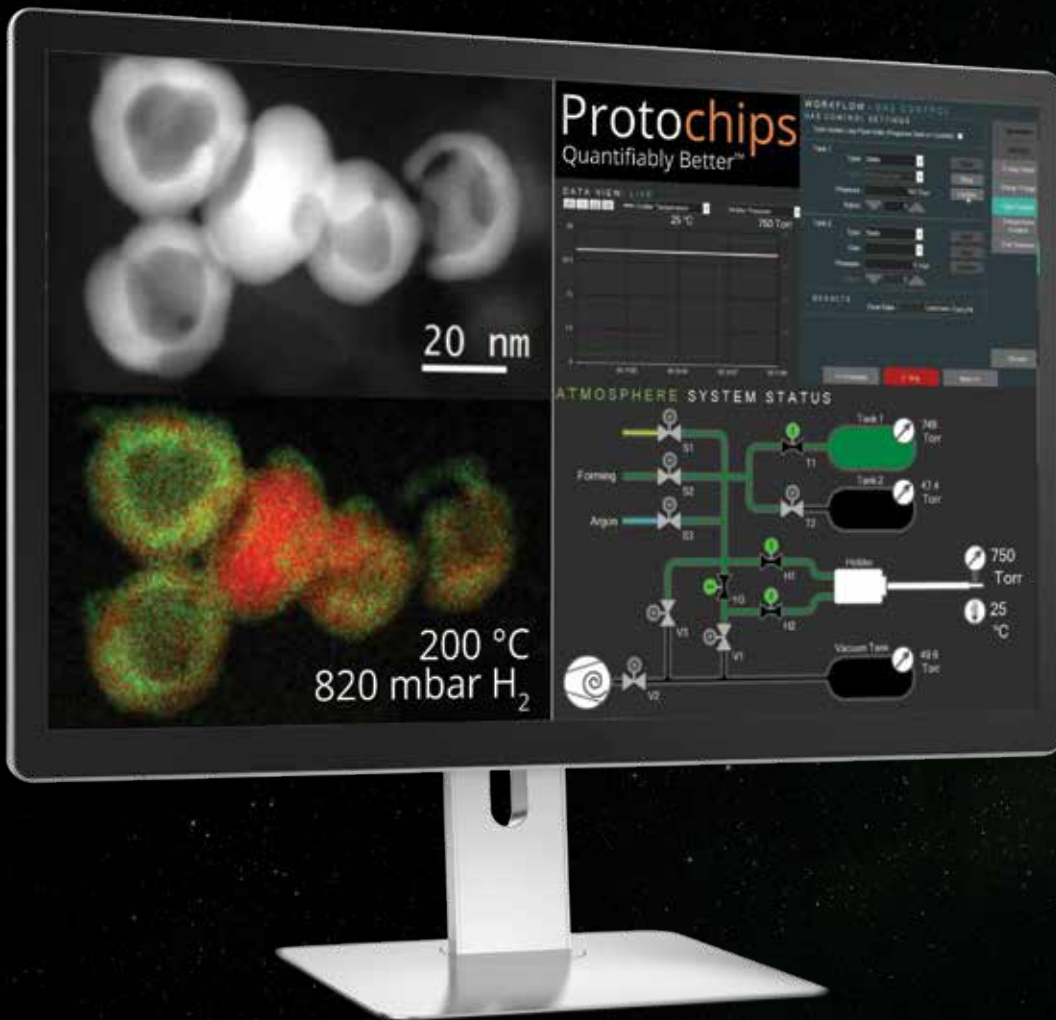
SCROLL PUMP



### *Designed with you in mind.*

From the automated safety features to the ultra-quiet scroll pump, the Atmosphere system works seamlessly in the background to let you focus on the microscope. Featuring two different gas tanks for precise pressure and flow control, the manifold is the core of Atmosphere and also houses software controlled gas mixing and thermal bake-out

controls. The design of the leak check station guarantees proper sample loading into the holder and allows the gas seals to be tested to  $8E-8$  Torr, ensuring vacuum integrity and giving you peace of mind. Combined with the performance of E-chips, Atmosphere offers groundbreaking possibilities with unparalleled ease of use.



## COMPLETE CONTROL OF YOUR EXPERIMENT

*During the experiment, your focus should be your sample, not the equipment.*

The Clarity™ workflow software for Atmosphere provides complete control of your experiment step by step from beginning to end. The software allows you to easily prepare the system for use, choose gases, and set the sample temperature and gas pressure, all while monitoring safety and logging all experimental data in the background automatically. Optional software synchronizes images and video with the heating and gas data, so analyzing your results is fast and easy.



## CREATE RELEVANT GAS ENVIRONMENTS

*Use Atmosphere to mimic the real environment of your sample.*

Whether you're studying nanoscale catalysts or material corrosion, you need control over the composition and movement of the gaseous environment. Atmosphere uses NIST certified volumetric blending techniques to precisely mix gasses ranging from H<sub>2</sub>O vapor to Helium and much more. Integrated sensors enable precise, rapid delivery of gasses to the holder at flow rates as low as 0.005 mL/min to as high as 1.0 mL/min, enabling comprehensive control of the experiment.

