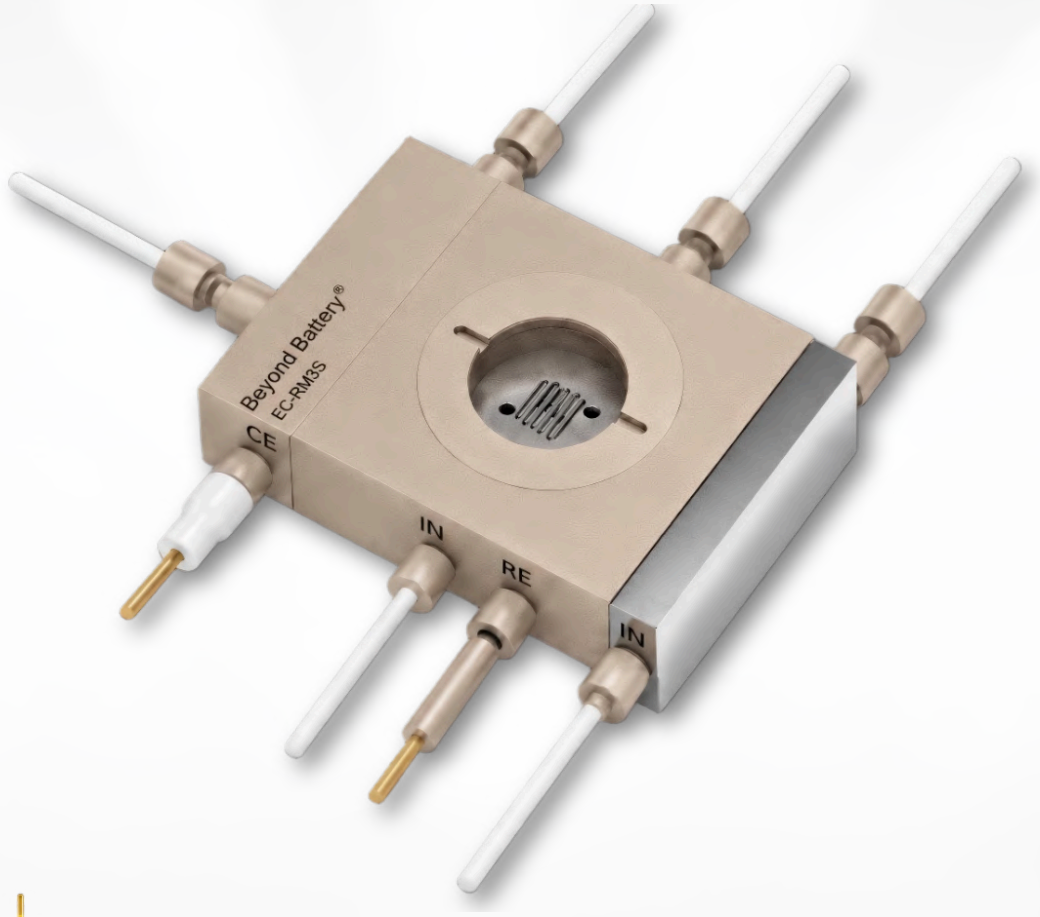
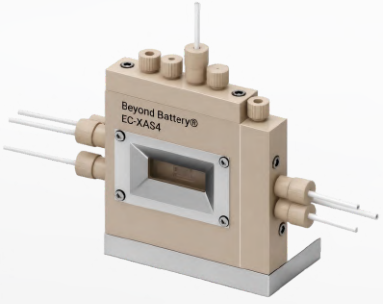
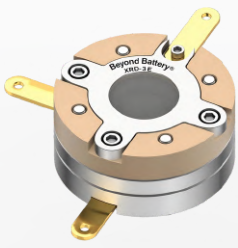
In Situ & Operando Cells for Electrochemistry & Battery Research

Comprehensive solutions for in situ and operando characterization of electrochemical reactions and battery materials







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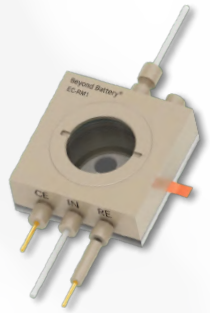

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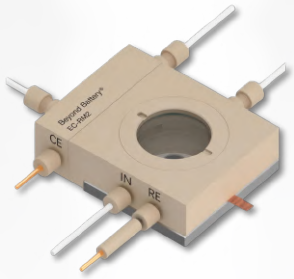
EC-RM1

Single-chamber, three electrode



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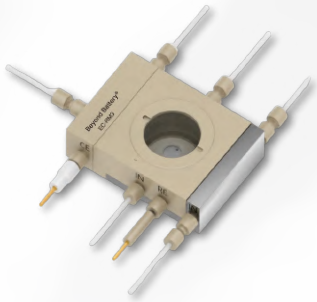
EC-RM2

Two-chamber, membrane



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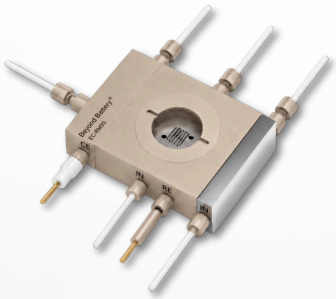
EC-RM3

Three-chamber, gas-diffusion



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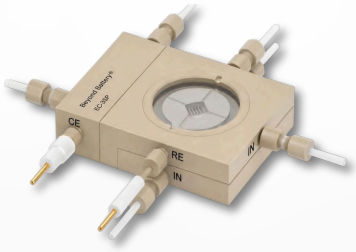
EC-RM3S

Three-chamber, serpentine gas channel



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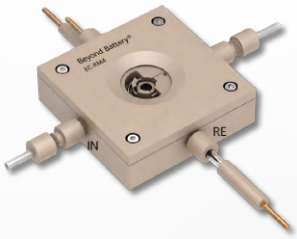
EC-RM3SP

Three-chamber, short-path



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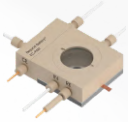
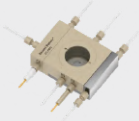
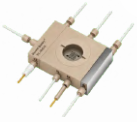
EC-RM4

Single-chamber, disk electrodes

In Situ Raman Electrochemical Cell Selection Guide

Model	Chamber structure	WE-optical window distance	Optical window	Best suited for
 EC-RM1	Single-chamber	< 6 mm	Quartz, Ø37 mm	Baseline mechanistic & interface studies
 EC-RM2	Two-chamber, replaceable ion-exchange membrane	< 6 mm	Quartz, Ø37 mm	Separated reactions, reduced iR drop
 EC-RM3	Three-chamber, gas-diffusion	< 6 mm	Quartz, Ø37 mm	Gas-fed CO_2RR flow studies
 EC-RM3S	Three-chamber, serpentine gas channel	< 6 mm	Quartz, Ø37 mm	High-rate gas-fed electrochemistry
 EC-RM3SP	Three-chamber, serpentine gas channel	< 3 mm	Sapphire, Ø38 mm	CO_2 electrolysis at medium-to-high current densities; interface-resolved studies
 EC-RM4	Single-chamber, disk electrodes	< 3 mm	Quartz, Ø25 mm	Fast screening with disk electrodes
 EC-MOD	Modular flow cell, 1- or 2-chamber	< 1.5 mm	Sapphire/quartz; Kapton film; beryllium (optional),15 × 15 mm	Multi-technique Raman, FTIR, UV–Vis, XRD, and XAS studies

In Situ & Operando Electrochemical Cells

EC-RM1

In Situ Raman Spectroelectrochemical Cell

A compact three-electrode spectroelectrochemical cell for operando Raman monitoring of electrochemical interfaces.

Product Overview

The EC-RM1 provides direct Raman access to a plate-type working electrode through a quartz optical window while maintaining three-electrode electrochemical control. Its compact single-chamber design supports both static electrolyte filling and external electrolyte circulation, making it suitable for mechanistic studies in electrocatalysis, battery materials, and electrochemical interface research.

Technical Specifications

Working electrode area	1 cm² (customizable)
WE-optical window distance	< 6 mm
Optical window diameter	Ø37 mm (effective diameter Ø34 mm)
Chamber structure	Single-chamber
Working electrode	Plate-type electrodes (e.g., Au, Pt, glassy carbon, ITO, FTO, and carbon paper)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Platinum wire electrode
Cell body material	PEEK + Ti
Optical window material	Quartz
Cell body dimensions	L70 × W70 × H19 mm

Key Features

Direct Interface Observation

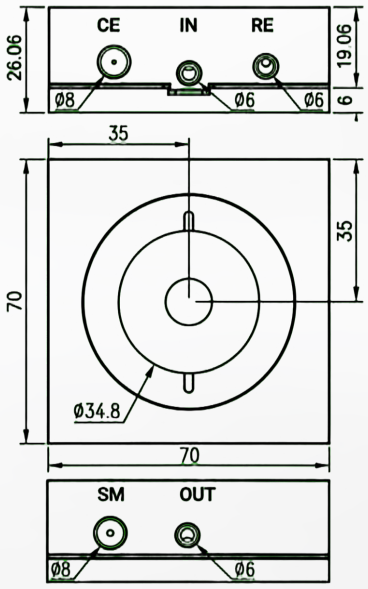
Enables direct optical access to a single electrochemical interface for fundamental reaction studies

Minimal System Complexity

Single-chamber configuration provides a simplified reaction environment for baseline mechanistic analysis

Interface Evolution Analysis

Enables investigation of electrode surface reconstruction and interfacial structural changes during electrochemical operation



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia Qontor), HORIBA (LabRAM HR Evolution, iHR550), and Ocean Optical Instruments (HRS-5A)

Potentiostat Compatibility

Compatible with commercial three-electrode electrochemical workstations, including CH Instruments (CHI660E, CHI760E, CHI1140C), Bio-Logic (VMP3), and Corrtest Instruments (CS350M)

Published Application Example

In Situ Raman Monitoring of Glycerol Electrooxidation

The cell used in this study, supplied by Beyond Battery under product code EC-RM1, was coupled with an HRS-5A Raman spectrometer to investigate an Au_1Cu_1–Ag/AgBr catalyst supported on carbon paper. Its single-compartment, three-electrode configuration enabled time-resolved Raman acquisition directly from the working electrode under an applied potential of 1.43 V. Raman changes near 1060 and 1400 cm^{-1} were monitored during electrolysis.

