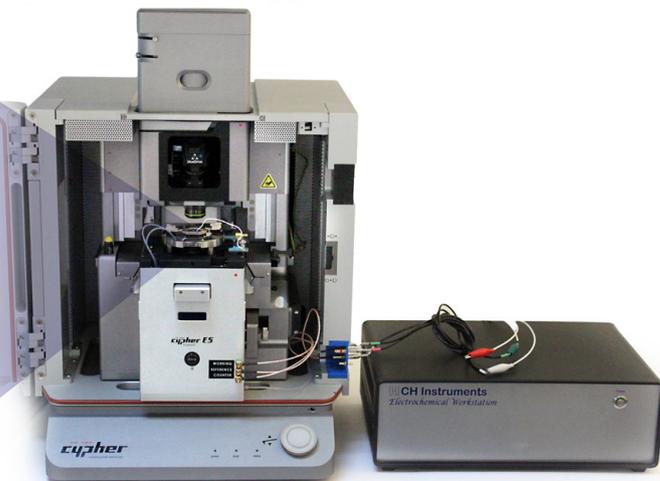


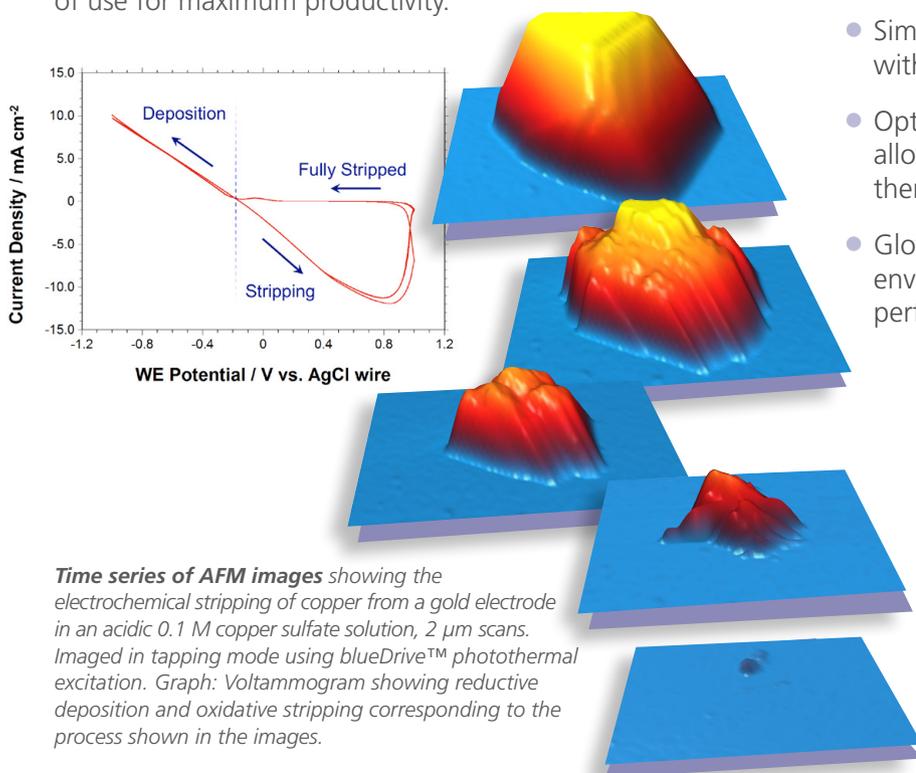
Electrochemistry Cell for the Cypher ES AFM



The **Electrochemistry Cell** for the Asylum Research **Cypher ES** AFM is the premier solution for *in situ* AFM characterization of electrochemical processes. Its simple modular design provides great versatility and compatibility with a wide range of materials. Best of all, it is based on the Cypher ES AFM— the world's highest resolution, fast scanning AFM with superior environmental control and ease of use for maximum productivity.