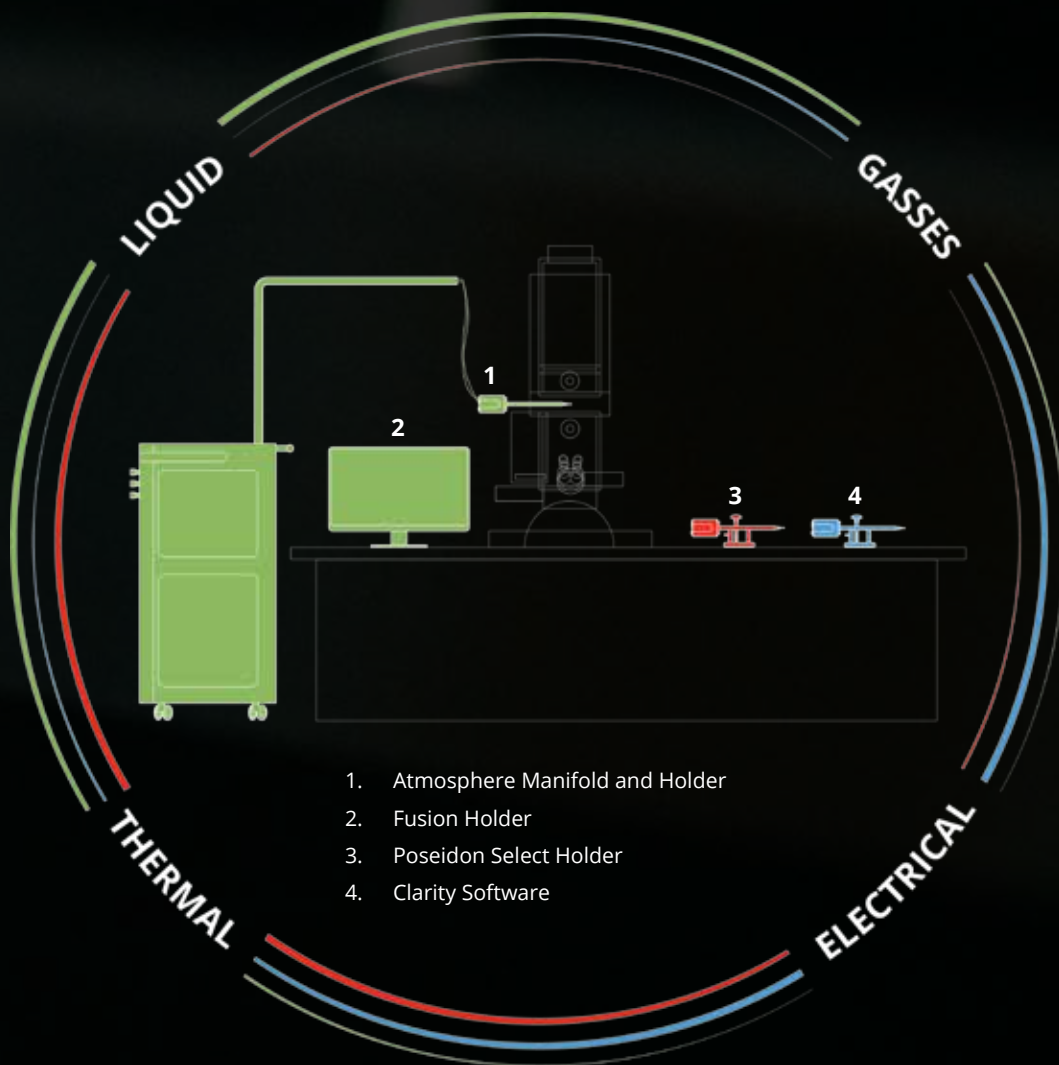
# EXPAND YOUR POSSIBILITIES



## ATMOSPHERE SPECIFICATIONS

<b>Resolution</b>	<1.5 Å (TEM dependent)
<b>Pressure</b>	1.0 Torr - 760.0 Torr
<b>Temperature</b>	25°C - 1000°C
<b>Flow Rate</b>	0.005 mL/min – 1.000 mL/min
<b>Gas Mixing</b>	1.0% - 99.0% mixtures of up to 3 gasses
<b>H<sub>2</sub>O Vapor</b>	1.0 Torr – 18.7 Torr
<b>Gas Analysis</b>	Compatible (RGA dependent)
<b>Tip Volume</b>	< 1 µL
<b>EDS Capability</b>	>3,000 CPS (Detector dependent)
<b>Software Control</b>	Gas composition, flow rate, pressure, temperature
<b>Data Synchronization</b>	Clarity Echo compatible with Gatan® GMS 1, 2, and 3
<b>Imaging</b>	TEM and STEM Optimized
<b>Holder Assembly</b>	Less than 15 minutes

\*Gatan, DigitalMicrograph and GMS are the trademarks of Gatan, Inc



## ENHANCE YOUR LAB WITH FULL IN SITU CAPABILITIES



*"The ability to image nanomaterial synthesis and degradation in real time under realistic environmental conditions is revealing highly unexpected phenomena. The elemental mapping capability of our Atmosphere system is enabling us to better interpret complementary data obtained from bulk analysis techniques such as extended X-ray absorption fine structure."*

- Dr. Sara Haigh, Materials Science Department University of Manchester



*"We've used the Protochips Atmosphere System to observe and study restructuring processes at the atomic scale in more than half a dozen different types of catalysts, which been a very exciting time, since many findings were completely unexpected. From a practical point of view, we've found that the system is relatively easy to use."*

- Dr. George Graham, Catalyst Researcher at University of Michigan



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EU 002598318-0001+0002; EU 003371632-0001+0002

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