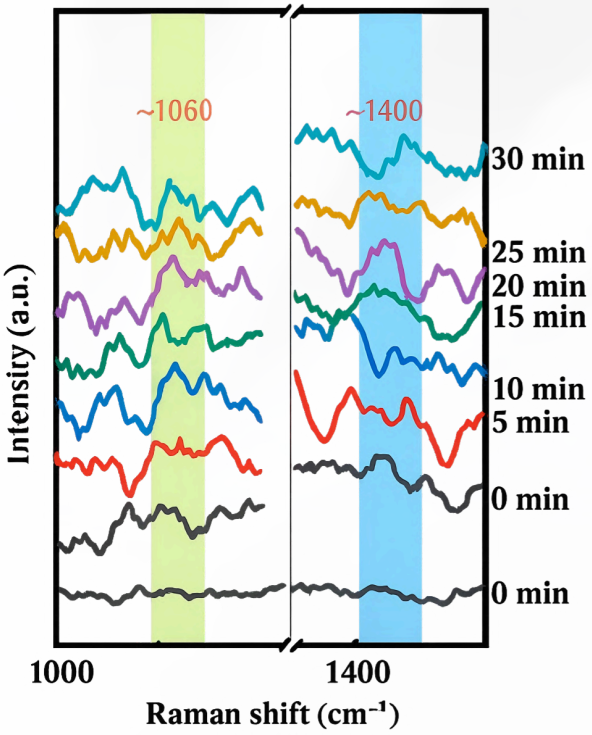
Demonstrated EC-RM1 Capabilities

- Simultaneous Raman and electrochemical measurements
- Continuous monitoring under an applied potential
- Compatibility with catalyst-coated carbon paper

Additional Published Applications

- Chen, W. et al. ACS Sustainable Chem. Eng. 2025, 13, 11607–11616.
- Lv, H. et al. Nat. Commun. 2023, 14, 3117.

Product Identification Note: *EC-RM1 is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*



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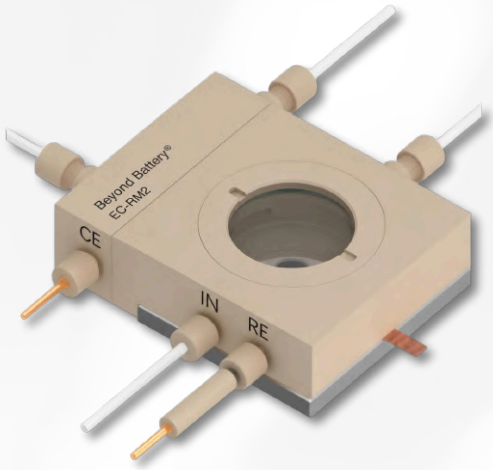
In Situ & Operando Electrochemical Cells



EC-RM2

In Situ Raman Spectroelectrochemical Cell

A two-chamber cell with a replaceable ion-exchange membrane for in situ Raman monitoring of electrochemical interfaces.

Product Overview

The EC-RM2 provides direct Raman access to a sheet-type working electrode through a quartz optical window while maintaining three-electrode electrochemical control. Its two-chamber, replaceable-membrane design separates the cathode and anode chambers, minimizes anodic interference at the cathode, and supports both syringe filling and external electrolyte circulation.

Technical Specifications

Working electrode area	1 cm² (customizable)
WE-optical window distance	< 6 mm
Optical window diameter	Ø37 mm (effective diameter Ø34 mm)
Chamber structure	Two-chamber
Working electrode	Sheet-type electrode (e.g., Au, Pt, glassy carbon, ITO, FTO, and carbon paper)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Platinum wire electrode or graphite rod electrode
Cell body material	PEEK + Ti
Optical window material	Quartz
Cell body dimensions	L89 × W70 × H25 mm

Key Features

Direct Interface Observation

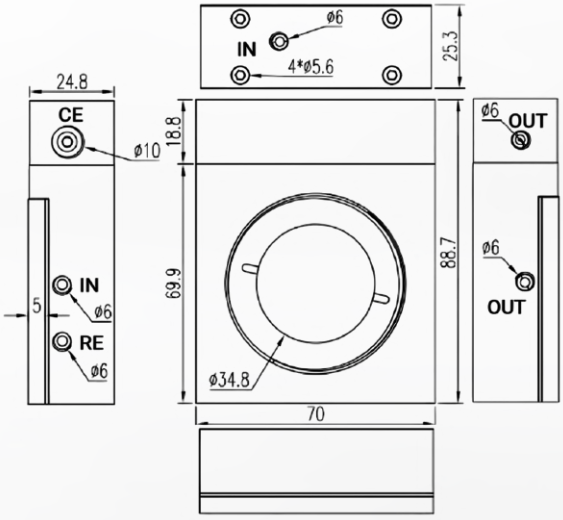
Positions the working electrode directly below the quartz window for in situ optical observation

Replaceable Membrane Separation

Separates the cathode and anode chambers using a replaceable ion-exchange membrane

Reduced iR Drop

Places the reference and working electrodes in the same chamber to reduce iR drop



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia Qontor), HORIBA (LabRAM HR Evolution, iHR550), and Ocean Optical Instruments (HRS-5A)

Potentiostat Compatibility

Compatible with commercial three-electrode electrochemical workstations, including CH Instruments (CHI660E, CHI760E, CHI1140C), Bio-Logic (VMP3), and Corrtest Instruments (CS350M)

Published Application Example

Two-Chamber In Situ Raman Monitoring of Methane Electrooxidation

The cell used in this study, supplied by Beyond Battery under product code EC-RM2, a two-chamber cell separated by a Fuma bipolar membrane, was coupled with a LabRAM Soleil microscope to study CH_4 electrooxidation over NiCo hydroxides on carbon cloth. Using 532 nm excitation, in situ Raman tracked potential-dependent catalyst evolution, oxygen-vacancy-related changes, and CO intermediates associated with CH_3COOH formation.

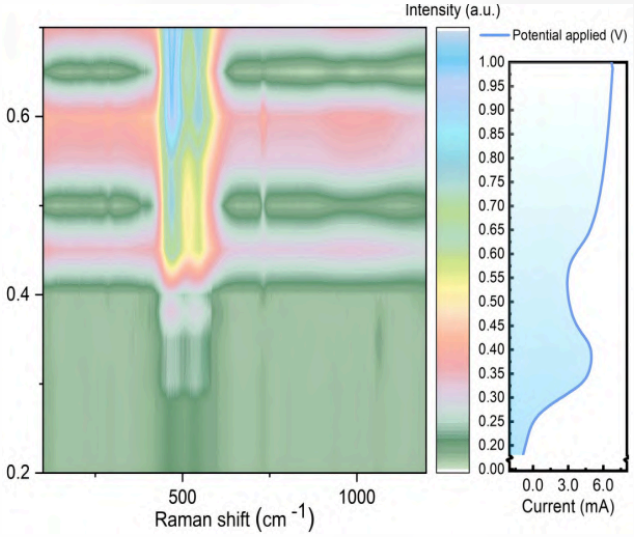
Demonstrated EC-RM2 Capabilities

- Bipolar-membrane-separated, two-chamber operation
- Simultaneous Raman and electrochemical measurements
- Compatibility with carbon-cloth-supported catalysts

Additional Published Applications

- Zhu, J. et al. Nat. Commun. 2024, 15, 1565.
- Li, Y. et al. Appl. Catal. B Environ. Energy 2024, 357, 124250.

Product Identification Note: *EC-RM2 is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*



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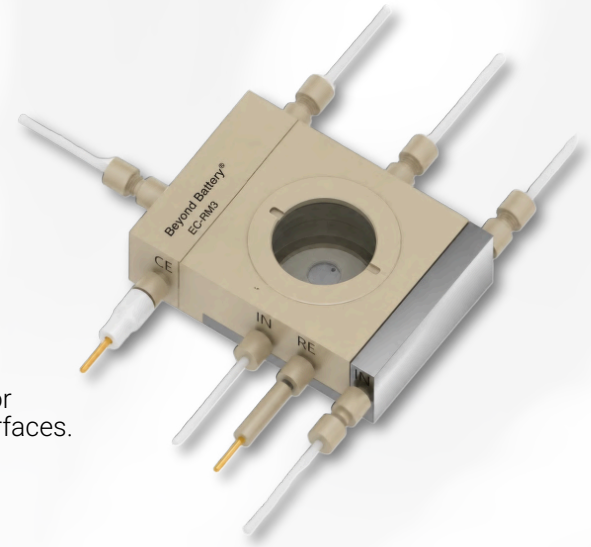
In Situ & Operando Electrochemical Cells



EC-RM3

In Situ Raman Spectroelectrochemical Cell

A three-chamber gas-diffusion spectroelectrochemical cell for operando Raman monitoring of gas-fed electrochemical interfaces.

Product Overview

The EC-RM3 combines direct Raman access with a membrane-separated three-chamber configuration for gas-fed electrochemical studies. A dedicated gas channel supplies reactant gas to the working electrode in the cathode chamber, enabling operando investigation of gas–liquid–solid interfaces under three-electrode control.

Technical Specifications

Working electrode area	1 cm² (customizable)
WE-optical window distance	< 6 mm
Optical window diameter	Ø37 mm (effective diameter Ø34 mm)
Chamber structure	Three-chamber
Working electrode	Sheet-type gas-diffusion electrode (e.g., Au, Pt, glassy carbon, ITO, and FTO)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Platinum wire electrode or graphite rod electrode
Cell body material	PEEK + Ti
Optical window material	Quartz
Cell body dimensions	L99 × W70 × H25 mm

Key Features

Gas-Fed Interface Monitoring

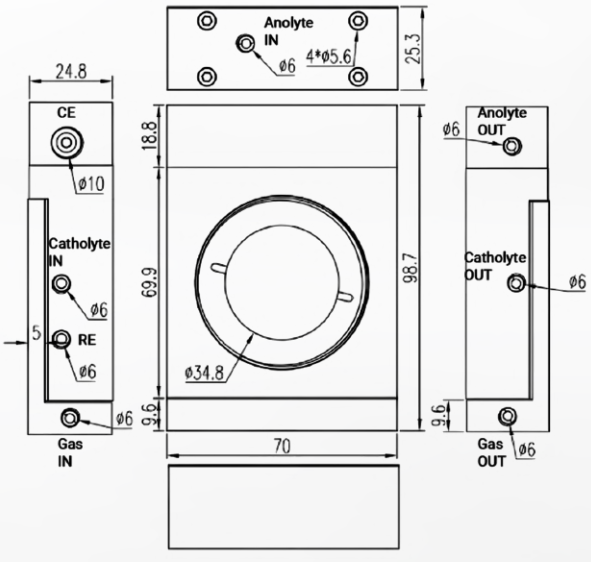
Provides direct Raman access to the gas-diffusion cathode interface under continuous reactant gas supply

Membrane-Separated Reaction Control

Separates cathodic and anodic compartments to reduce product crossover and minimize inter-reaction interference

Operando Interfacial Analysis

Enables real-time investigation of reaction intermediates, catalyst evolution, and gas–liquid–solid interfacial processes



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia Qontor), HORIBA (LabRAM HR Evolution, iHR550), and Ocean Optical Instruments (HRS-5A)

Potentiostat Compatibility

Compatible with commercial three-electrode electrochemical workstations, including CH Instruments (CHI660E, CHI760E, CHI1140C), Bio-Logic (VMP3), and Corrtest Instruments (CS350M)

Published Application Example

In Situ Raman Monitoring of CO_2 Electroreduction

The cell used in this study, supplied by Beyond Battery under product code EC-RM3, a modified three-electrode flow-cell configuration, was used to investigate Cu_2O catalysts with controlled surface roughness during CO_2 electroreduction. Catalyst-loaded carbon paper served as the working electrode, with Ag/AgCl and a graphite rod as the reference and counter electrodes. In situ spectroscopy tracked *CO adsorption and Cu^+ evolution, linking catalyst surface structure to C_2^+ product selectivity.