The Highest Performance Electrochemical AFM

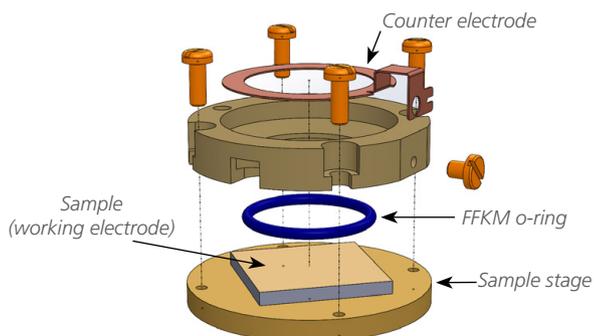
- Fully sealed EC cell with uniquely designed probe holder and liquid cup for easy imaging in fluid
- Compatible with most common solvents, electrolytes and electrode materials
- Simple to clean and assemble, even with gloves
- Optional heating and cooling stages allow investigation of electrochemical thermodynamics
- Glovebox option provides the ultimate environmental control with no performance compromises



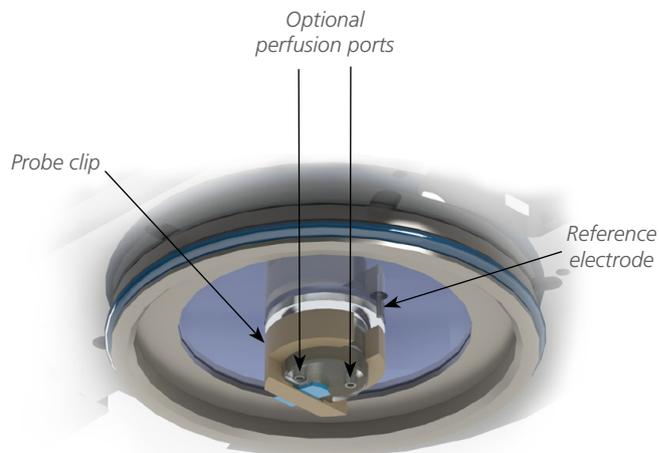
Time series of AFM images showing the electrochemical stripping of copper from a gold electrode in an acidic 0.1 M copper sulfate solution, 2 μm scans. Imaged in tapping mode using blueDrive™ photothermal excitation. Graph: Voltammogram showing reductive deposition and oxidative stripping corresponding to the process shown in the images.

Designed for the Rigors of EC Research

- The EC Cell liquid cup features a ~200 μL working volume—large enough to avoid significant reaction-induced concentration changes and small enough to conserve reagents—and prevents low surface tension liquids from leaking.
- Sample chamber prevents electrolyte evaporation and provides secondary containment against spills.
- Quartz-constructed probe holder dips the AFM probe and the reference electrode into the liquid volume.
- The EC Cell liquid cup and probe clip are provided in both glass-filled PEEK and PPS (Ryton®) for compatibility with most solvent electrolyte materials. A perfluoroelastomer O-ring (FFKM, P-Rex®) seals against the working electrode.
- The liquid cup forms a well-defined working electrode surface area, ~55 mm^2 , enabling quantitative electrochemistry and eliminating electric field edge effects.
- Ring-shaped counter electrode avoids directional artifacts.
- Shielded electrode connections preserve highly sensitive signals and route neatly to an external potentiostat.
- Optional glovebox integration for the ultimate sub-ppm control of water and oxygen levels.



