DENS solutions

Stream∞

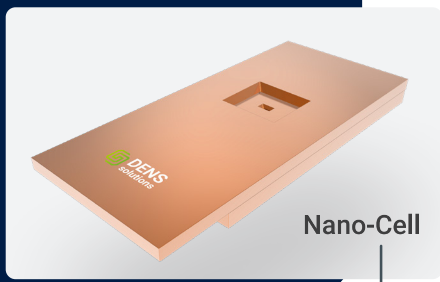
In Situ TEM **Liquid + Heating + Biasing**

we care
we innovate
we deliver

Introduction

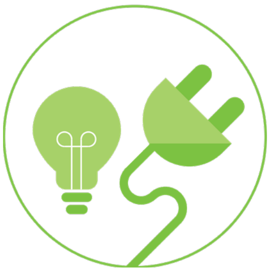
Liquid phase transmission electron microscopy (LPTEM) enables the observation of time-resolved dynamics of a sample in liquid state as a function of stimuli, such as heat, potential and flow, at higher spatial resolution. The technique has become increasingly popular, contributing greatly to a wide range of fields, including materials science, energy and life science.

The DENSsolutions Stream Infinity solution is an enhanced version of Stream, designed to truly advance and expand your research capabilities. Uniquely, the innovative solution features a new pioneering 8-contact environmental TEM holder that allows you to perform electrochemistry as a function of temperature in liquid environments. The core of the Stream Infinity system is our patented Nano-Cell (NC), which consists of a functional and seal chip - together forming a leak-tight compartment that enables you to safely perform liquid experiments inside the electron microscope.



Typical applications

Materials synthesis



Batteries

Electrocatalysis

Fuel cells

Corrosion

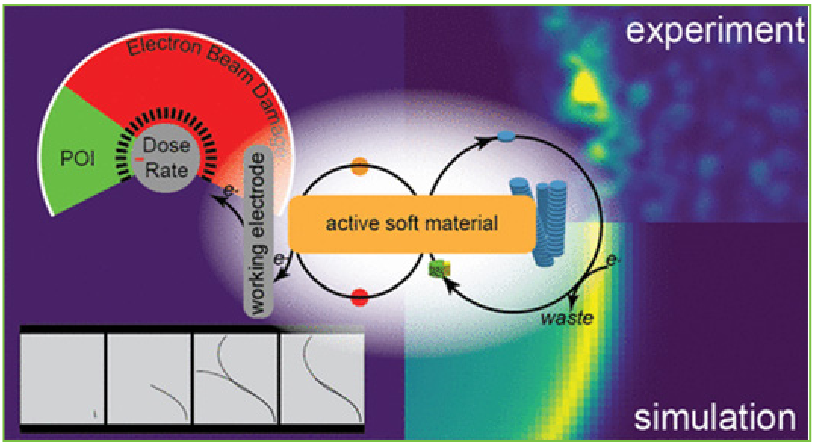
Life science

Selected Publications

Observing the Dynamics of an Electrochemically Driven Active Material with Liquid Electron Microscopy

Electrochemical liquid electron microscopy has been used to explore the self-assembly dynamics of active molecular materials. This study examines these dynamics across various scales, from the nanoscale behavior of individual fibers to the micrometer-scale hierarchical evolution of fiber clusters.