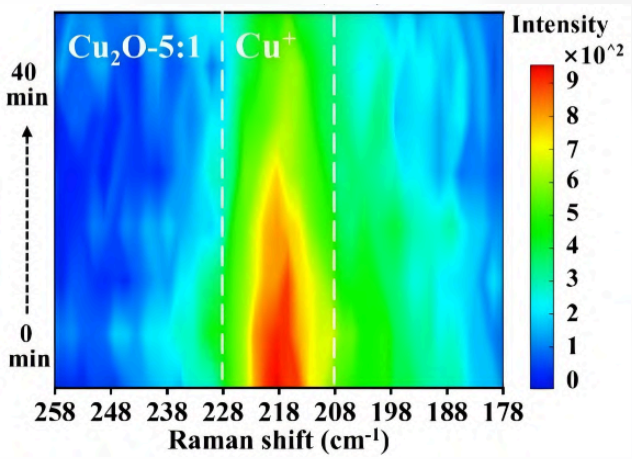
Demonstrated EC-RM3 Capabilities

- Operando monitoring in a gas-fed flow-cell configuration
- Compatibility with catalyst-loaded carbon-paper electrodes
- Tracking of reaction intermediates and catalyst-state evolution

Additional Published Applications

- Chang, B. et al. Chem. Eng. J. 2024, 496, 153993.
- Jia, G. et al. Nano Res. 2025, 18, 94907265.

Product Identification Note: *EC-RM3 is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*



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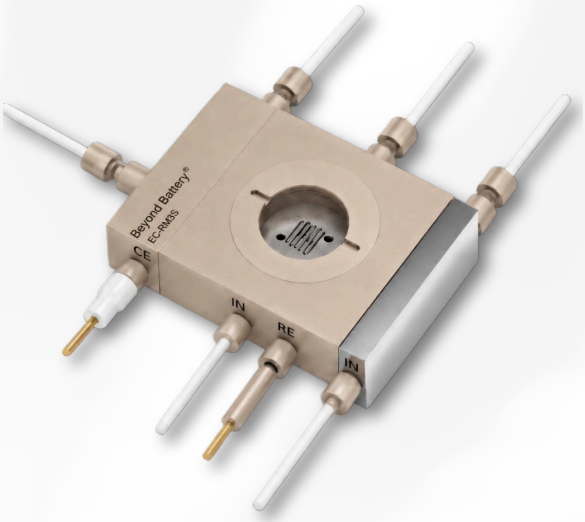
In Situ & Operando Electrochemical Cells



EC-RM3S

In Situ Raman Spectroelectrochemical Cell

An upgraded three-chamber Raman cell with a serpentine gas channel for enhanced reactant delivery in high-rate gas-fed electrochemistry.

Product Overview

The EC-RM3S is an upgraded version of the EC-RM3 in situ Raman Spectroelectrochemical Cell. It retains the membrane-separated three-chamber configuration and direct Raman access of the EC-RM3, while incorporating a serpentine flow channel within the gas chamber. The extended gas flow path increases the contact time between the reactant gas and the catalyst layer, allowing the gas to participate more effectively in the electrochemical reaction.

Technical Specifications

Working electrode area	1 cm² (customizable)
WE-optical window distance	< 6 mm
Optical window diameter	Ø37 mm (effective diameter Ø34 mm)
Chamber structure	Three-chamber gas-diffusion configuration with a serpentine flow channel
Working electrode	Sheet-type gas-diffusion electrode (e.g., Au, Pt, glassy carbon, ITO, and FTO)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Platinum wire electrode or graphite rod electrode
Cell body material	PEEK + Ti
Optical window material	Quartz
Cell body dimensions	L99 × W70 × H25 mm

Key Features

Serpentine Gas Flow Channel

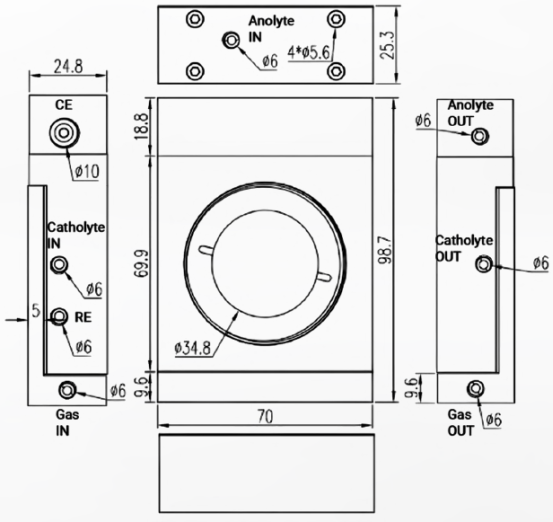
Extends the gas flow path across the working electrode for controlled reactant delivery

Extended Gas-Catalyst Contact

Increases gas residence time to enhance interaction between the reactant gas and catalyst layer

Enhanced Gas-Fed Interface Control

Supports more effective gas participation during operando Raman investigation of electrochemical interfaces



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia Qontor), HORIBA (LabRAM HR Evolution, iHR550), and Ocean Optical Instruments (HRS-5A)

Potentiostat Compatibility

Compatible with commercial three-electrode electrochemical workstations, including CH Instruments (CHI660E, CHI760E, CHI1140C), Bio-Logic (VMP3), and Corrtest Instruments (CS350M)

Published Application Example

In Situ SERS Monitoring of CO_2 Electroreduction

The cell used in this study, supplied by Beyond Battery under product code EC-RM3S, a gas-fed flow-cell configuration, was used to investigate copper electrodes with different Cu(100)/(111) grain-boundary densities during CO_2 electroreduction in neutral electrolyte. Catalyst-coated gas-diffusion layers served as the working electrodes, with Ag/AgCl and platinum wire as the reference and counter electrodes. In situ SERS tracked Cu–OH and adsorbed *CO species, linking hydroxyl-rich grain boundaries to enhanced ethylene selectivity.

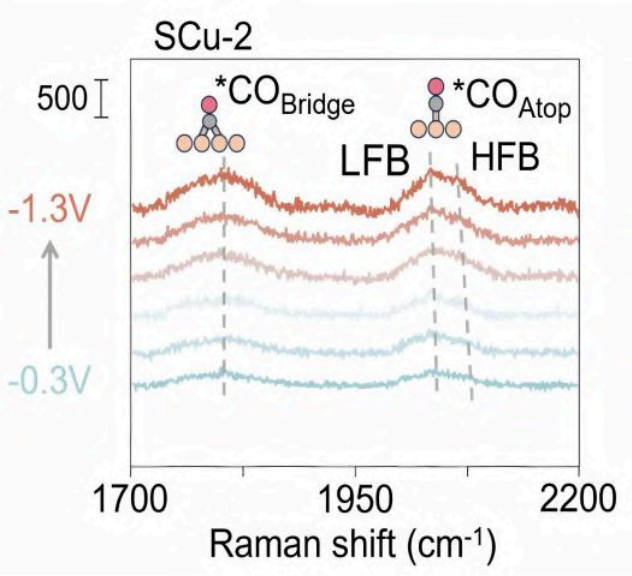
Demonstrated EC-RM3S Capabilities

- Operando SERS monitoring in a gas-fed flow-cell configuration
- Compatibility with catalyst-coated gas-diffusion electrodes
- Tracking of Cu–OH and adsorbed *CO surface species

Application Studies

Additional application studies are underway.

Product Identification Note: *EC-RM3S is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*



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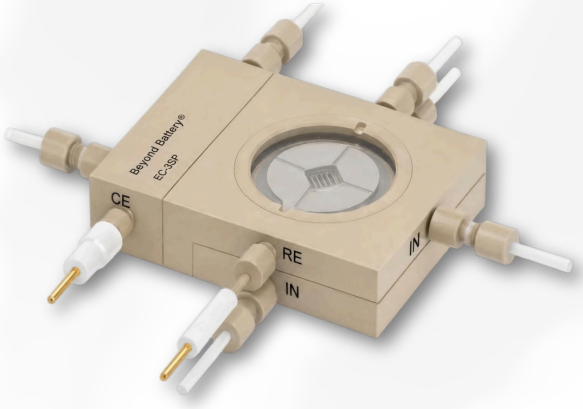
In Situ & Operando Electrochemical Cells

EC-RM3SP

In Situ Raman Spectroelectrochemical Cell

A short-path, large-window Raman cell for interface-resolved operando analysis of gas-diffusion electrodes under industrially relevant conditions.



Product Overview

The EC-RM3SP is optimized for high-sensitivity operando Raman analysis of gas-diffusion electrodes under gas-fed conditions. Its high-transmittance sapphire window is positioned less than 3 mm from the working electrode, providing a short optical path for interface-resolved Raman acquisition. The three-chamber architecture and serpentine gas flow field support controlled reactant delivery and compartment separation, making the cell suitable for advanced gas-diffusion electrocatalysis and industrially relevant CO_2 electrolysis studies.