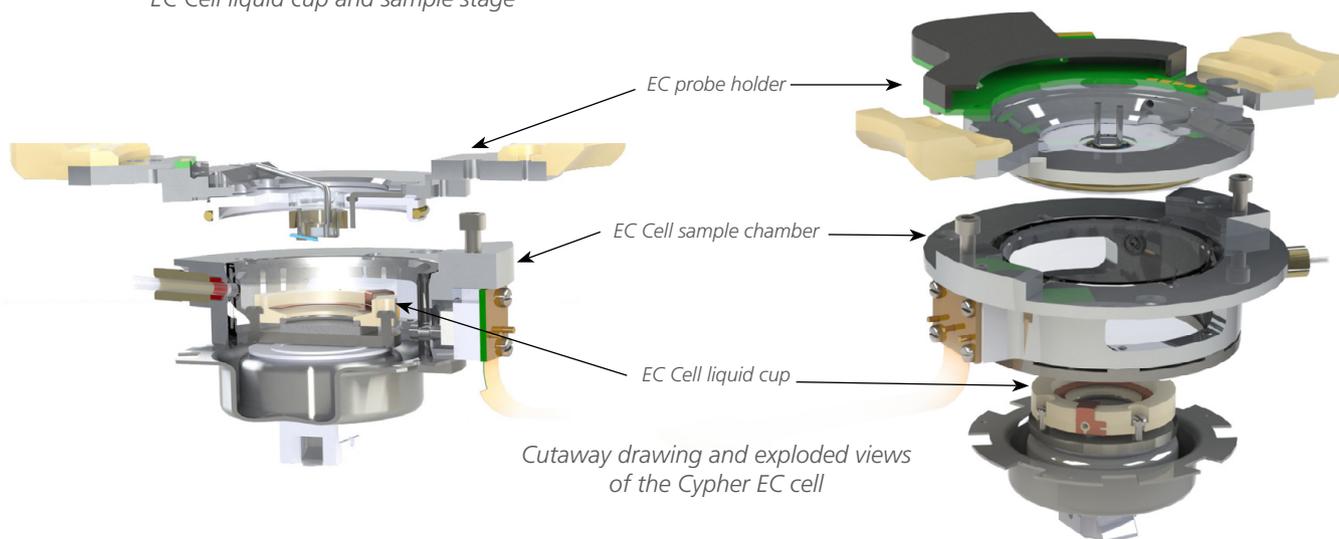
EC Cell liquid cup and sample stage



Partial bottom view of the EC probe holder

Experimental Versatility and Simplest User Experience

- Optional heating and cooling stages allow investigation of electrochemical thermodynamics.
- Two gas ports and two optional liquid perfusion ports enable hassle-free gas and electrolyte exchange.
- Connect to your choice of commercial potentiostats, or we can suggest a suitable general-purpose model.
- Modular counter and reference electrodes allow you to choose the most appropriate materials.
- EC Cell is compatible with round and square samples, diameters from 9-15 mm.
- All components are fast and simple to clean and assemble, even wearing gloves.

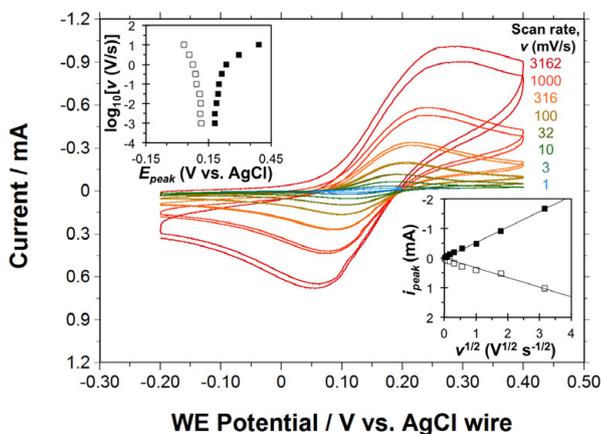
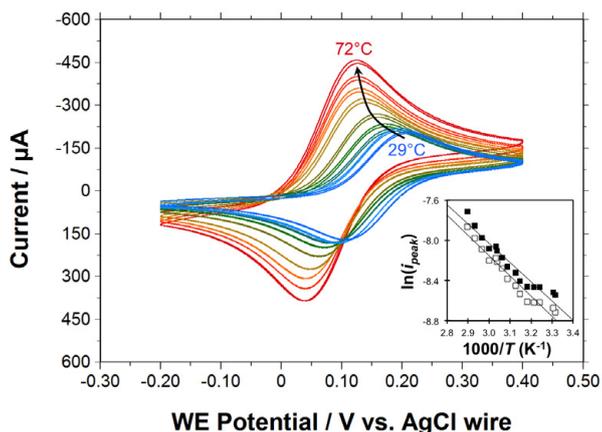