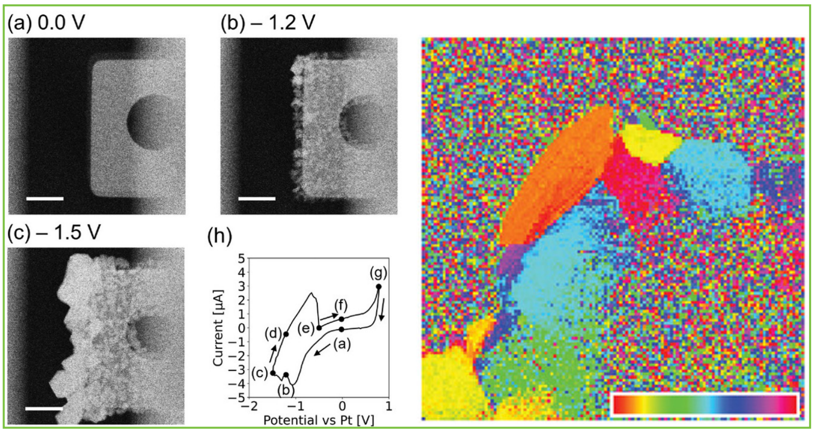
W. Gibson, J. Mulvey, J. Patterson et al. ACS Nano 18, 18 (2024) 11898–11909



Toward Quantitative Electro-deposition via In Situ Liquid Phase Transmission Electron Microscopy: Studying Electroplated Zinc Using Basic Image Processing and 4D STEM

Our Stream customers performed in situ Zn electroplating and analyzed the data via basic image processing. In combination with the 4D STEM analysis, it allowed them to access the information on the crystallographic orientation of the grown Zn nucleates and take a step forward toward live quantification of in situ electrodeposition processes.

J. Park, R. E.Dunin-Borkowski, S. Basak, and R.-A. Eichel, et al. Small Methods 2024. 2400081



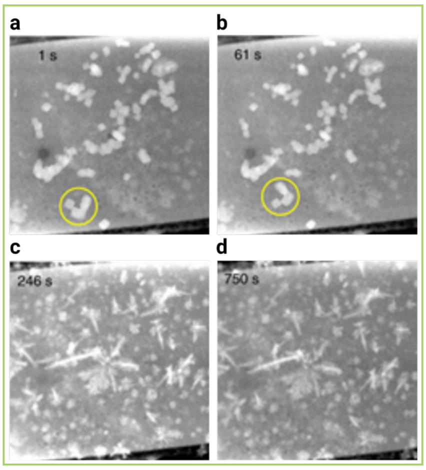
Selected HAADF images during Zn plating process with the corresponding CV curve.

Angle map image after radial Fourier analysis. The inset color bar represents converted angle values between 0 and 360°.

Imaging electrochemically synthesized Cu_2O cubes and their morphological evolution under conditions relevant to CO_2 electroreduction

Here, using liquid cell transmission electron microscopy, our Stream customers show the formation of cubic copper oxide particles from copper sulfate solutions during direct electrochemical synthesis and their subsequent morphological evolution in a carbon dioxide-saturated 0.1 M potassium bicarbonate solution under a reductive potential.