Technical Specifications

Working electrode area	1 cm² (customizable)
WE-optical window distance	< 3 mm
Optical window diameter	Ø38 mm (effective diameter Ø22 mm)
Chamber structure	Three-chamber
Working electrode	Sheet-type gas-diffusion electrode (e.g., Au, Pt, glassy carbon, ITO, and FTO)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Platinum wire or graphite rod electrode
Cell body material	PEEK
Optical window material	Sapphire
Cell body dimensions	L89 × W70 × H20 mm

Key Features

Short-Path Raman Access

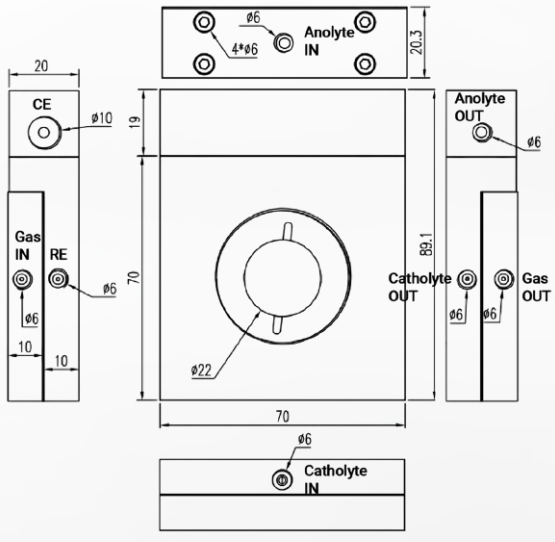
A WE-optical window distance of less than 3 mm minimizes electrolyte-induced signal attenuation for sensitive interface-resolved measurements

Broad Raman System Compatibility

Compatible with commercial Raman microscope systems, enabling convenient integration into operando spectroelectrochemical measurements

Controlled Gas-Diffusion Interface

Serpentine gas flow enhances delivery across the 1 cm² GDE, while close reference-electrode placement minimizes uncompensated resistance



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia Qontor), HORIBA (LabRAM HR Evolution, iHR550), and Ocean Optical Instruments (HRS-5A)

Potentiostat Compatibility

Compatible with commercial three-electrode electrochemical workstations, including Donghua Testing Technology (DH7001A), CH Instruments (CHI1140C), Corrtest Instruments (CS2350), and DHElecchem systems

Published Application Example

Operando Raman Tracking of Cu-Site Reconstruction during CO_2 Methanation

The cell used in this study, supplied by Beyond Battery under product code EC-RM3SP, enabled potential-dependent operando Raman monitoring of ZrO_2-supported Cu single-atom catalysts during CO_2 electroreduction, revealing the reconstruction of CuN_4 sites into a CuN_1O_2 coordination environment and tracking key surface species, including *COOH, $*HCO_3^-$, and CO_3^{2-}. The reconstructed CuN_1O_2 catalyst achieved CH_4 Faradaic efficiencies of 87.06 ± 3.22% at −500 mA cm^{-2} and 80.21 ± 1.01% at −1000 mA cm^{-2}, demonstrating improved activity and stability over the original CuN_4 structure.

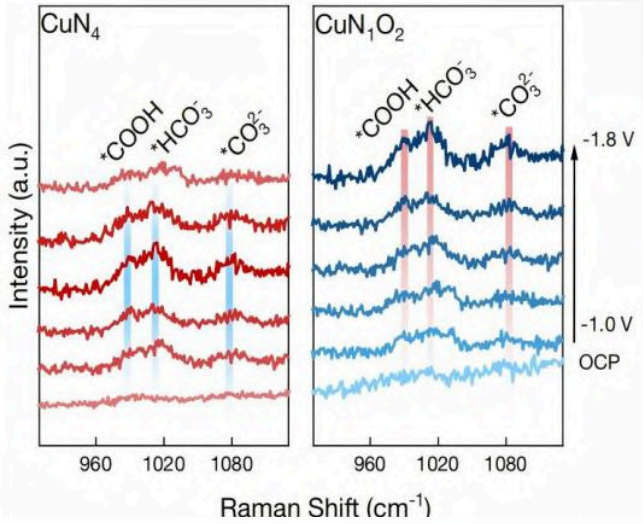
Demonstrated EC-RM3SP Capabilities

- Operando Raman monitoring at gas-diffusion electrodes
- Tracking of electrochemically induced catalyst reconstruction
- Potential-dependent detection of CO_2RR surface intermediates

Application Studies

Additional application studies are underway.

Product Identification Note: *EC-RM3SP is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*



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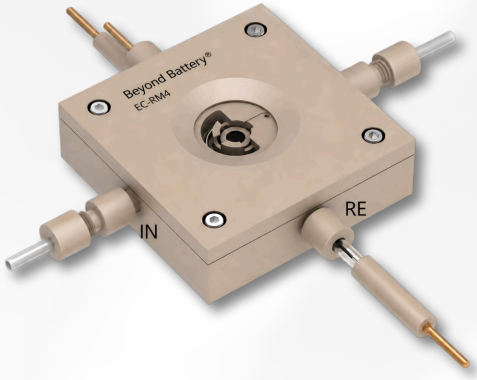
In Situ & Operando Electrochemical Cells

EC-RM4

In Situ Raman Spectroelectrochemical Cell

An in situ Raman spectroelectrochemical cell with a short optical path and interchangeable disk electrodes.



Product Overview

The EC-RM4 is designed for in situ Raman characterization of electrode materials during electrochemical testing. The working electrode is positioned directly beneath a transparent optical window, enabling spectral acquisition during operation. Its PEEK and high-purity titanium construction supports flow-system testing and syringe-based electrolyte filling, while allowing rapid assembly, disassembly, and cleaning.

Technical Specifications

WE-optical window distance	< 3 mm
Optical window diameter	Ø25 mm (effective diameter Ø20 mm)
Chamber structure	Single-chamber
Electrode system	Three-electrode
Working electrode	Ø5 mm glassy carbon disk electrode (standard); Au, Pt, Ag, or other disk electrodes (optional)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Platinum wire electrode
Cell body material	PEEK + Ti
Optical window material	Quartz
Cell body dimensions	L65 × W65 × H19 mm

Key Features

Short Optical Path

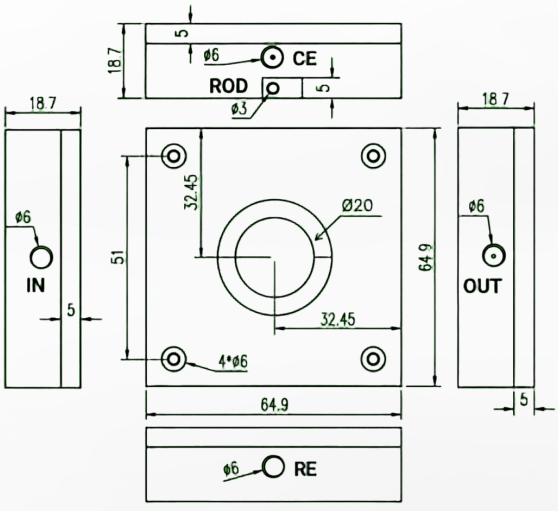
A WE-optical window distance of less than 3 mm supports Raman acquisition from the working electrode

Interchangeable Disk Electrodes

Supplied with a Ø5 mm glassy carbon electrode and compatible with optional Au, Pt, and Ag disk electrodes

Flexible Electrolyte Handling

Supports flow-system operation and direct electrolyte filling using a syringe



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including WITec (alpha300 R), Renishaw (inVia), and HORIBA (XploRA, LabRAM HR)

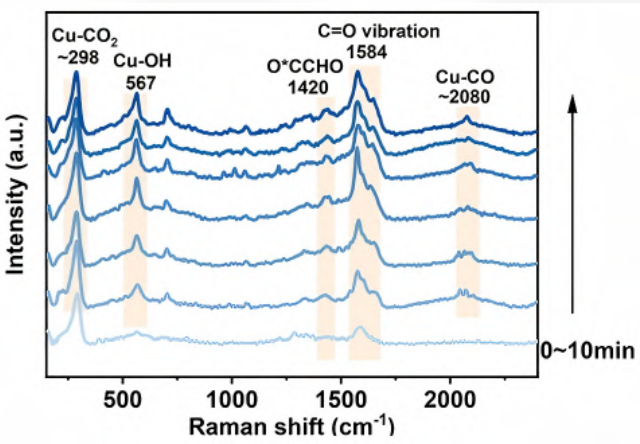
Potentiostat Compatibility

Compatible with commercial three-electrode electrochemical workstations, including Donghua Testing Technology (DH7001A), CH Instruments (CHI1140C), Corrtest Instruments (CS2350), and DHElecchem systems

Published Application Example

In Situ Raman Detection of $Cu^{\delta+}$–OH Species during CO_2-to-Ethylene Conversion

The cell used in this study, supplied by Beyond Battery under product code EC-RM4, an in situ Raman spectroelectrochemical cell, was used to monitor Cu/200-C_3N_4 during CO_2 electroreduction. Time-resolved spectra revealed signals assigned to Cu–CO_2, $Cu^{\delta+}$–OH, *OCCHO, *COO-related species, and adsorbed *CO. Combined with ATR-FTIR spectroscopy and DFT calculations, the results indicated that stabilized $Cu^{\delta+}$–OH species promoted asymmetric *CO–*CHO coupling, steering the reaction pathway toward ethylene.



Reproduced from Wang, L. et al. Inorg. Chem. Front. 2026, 13, 1938–1945. CC BY 4.0.

Demonstrated EC-RM4 Capabilities

- Time-resolved in situ Raman monitoring during CO_2 reduction
- Detection of $Cu^{\delta+}$–OH and carbon-containing intermediates
- Mechanistic investigation under electrochemical reaction conditions

Additional Published Applications

- Han, M. et al. Catal. Sci. Technol. 2026, 16, 4323–4327.
- Tao, K. et al. Nanoscale Adv. 2026, 8, 3761–3768.

Product Identification Note: *EC-RM4 is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*

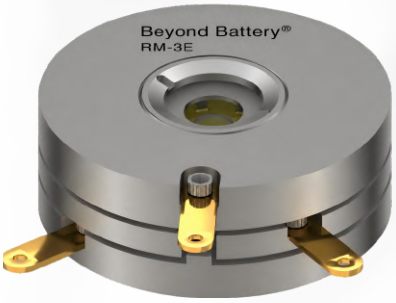
In Situ & Operando Raman Cells — Battery Test Cells

Sealed, glovebox-compatible cells for operando Raman during charge/discharge cycling

PAGE 18

RM-2E

Two-electrode



PAGE 20

RM-3E

Three-electrode

PAGE 22

RM-P2E

Two-electrode, pressurized or vacuum operation

PAGE 24

RM-P3E

Three-electrode, Li-wire RE, pressurized or vacuum operation

In Situ & Operando Battery Test Cells

RM-2E

In Situ Raman Battery Test Cell

A sealed two-electrode battery test cell for in situ Raman monitoring during electrochemical cycling.