Cutaway drawing and exploded views of the Cypher EC cell

Applications

The Cypher ES with the **EC Cell** excels at a wide range of measurements:

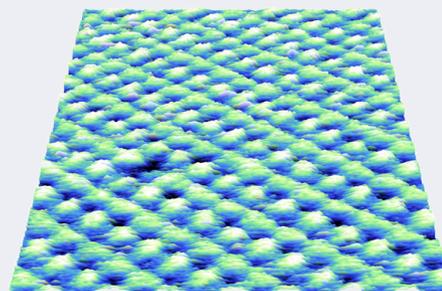
- Characterizing energy storage materials under bias, such as battery electrodes, membranes and solution-electrode interfaces
- Electrodeposition and stripping of metals
- Investigating kinetics of corrosion
- Monitoring morphology over time of electrode-attached biocatalysts, microorganisms, and other biophysical research
- Nucleation and growth of nanoparticles



Aqueous cyclic voltammetry of 1 mM ferro-/ferricyanide in 100 mM KCl with a Au-sputtered mica working electrode (WE). Each colored trace represents two scan cycles and shows the one-electron process $[\text{Fe}(\text{CN})_6]^{4-} \rightleftharpoons [\text{Fe}(\text{CN})_6]^{3-} + e^-$. (Top) Current response as a function of temperature, T , at a scan rate of 100 mV s^{-1} . Inset shows Arrhenius-type behavior with an activation energy of 0.17 eV (16.6 kJ mol^{-1}). Temperature is controlled in the Cypher ES sample chamber with the Heater or HeaterCooler stages. (Bottom) Current response as a function of scan rate, v , at ambient temperature (29°C). The potentiostat may be used to vary v over many orders of magnitude. Inset plots show the scan rate dependence of peak potential (E_{peak}) and peak current amplitude (i_{peak}).

Your electrochemical research will benefit from these core Cypher capabilities

Highest resolution imaging Cypher makes high resolution imaging easy. No other AFM makes true atomic resolution routine!



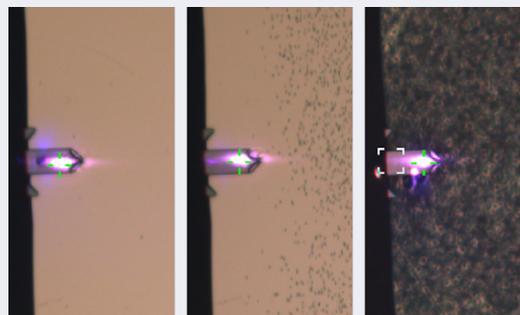
Atomic point defect in calcite imaged in the Cypher EC Cell in tapping mode using blueDrive, 5 nm scan.

blueDrive photothermal excitation blueDrive is simply a better way to tap — blueDrive tunes are clean and stable, and closely match the theoretical response. There's never a "forest of peaks" like you see when using piezo drive for tapping in liquid. You can image for hours with no setpoint adjustments. blueDrive also enables tapping mode operation in highly viscous media like ionic liquids.



Titanium dioxide substrate imaged in a highly viscous liquid using tapping mode with blueDrive, $5 \mu\text{m}$ scan.

Excellent top-view bright-field optics Cypher features diffraction-limited top-view optics that achieve $<1 \mu\text{m}$ resolution. Adjustable aperture and field diaphragms help optimize contrast on challenging samples.



Optical images through the top-view optics showing surface deposition of copper on gold over time. The probe is an AC40 cantilever, $40 \mu\text{m}$ long.

Specifications

The Electrochemistry Cell comes in a comprehensive kit that includes the EC liquid cup, EC probe holder, EC Sample holder and standard electrodes.