R. M. Arán-Ais, S.W. Chee, B. Roldan Cuenya et al. Nat. Comm. 11 (2020) 3489

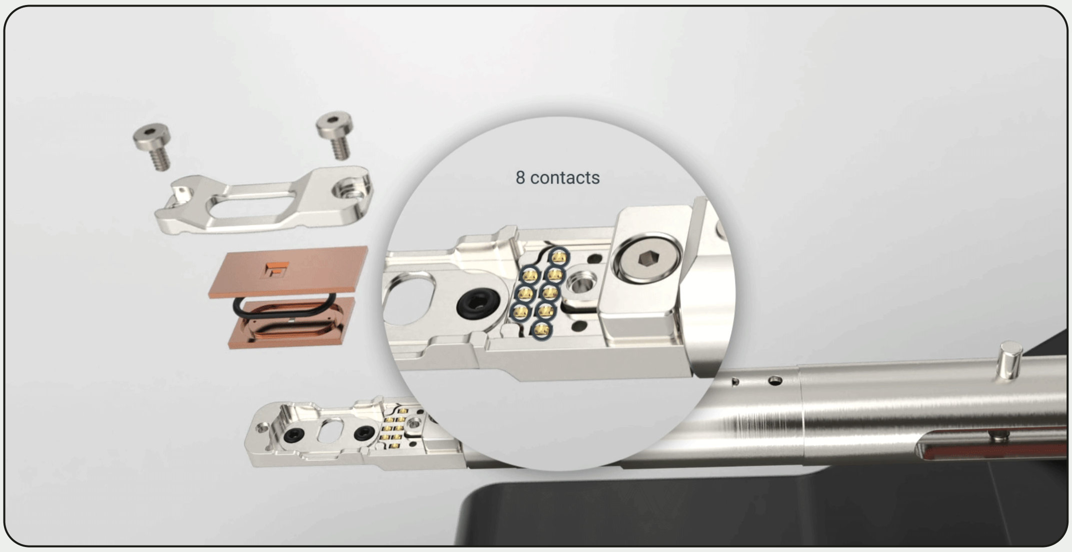


Evolution of Cu_2O cubes during reducing conditions. STEM images of the working electrode at different experimental times, a t = 1s, b t =61s, c t=246s, and d t=750s, acquired while keeping the potential at −0.7V in a CO_2-saturated 0.1M $KHCO_3$ solution.

Why Stream∞?

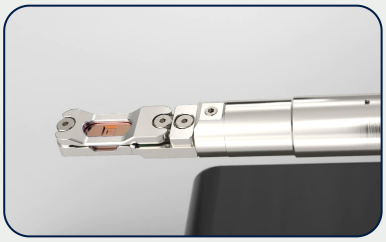
1 Perform electrochemistry as a function of temperature

The new Stream Infinity holder features eight electrical contacts that enable simultaneous application of electrical and thermal stimuli in a liquid environment. The contacts can be used for various electrically driven MEMS-based sensors and actuators, making the Infinity platform essentially a research playground.

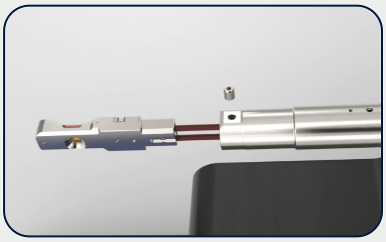


2 Easily switch between STEM and TEM mode

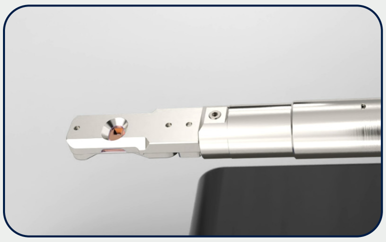
By flipping the tip 180 degrees, you can directly change the sample position to be either on the top or bottom without a need to disassemble the tip. This grants you the freedom to flawlessly switch between STEM or TEM mode, respectively, depending on your experimental needs, while maintaining the best resolution performance. Importantly, you can switch between both imaging modes within a matter of seconds.



STEM mode
(sample on top)