Product Overview

The RM-2E is a sealed two-electrode battery test cell integrating in situ Raman measurement with electrochemical cycling. Its short sample-to-window distance facilitates Raman signal collection, while spring-loaded compression enables adjustable stack loading and stable electrode contact. Designed for battery materials research, it supports real-time investigation of structural evolution, redox conversion, and interfacial changes during charge/discharge testing.

Technical Specifications

Electrode configuration	Two-electrode system
Sample-to-window distance	< 2 mm
Optical window diameter	Ø20 mm
Effective optical window diameter	Ø12 mm
Optical window material	Sapphire
Cell body material	Ti
Insulation material	PEEK
Current collector tab	Gold-plated copper
Cell body dimensions	Ø70 mm × H20 mm

Key Features

In Situ Raman Monitoring

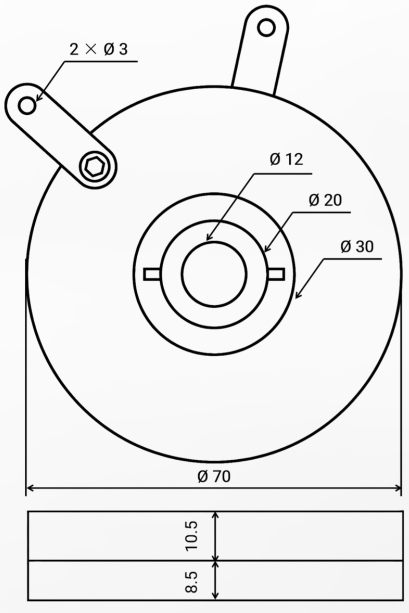
Enables Raman characterization of electrode materials during battery charge/discharge operation

Adjustable Spring Loading

Allows the applied load to be adjusted for comparative evaluation under different compression conditions

Glovebox-Compatible Sealing

The cell can be assembled in a glovebox and subsequently operated under ambient conditions with O-ring sealing



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia) and HORIBA (LabRAM Soleil Nano)

Electrochemical Testing Compatibility

Compatible with commercial electrochemical workstations, including CH Instruments (CHI660E), and battery testing systems, including NEWARE (CT-4008T)

Published Application Example

In Situ Raman Tracking of Four-Electron Iodine Conversion

The cell used in this study, supplied by Beyond Battery under product code RM-2E, was coupled with a Renishaw inVia Raman microscope (532 nm) and CHI660E workstation to investigate four-electron conversion in aqueous Zn–I_2 batteries. During cycling from 0.6 to 1.9 V, Raman spectra tracked I_3^-, I_5^-, I_2, and ICl_2^-, confirming reversible iodine conversion and HMTA-mediated suppression of polyiodide shuttling and I^+ hydrolysis.

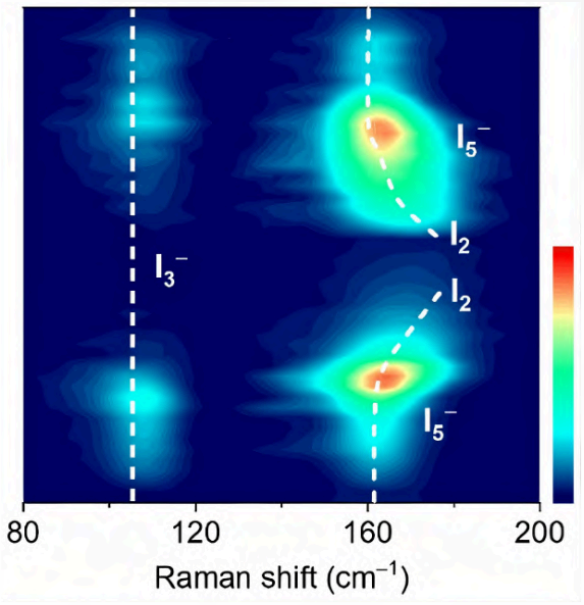
Demonstrated RM-2E Capabilities

- Simultaneous Raman acquisition and galvanostatic cycling
- Potential-resolved tracking of multiple iodine species
- Compatibility with two-electrode aqueous battery configurations

Additional Published Applications

- Hu, Y. et al. Energy Environ. Sci. 2026, 19, 1551–1564.
- Hao, J. et al. Sci. Adv. 2026, 12, eaed8075.

Product Identification Note: *RM-2E is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation. This study used the 2025 version of the RM-2E; the current model may differ in design and specifications.*



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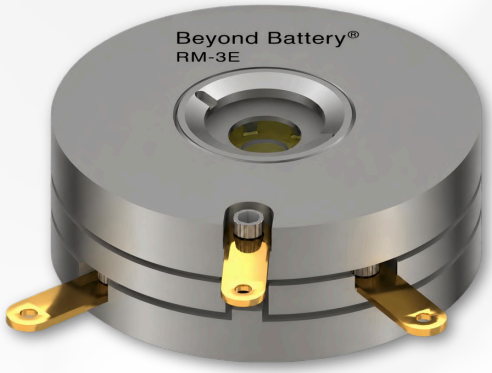
In Situ & Operando Battery Test Cells

RM-3E

In Situ Raman Battery Test Cell

A sealed three-electrode battery test cell with a lithium-wire reference electrode for in situ Raman monitoring.



Product Overview

The RM-3E is a sealed three-electrode battery test cell integrating in situ Raman measurement with electrochemical cycling. A spring-loaded lithium-wire reference electrode is connected to an independent middle current collector, forming a dedicated reference-electrode circuit for three-electrode testing. Its layered current-collector structure, adjustable spring compression, and O-ring sealing support stable electrode contact, reproducible assembly, and in situ investigation of battery materials during charge/discharge cycling.

Technical Specifications

Electrode configuration	Three-electrode system
Sample-to-window distance	< 2 mm
Optical window diameter	Ø20 mm
Effective optical window diameter	Ø12 mm
Optical window material	Sapphire
Cell body material	Ti
Insulation material	PEEK
Current collector tab	Gold-plated copper
Cell body dimensions	Ø70 mm × H24 mm
Reference electrode	Lithium wire (user provide)

Key Features

Lithium-Wire Reference Electrode

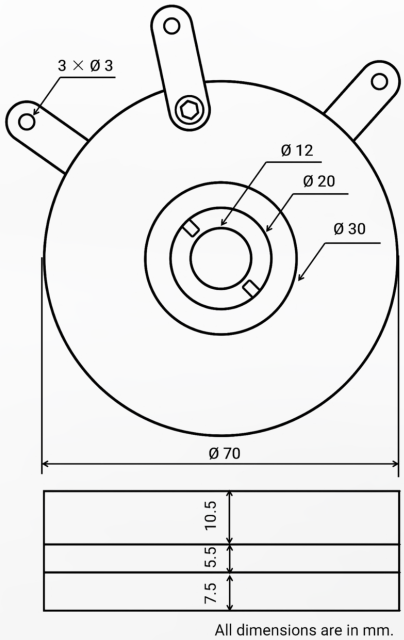
Spring-loaded contact connects the lithium wire to the middle current collector, establishing the reference-electrode circuit

Adjustable Spring Loading

Allows the applied load to be adjusted for comparative evaluation under different compression conditions

Glovebox-Compatible Sealing

The cell can be assembled in a glovebox and subsequently operated under ambient conditions with O-ring sealing



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia) and HORIBA (LabRAM Soleil Nano)

Electrochemical Testing Compatibility

Compatible with commercial electrochemical workstations, including Bio-Logic (VSP-3E), and battery testing systems, including LAND (CT3004A)

Published Application Example

In Situ Raman Tracking of Sodium Storage in Hard Carbon

The cell used in this study, supplied by Beyond Battery under product code RM-3E, was coupled with a HORIBA LabRAM Soleil Nano confocal Raman spectrometer to compare pristine T2 and Bi/N-modified T2-BiN hard-carbon anodes during sodium-ion battery cycling. In situ spectra revealed a pronounced G-band redshift and reduced D-band intensity for T2-BiN, indicating enhanced Na^+ intercalation-induced C–C bond strain and increased Na^+ adsorption at defect sites.

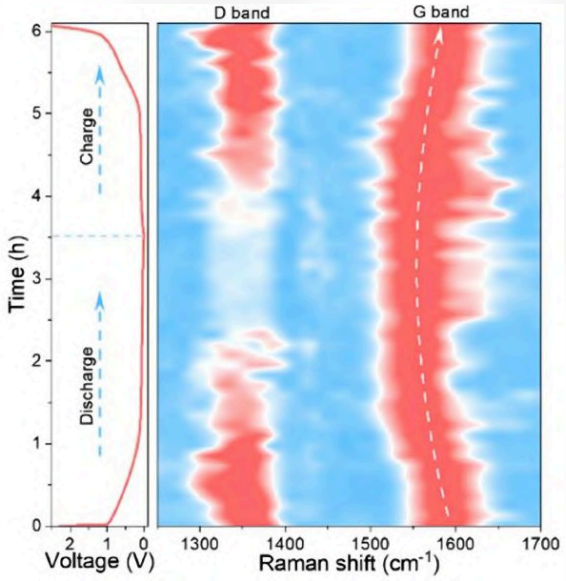
Demonstrated RM-3E Capabilities

- In situ Raman monitoring during battery charge/discharge cycling
- Comparative tracking of D- and G-band evolution
- Identification of Na^+ intercalation and defect-site adsorption

Application Studies

Additional application studies are underway.

Product Identification Note: *RM-3E is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation. This study used the 2025 version of the RM-3E; the current model may differ in design and specifications.*



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In Situ & Operando Battery Test Cells

RM-P2E

In Situ Raman Pressure Battery Test Cell

A sealed two-electrode cell for in situ Raman monitoring during battery cycling under pressurized or vacuum conditions.

Product Overview

The RM-P2E is a sealed two-electrode battery test cell integrating in situ Raman measurement with electrochemical cycling under controlled pressure or vacuum conditions. Its sapphire optical window and short sample-to-window distance facilitate Raman signal collection, while the titanium cell body, PEEK insulation, and O-ring sealing provide chemical resistance and reliable airtightness. Designed for battery materials research, it supports real-time monitoring of structural and interfacial changes during charge/discharge testing at pressures up to 1 MPa. Vacuum operation is supported by replacing the pressure gauge with a compatible vacuum gauge.