Requirements

- **Cypher ES AFM scanner.** The EC Cell is designed for environmental control with easy assembly.
- **Potentiostat.** Customer choice of brand. CH Instruments 630E model may be purchased from Asylum Research.
- **blueDrive photothermal excitation.** Allows for tapping mode (AC) imaging. *Note there is no tapping piezo on the EC Cell probe holder.*

EC Cell Liquid Cup

Makes contact with electrolyte

- **Electrolyte containment cup.** Glass-filled PEEK or PPS, both included. Working volume with probe holder fully engaged is 150-250 μL .
- **O-ring seal to working electrode.** FFKM perfluoroelastomer. 8.4 mm ID sets working electrode active area to $\sim 55 \text{ mm}^2$ for quantitative analyses. Edges and sides of sample are not exposed to liquid.
- **Counter electrode.** Copper; concentric design; 12.7 mm OD 9.5 mm ID, and 0.13 mm thick, for a two-sided total surface area of $\sim 120 \text{ mm}^2$. Pt version available as an option. *Note: Customer can easily form electrode from metal wire of their choice.*
- **Sample (working electrode).** Customer choice; 9-15 mm circular diameter or square range, but always with an exposed area of $\sim 55 \text{ mm}^2$. Sample substrate can be conducting or insulating with a thickness range from 0.5-2.0 mm.

EC Probe Holder

Makes contact with electrolyte

- **Probe support and optical window.** Fused silica (quartz) downtube probe support and optical window; 5 mm OD; 5 mm dipping height.
- **O-ring seal to sample chamber.** FFKM perfluoroelastomer; 8.4 mm ID. 0.8 mm cross section diameter.
- **Probe clip.** Glass-filled PEEK or PPS; 5.0 mm ID; 7.0 mm OD. Both included.
- **Reference electrode wire.** Ag wire comes standard; customer choice. Sealed with FFKM O-ring or PTFE (Teflon®) tape. Feedthrough hole 1.0 mm in diameter.
- **Optional with two liquid perfusion ports.** Compatible with FEP tubing, 0.8 mm OD, 0.4 mm ID.

Note: *No adhesives contact electrolyte*

Cypher ES Sample Chamber

Does not come into direct contact with the electrolyte. Makes contact with chamber atmosphere.

- **Chamber wall.** Fused silica; 25.4 mm ID with three metal rust-proof magnetic nickel contacts for working, ground, and counter electrode connections. Inquire about optional humidity sensor.
- **Gas perfusion/exchange ports.** FEP, 1.6 mm OD, 0.8 mm ID.
- **Bellows.** For emergency liquid containment and mechanically-adaptive atmosphere isolation. FFKM perfluoroelastomer.
- **Chassis.** Nickel plated Invar® metal. Chassis does not come into contact with liquid.

Note: *Chamber is not intended to be filled with liquid.*

Compatible with Common Electrolyte Solvent

- Aqueous salt solutions and buffers (e.g. KCl, phosphate buffered saline, HEPES)
- Organic solvents (e.g. toluene, THF, dimethoxyethane)
- Halogenated solvents (e.g. chloroform, chlorobenzene)
- Organic amines (e.g. ethylenediamine)
- Caustics (e.g. HCl, NaOH). *Note: HF will etch the quartz.*
- Organic carbonates (e.g. propylene carbonate, ethylene carbonate)
- Ionic liquids (e.g. imidazolium/pyridinium/substituted-ammonium cations with NTf_2^- / PF_6^- / halide anions)

Operating Modes Available with the EC Cell

AM-FM Viscoelastic Mapping; Contact; Contact Resonance Viscoelastic Mapping; Dual AC; Dual AC Resonance Tracking (DART); Fast Force Mapping (FFM); Force Mapping (Force Volume); Force Modulation; Frequency Modulation; Lateral Force (LFM); Loss Tangent Imaging; Magnetic Force Microscopy (MFM); Nanolithography and Nanomanipulation; Phase Imaging; Tapping (AC Mode); Tapping with digital Q control. **Note:** *The EC Cell probe holder is fully functional for non-EC imaging in air or liquid. For some applications, its dipping-style architecture may be ideal compared to other Cypher probe holders.*

See Cypher brochure for further Cypher ES specifications.

Visit www.Oxford-Instruments.com/AFM to learn more

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