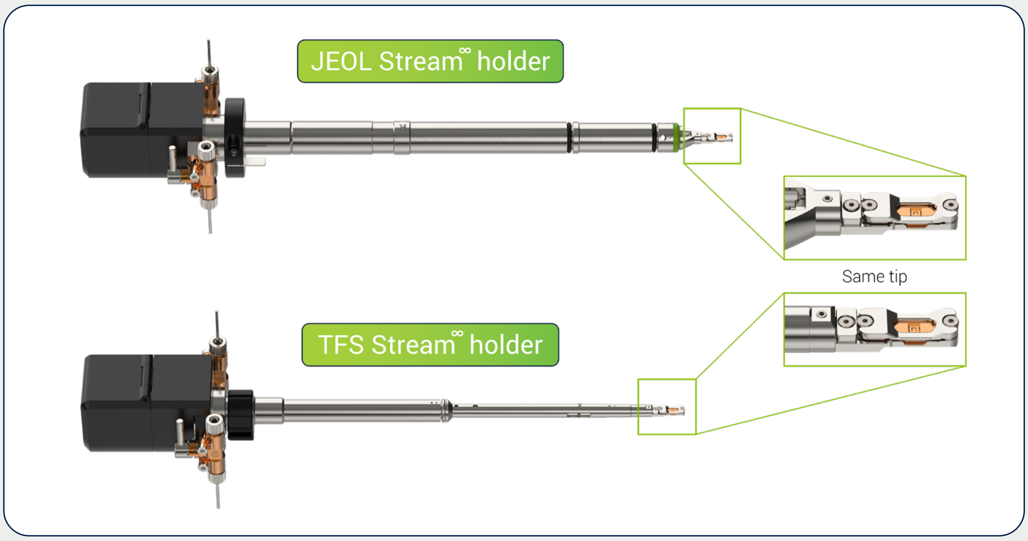
Flip the tip



TEM mode
(sample on the bottom)

3 Securely transfer your sample from one microscope to another

The universal tip of the Infinity holder works as a cartridge that can be moved from one holder body to another, without disassembling the universal Nano-Cell. This feature enables complementary cross-platform studies of the same sample in SEM, beamline setups or using TEM's from JEOL or Thermo Fisher Scientific (TFS). These setups can either be located in the same lab, user facility or even in different universities/institutes, allowing for correlating experimental results in different platforms.



4 Perform liquid and gas studies with the same holder

Gas Supply System

Liquid Supply System

The new environmental Infinity holder is your all-in-one solution for both gas and liquid experiments. Simply choose the appropriate function for the chips and connect the necessary gas or liquid supply system. Our extensive range of chip types includes gas-heating (GH), liquid-heating (LH), gas-heating-biasing (GHB), and liquid-heating-biasing (LHB), offering unparalleled versatility for your experimental needs. New MEMS chip designs can further expand the application space of the Infinity system.

System Specifications

Specification	Thermo Fisher Scientific	JEOL
Polepiece compatibility	Twin, S-twin, X-twin	UHR, FHP, HRP, WGP
EDS compatibility	Side entry, Super-X, Ultra-X*	Side entry
EELS compatibility	Yes	Yes
Number of electrical contacts	8	8
System operation modes	Liquid + Heating | Liquid + Biasing | Liquid + Heating + Biasing	
Number of heating electrodes	4	
Number of biasing electrodes	3 (WE, CE, RE) +1	
Nano-Cell compatibility	Universal chips for TFS and JEOL holders	
Liquid inlet/outlet	Directly on the chip	
Modular holder design	Yes, removable tip	
Tip compatibility	Universal tip for TFS and JEOL** holder	
Flipping the tip	Yes (180 degrees)	
Sample position	Top or bottom window (STEM or TEM optimized)	
Holder tubing	Individual Fused Silica or PEEK	
Fluidic control method	Integrated pressure-based pumps (inlet + outlet)	
Inlet pressure range	0 – 4500 mbar***	
Outlet pressure range***	- 800 – 0 mbar***	
Liquid operation mode	Static or flow (infusion & withdrawal)	
Liquid flow measurement	Yes, dedicated flow meter	
Liquid flow range (measured)	0 to 8000 nl/min	
Gas purging	Yes (remove liquid from the cell using gas)	
Perform gas experiments	Yes (via an upgrade)	

** Contact DENSsolutions for more information*

*** Applicable to JEOL TEMs with HRP and WGP pole pieces*

**** Relative pressure*

Microscopy TODAY
2021 Innovation Award

Complete 'plug & play' package

1. **Stream Infinity TEM holder**
2. **Nano-Cells starter pack**
3. **Laptop with dedicated software**
4. **Liquid Supply System** (including pressure-based pumps)
5. **Heating control unit** (not shown, integrated in the LSS)
6. **PalmSens 4C potentiostat** (not shown, integrated in the LSS)
7. **Holder leak test system** (optional)

Including:
Supporting tools

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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Stream∞
Liquid + Heating + Biasing

Version 5.1.1