Technical Specifications

Electrode configuration	Two-electrode system
Sample-to-window distance	< 2 mm
Optical window diameter	Ø20 mm
Effective optical window diameter	Ø12 mm
Maximum pressure	1 MPa
Optical window material	Sapphire
Cell body material	Ti
Insulation material	PEEK
Current collector tab	Gold-plated copper
Cell body dimensions	Ø70 mm × H30 mm

Key Features

In Situ Raman Monitoring

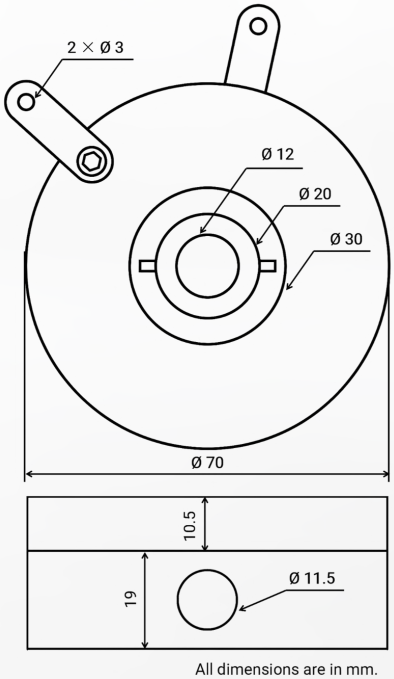
Enables real-time Raman characterization of electrode materials during battery charge/discharge operation

Pressure/Vacuum Operation

Supports electrochemical cycling under controlled pressure or vacuum conditions with interchangeable gauges

Glovebox-Compatible Sealing

Provides reliable airtight sealing for glovebox assembly and subsequent operation under ambient conditions



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia) and HORIBA (LabRAM Soleil Nano)

Electrochemical Testing Compatibility

Compatible with commercial electrochemical workstations, including CH Instruments (CHI660E), and battery testing systems, including NEWARE (CT-4008T)

Related Published Application

In Situ Raman Tracking of Stepwise Polyiodide Conversion

The cell used in this study, supplied by Beyond Battery under product code RM-2E, was coupled with a Renishaw inVia Raman microscope using 532 nm excitation and a CHI660E workstation to investigate KB–I_2 cathodes in aqueous Zn–I_2 batteries. During galvanostatic cycling, in situ Raman spectra tracked I_3^- and I_5^- intermediates, revealing that ectoine promoted a stepwise $I_5^- \rightarrow I_3^- \rightarrow I^-$ conversion pathway while suppressing polyiodide shuttling.

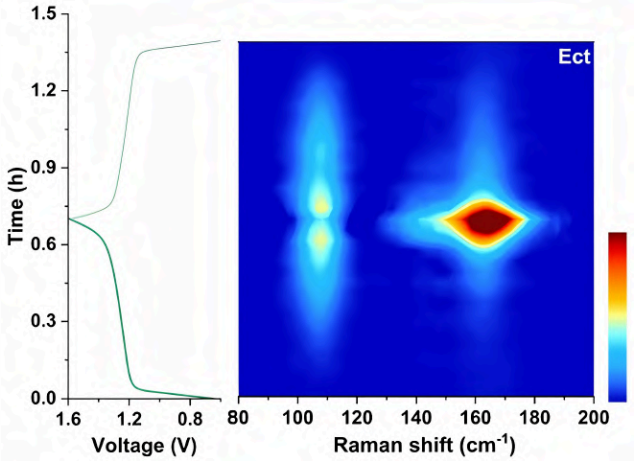
Capabilities Relevant to the RM-P2E

- Simultaneous Raman acquisition and galvanostatic cycling
- Real-time differentiation of I_3^- and I_5^- intermediates
- Electrolyte-dependent tracking of iodine conversion pathways

Ongoing Application Studies

Application studies using this model are currently underway.

Note: RM-2E is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation. This study used the base model (RM-2E) of the RM-P2E; the RM-P2E adds pressure monitoring and optional vacuum operation, but neither controlled-pressure nor vacuum Raman measurements were performed in this study.



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In Situ & Operando Battery Test Cells

RM-P3E

In Situ Raman Pressure Battery Test Cell

A sealed three-electrode cell for in situ Raman monitoring during battery cycling under pressurized or vacuum conditions.

Product Overview

The RM-P3E is a sealed three-electrode battery test cell integrating in situ Raman measurement with electrochemical cycling under controlled pressure or vacuum conditions. Its sapphire optical window and short sample-to-window distance facilitate Raman signal collection, while the three-electrode configuration enables working-electrode potential monitoring against a reference electrode. A high-purity titanium body, PEEK insulation, adjustable spring loading, O-ring sealing, and an integrated pressure gauge support reliable, glovebox-compatible testing under pressurized conditions. Vacuum operation is supported by replacing the pressure gauge with a compatible vacuum gauge.

Technical Specifications

Electrode configuration	Three-electrode system
Sample-to-window distance	< 2 mm
Optical window diameter	Ø20 mm
Effective optical window diameter	Ø12 mm
Maximum pressure	1 MPa
Optical window material	Sapphire
Cell body material	Ti
Insulation material	PEEK
Current collector tab	Gold-plated copper
Cell body dimensions	Ø70 mm × H40 mm

Key Features

In Situ Raman Monitoring

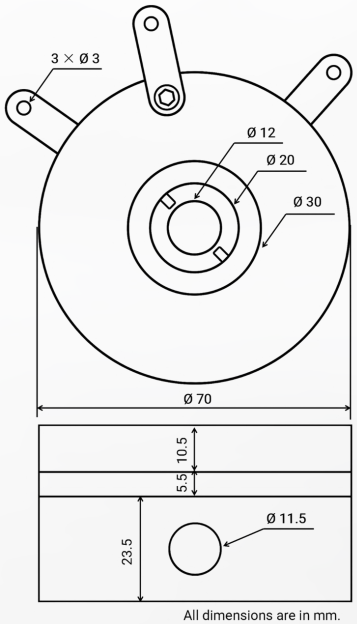
Enables real-time Raman characterization of electrode materials during battery charge/discharge operation

Three-Electrode Configuration

Supports monitoring of the working-electrode potential against an independently connected reference electrode (lithium wire is excluded)

Pressure/Vacuum, Glovebox-Compatible Design

Combines interchangeable pressure or vacuum monitoring, adjustable spring loading, and airtight O-ring sealing for sealed battery testing



All dimensions are in mm.

Instrument Compatibility

Raman System Compatibility

Compatible with commercial Raman microscope systems, including Renishaw (inVia) and HORIBA (LabRAM Soleil Nano)

Electrochemical Testing Compatibility

Compatible with commercial electrochemical workstations, including Bio-Logic (VSP-3E), and battery testing systems, including LAND (CT3004A)

Related Published Application

In Situ Raman Tracking of Sodium Storage in Hard Carbon

The cell used in this study, supplied by Beyond Battery under product code RM-3E, was coupled with a HORIBA LabRAM Soleil Nano confocal Raman spectrometer to compare pristine T2 and Bi/N-modified T2-BiN hard-carbon anodes during sodium-ion battery cycling. In situ spectra revealed a pronounced G-band redshift and reduced D-band intensity for T2-BiN, indicating enhanced Na^+ intercalation-induced C–C bond strain and increased Na^+ adsorption at defect sites.

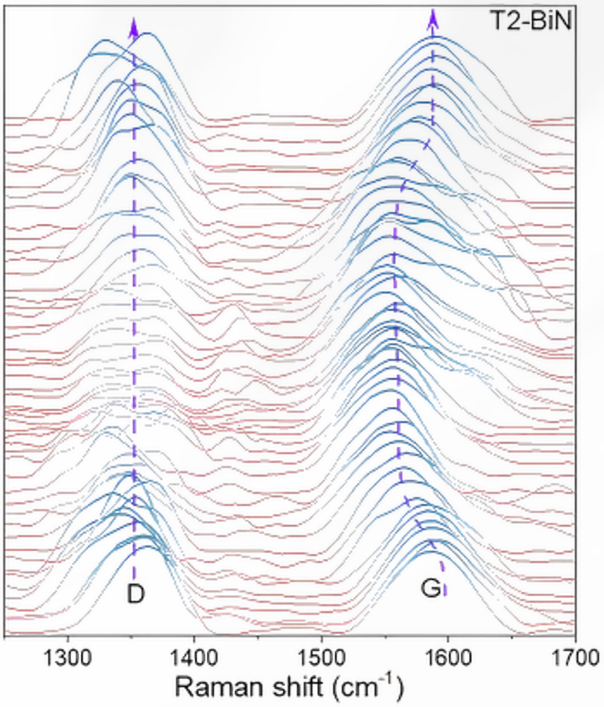
Capabilities Relevant to the RM-P3E

- In situ Raman monitoring during battery charge/discharge cycling
- Comparative tracking of D- and G-band evolution
- Identification of Na^+ intercalation and defect-site adsorption

Ongoing Application Studies

Application studies using this model are currently underway.

Note: RM-3E is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation. This study used the base model (RM-3E) of the RM-P3E; the RM-P3E adds pressure monitoring and optional vacuum operation, but neither controlled-pressure nor vacuum Raman measurements were performed in this study.



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In Situ & Operando Electrochemical Cells

EC-IR1 / EC-IR2

In Situ Infrared Spectroelectrochemical Cell

H-type in situ infrared spectroelectrochemical cells with internal- and external-reflection configurations for real-time interfacial analysis.

Product Overview

The EC-IR1 / EC-IR2 are in situ infrared spectroelectrochemical cells for real-time analysis of electrode interfaces and reaction intermediates. EC-IR1 supports internal-reflection ATR-SEIRAS with an Au-coated Si working substrate and bottom magnetic stirring, while EC-IR2 supports external-reflection IRRAS with a micrometer-adjustable Ø10 mm glassy carbon electrode for precise control of the thin electrolyte layer and reflected signal.

Technical Specifications

Chamber structure	Two-chamber
Electrode system	Three-electrode
Reflection configuration	Internal reflection (EC-IR1), external reflection (EC-IR2)
Cell volume	< 20 mL
Working electrode	Au-coated Si (EC-IR1); Ø10 mm glassy carbon (EC-IR2)
Counter electrode	Graphite electrode
Reference electrode	Ag/AgCl electrode
Optical window material	Single-crystal Si (EC-IR1); Ge, ZnSe, CaF_2, or Si (EC-IR2)
Cell body material	PEEK

Key Features

Internal- and External-Reflection Options

EC-IR1 supports internal-reflection ATR-SEIRAS, while EC-IR2 supports external-reflection IRRAS.

Membrane-Separated Two-Chamber Design

H-type dual chambers with a replaceable membrane and independent gas inlet/outlet ports.

Model-Specific Interface Control

EC-IR1 provides bottom magnetic stirring, while EC-IR2 uses micrometer adjustment for precise control of the thin electrolyte layer and reflected signal.

Typical Applications

Electrode-Interface Analysis

In situ monitoring of adsorbed species, surface intermediates and electrolyte interactions under potential control.

Electrocatalytic Mechanism Studies

Investigating reaction pathways in CO_2RR, ORR, OER, HER and other electrochemical processes.

Catalyst Surface Comparison

Evaluating the effects of catalyst composition, crystal facets and surface modification on interfacial adsorption.

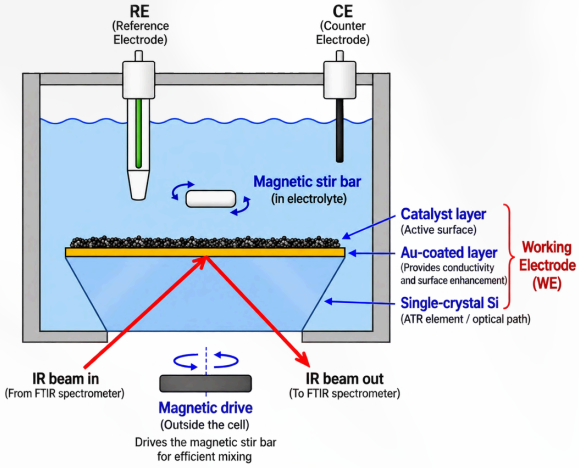
Reflection-Mode FTIR Studies

Internal-reflection ATR-SEIRAS measurements with EC-IR1 and external-reflection IRRAS measurements with EC-IR2.

Model Selection Guide

EC-IR1 — Internal Reflection

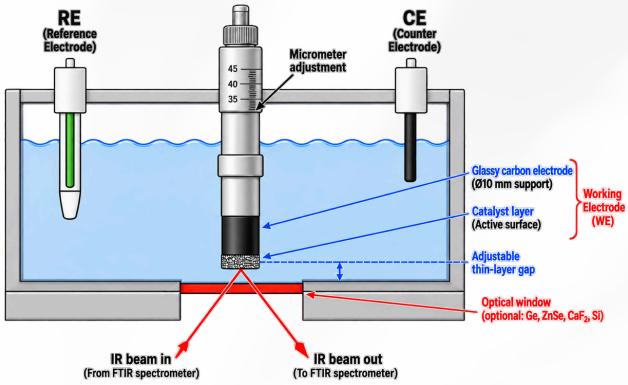
An internal-reflection configuration using an Au-coated single-crystal Si working electrode with bottom magnetic stirring. Recommended for surface-enhanced in situ infrared measurements of adsorbed species and reaction intermediates at the electrode–electrolyte interface. Ideal for catalyst-coated Au/Si substrates requiring surface-sensitive detection and controlled electrolyte mixing.



EC-IR1 Internal-Reflection ATR-SEIRAS Schematic

EC-IR2 — External Reflection

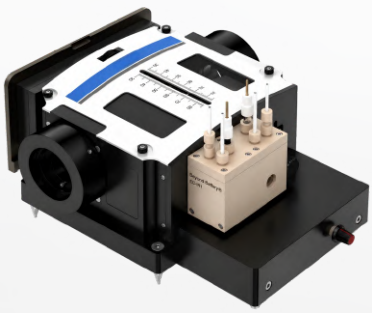
An external-reflection configuration using a Ø10 mm glassy carbon working electrode with integrated micrometer adjustment. The working-electrode-to-optical-crystal distance can be precisely adjusted to control the infrared electrolyte-layer thickness and reflected signal intensity. Ideal for catalyst-coated glassy carbon electrodes and tunable thin-layer measurements.



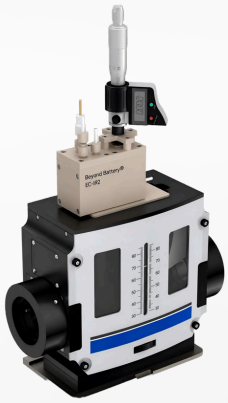
EC-IR2 External-Reflection IRRAS Schematic

EC-IR1 Cell View

EC-IR2 Cell View



EC-IR1 Mounted on VeeMAX III



EC-IR2 Mounted on VeeMAX III

Required Optical Accessory

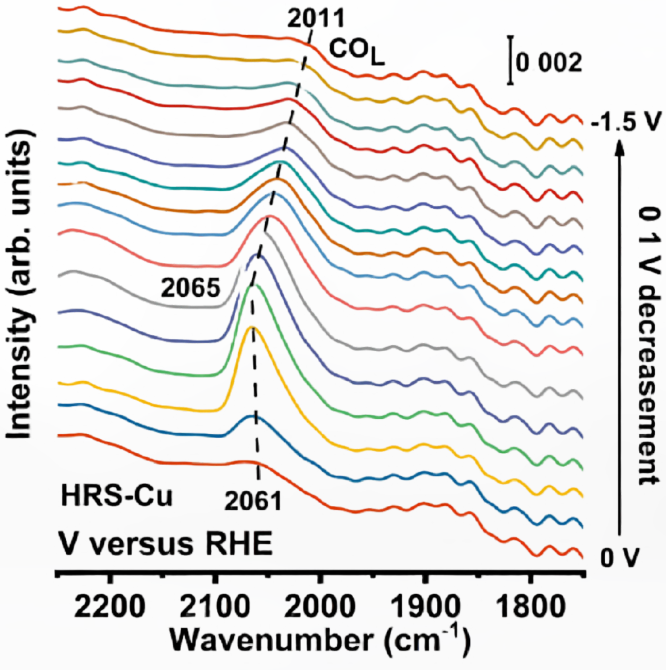
The EC-IR1 / EC-IR2 are designed for use with the PIKE Technologies VeeMAX III Variable Angle Specular Reflectance Accessory. Its all-reflective optical design provides adjustable incidence angles for precise beam alignment in internal- and external-reflection FTIR measurements. For ATR configurations, optical throughput can exceed 50% with a 45° ZnSe crystal, with a penetration depth of 0.4–46 µm depending on the crystal and sample. The VeeMAX III is required for operation and is sold separately. Please specify the FTIR spectrometer brand and model when ordering.

Manufacturer	PIKE Technologies
Model	VeeMAX III
Incidence angle	30°–80°
Accessory dimensions	W177 × D92 × H162 mm

Published Application Example

Facet-Dependent CO Adsorption during CO_2 Electroreduction

The EC-IR1 was employed for internal-reflection ATR-SEIRAS measurements of adsorbed CO intermediates on Cu films with different facet exposure during CO_2 electroreduction. Using catalyst-coated Au/Si working electrodes in 0.1 M KOH, potential-dependent spectra distinguished reactive linearly bonded CO (CO_L, ~2050 cm^{-1}) from bridge-bonded CO (CO_B, ~1800 cm^{-1}). The results revealed higher *CO coverage on Cu(100)-rich HRS-Cu, supporting enhanced C-C coupling toward C_2^+ products. Separate flow-cell tests achieved Faradaic efficiencies of 58.6% for ethylene and 86.6% for C_2^+ products.



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Demonstrated EC-IR1 Capabilities

- Supports internal-reflection ATR-SEIRAS using catalyst-coated Au/Si working electrodes.
- Enables potential-dependent tracking of interfacial adsorbates, including linearly and bridge-bonded CO species.
- Supports comparative investigation of catalyst facets, surface coverage and electrochemical reaction pathways.

Additional Published Applications

Additional application studies using the EC-IR1 / EC-IR2 are currently underway.

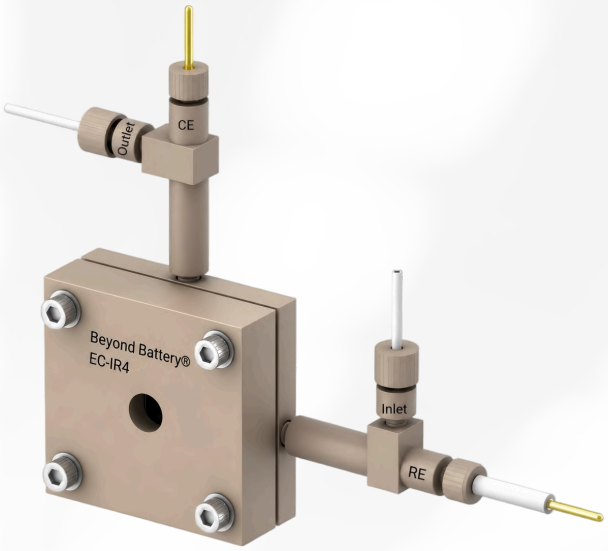
Product Identification Note: *EC-IR1 is the Beyond Battery product code for the same cell reported in the cited publications. The original articles use a different product designation.*

In Situ & Operando Electrochemical Cells

EC-IR4

In Situ Infrared Spectroelectrochemical Cell

A thin-layer in situ transmission FTIR cell for potential-controlled monitoring of electrochemically generated species and reaction intermediates.



Product Overview

The EC-IR4 is a thin-layer transmission FTIR spectroelectrochemical cell for monitoring electrochemically generated species, reaction intermediates and redox-state changes under potential control. Its platinum mesh working electrode provides an infrared transmission path through the active region, while the CaF_2 window and three-electrode configuration support in situ measurements. Gas inlet and outlet ports enable purging and controlled-atmosphere operation.

Technical Specifications

Measurement mode	Transmission FTIR
Electrode system	Three-electrode
Solution-layer thickness	0.5 mm
Working electrode	Platinum mesh electrode
Counter electrode	Platinum wire electrode
Reference electrode	Platinum electrode
Optical window material	CaF_2 (sold separately)
Cell body material	PEEK
Optical window size	34 × 36 mm
Clear aperture	Ø10 mm
Gas connections	Inlet and outlet ports

Key Features

Thin-Layer Transmission FTIR Geometry

The CaF_2 optical window and controlled electrolyte layer provide a direct transmission path for potential-dependent FTIR measurements.

Potential-Controlled Three-Electrode Measurements

Independent electrode connections support in situ spectroelectrochemical measurements under controlled potential.

Controlled-Atmosphere Operation

Integrated gas inlet and outlet ports enable gas purging and atmosphere control during measurements.

Typical Applications

Electrochemically Generated Species

Monitoring intermediates, products and redox-state changes under potential control.

Molecular Electrocatalysis

Investigating solution-phase molecular catalysts and their electrochemical transformations.

Reaction-Pathway Studies

Tracking catalyst activation, intermediate formation and degradation pathways.

Controlled-Atmosphere Measurements

Studying gas-sensitive or gas-involving electrochemical reactions under purge or controlled-atmosphere conditions.

Instrument Compatibility

FTIR Spectrometer Compatibility

Compatible with commercial FTIR spectrometers supporting transmission measurements. Sample-compartment and optical alignment requirements should be confirmed before use.

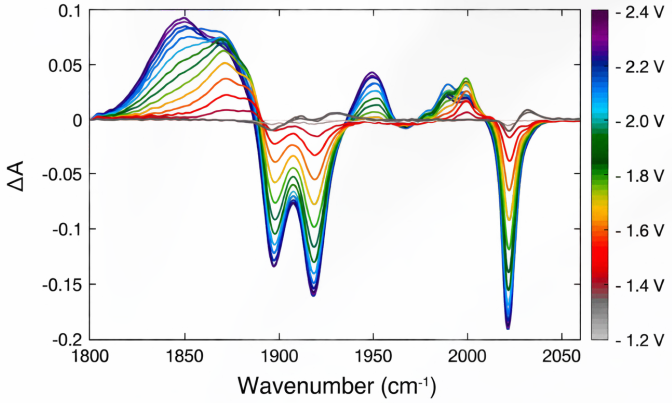
Potentiostat Compatibility

Compatible with commercial potentiostats supporting three-electrode measurements. Connection requirements should be confirmed before use.

Related Published Application

Transmission-Mode IR Spectroelectrochemistry of Electrocatalytic Intermediates

Kiefer et al. used a transmission-mode OTTLE cell equipped with Pt minigrid working and auxiliary electrodes, an Ag-wire pseudoreference electrode, a 200 µm polyethylene spacer and 2 mm CaF_2 windows to investigate $Re(bpy)(CO)_3Cl$. Potential-dependent FTIR spectra tracked the starting complex, singly reduced species and Re–Re dimer, while 2D-IR cross-peaks at 1948 and 1986 cm^{-1} confirmed dimer formation in acetonitrile.



Source: Kiefer, L. M. et al. J. Phys. Chem. Lett. 2021, 12, 3712–3717.

Capabilities Relevant to the EC-IR4

- Enables thin-layer transmission FTIR measurements under electrochemical control.
- Tracks the potential-dependent formation and consumption of solution-phase intermediates.
- Supports controlled-atmosphere studies of molecular electrocatalysts and degradation pathways.

Ongoing Application Studies

Application studies using this model are currently underway.

Note: The referenced study used a transmission-mode OTTLE cell with a configuration comparable to the EC-IR4 and is included solely as a related application example.

In Situ & Operando Electrochemical Cells

EC-UV1 / EC-UV2

In Situ UV–Vis Spectroelectrochemical Cell

In situ UV–Vis cells for potential-controlled optical monitoring in single-compartment and membrane-separated configurations.

Product Overview

The EC-UV Series is designed for in situ UV–Vis spectroelectrochemical studies under electrochemical control. EC-UV1 features a compact single-chamber design with an ITO working electrode and sapphire optical window, while EC-UV2 provides a membrane-separated H-type configuration with gas access to the working compartment. The series supports potential-dependent optical monitoring of redox processes and electroactive interfaces.

Technical Specifications

Chamber structure	Single-chamber (EC-UV1); Two-chamber (EC-UV2)
Electrode system	Three-electrode
Working electrode	ITO or FTO electrode; customizable
Counter electrode	Pt wire or graphite rod electrode
Reference electrode	Standard Ø6 mm reference electrode
Cell body material	PEEK
Optical window material	Sapphire
Optical window diameter	Ø25 mm
Membrane separation	Replaceable membrane (EC-UV2)

Key Features

Shimadzu UV-2600 Compatibility

Designed for in situ UV–Vis measurements with the Shimadzu UV-2600 spectrophotometer.

Potential-Controlled UV–Vis Monitoring

Combines electrochemical control with real-time monitoring of potential-dependent absorption changes.

Flexible Cell Configurations

EC-UV1 offers a single-chamber design, while EC-UV2 provides a membrane-separated H-type configuration with gas access.

Typical Applications

Redox Process Monitoring

Tracking potential-dependent UV–Vis spectral changes during oxidation and reduction.

Electrocatalyst & Electroactive Material Studies

Monitoring catalyst states, intermediates and electroactive interfaces under applied potentials.

Time-Resolved Spectroelectrochemistry

Following transient optical responses during potential-step or pulsed measurements.

Membrane-Separated & Gas-Controlled Studies

Using EC-UV2 for compartment-separated or gas-controlled measurements.

Model Selection Guide

EC-UV1 — Single-chamber

A compact single-chamber design with an ITO working electrode and sapphire optical window. Recommended for conventional in situ UV–Vis spectroelectrochemical measurements. Select this model when direct monitoring of potential-dependent spectral changes is required.

EC-UV2 — Two-chamber, Membrane-separated

An H-type two-chamber design with a replaceable membrane and gas access to the working compartment. Recommended for in situ UV–Vis studies requiring electrode-compartment separation. Select this model when membrane separation or controlled gas introduction is required.

Related Published Application

Potential-Dependent In Situ UV–Vis Monitoring of Ir-Based OER Catalysts

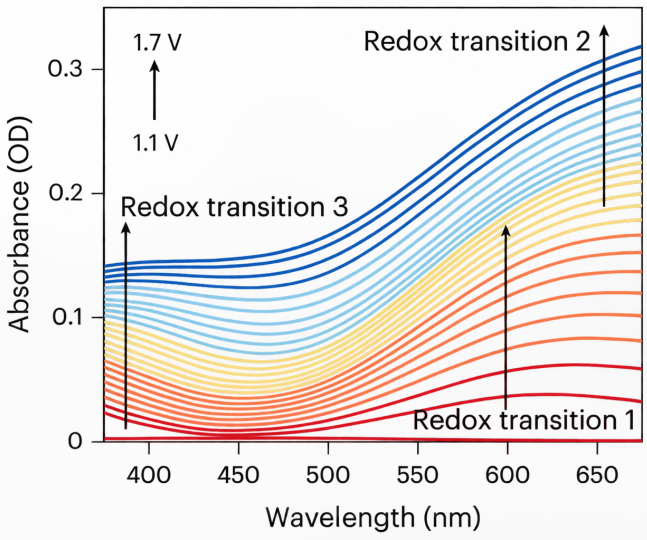
Shen et al. used a custom transmission-type in situ UV–Vis electrochemical cell compatible with a Shimadzu UV-2600 to investigate the oxidation-state evolution of CeO_2–IrO_2 and IrO_2 during oxygen evolution. The catalyst was deposited on a transparent FTO working electrode in the optical path. Potential-dependent and time-resolved UV–Vis measurements revealed sequential Ir redox transitions and correlated absorbance changes with electrochemical charge accumulation.

Capabilities Relevant to the EC-UV Series

- Supports potential-dependent in situ UV–Vis monitoring during electrochemical polarization.
- Enables transmission measurements with transparent conductive working electrodes.
- Supports kinetic and pulsed-potential studies of redox-state changes.

Ongoing Application Studies

Application studies using this series are currently underway.



Reproduced from Shen, W. et al. Nat. Nanotechnol. 2026, 21, 598–605. CC BY 4.0.

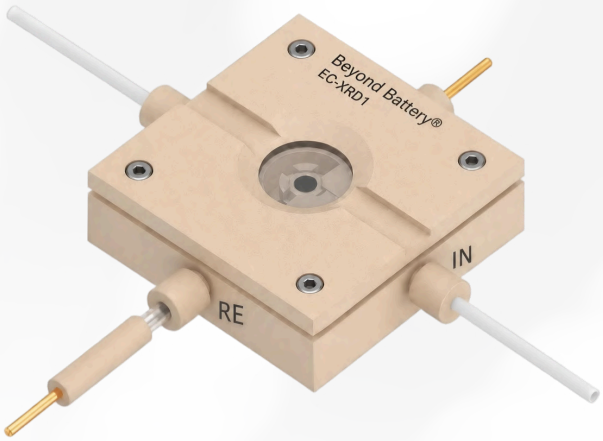
Note: *The referenced study used a custom transmission-type in situ UV–Vis electrochemical cell compatible with a Shimadzu UV-2600 and a catalyst-coated FTO working electrode. The commercial cell model and manufacturer were not identified, and the study is included solely as a related application example.*

In Situ & Operando Electrochemical Cells

EC-XRD1

In Situ XRD Electrochemical Cell

A compact three-electrode cell for operando XRD monitoring of electrochemical phase and structural evolution.



Product Overview

The EC-XRD1 provides direct X-ray access to an interchangeable disk working electrode through an X-ray-transparent beryllium (Be) window while maintaining three-electrode electrochemical control. Its compact flow-compatible design supports both syringe filling and external electrolyte circulation, making it suitable for tracking phase transformations and structural evolution of electrode materials under applied electrochemical conditions.

Technical Specifications

WE-optical window distance	< 3 mm
Optical window diameter	Ø25 mm (effective diameter Ø20 mm)
Chamber structure	Single-chamber
Electrode system	Three-electroder
Working electrode	Ø5 mm glassy carbon disk electrode (standard); Au, Pt, Ag, graphite, or pyrolytic graphite disk electrodes (optional)
Reference electrode	Ag/AgCl or Ag/Ag⁺ electrode
Counter electrode	Ø1 mm Platinum wire electrode
Cell body material	PEEK + Ti
Optical window material	Beryllium (Be)
Cell body dimensions	L65 × W65 × H19 mm

Note: Solid beryllium is relatively stable and poses low skin-contact risk; avoid inhaling dust or aerosols and wash hands after handling.

Key Features

Direct Structural Observation

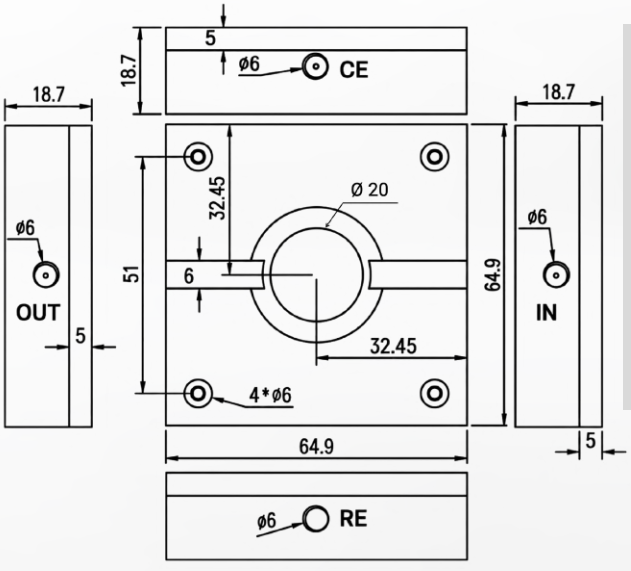
Be-window access and a short X-ray path enable direct probing of the working-electrode surface

Flexible Disk-Electrode Selection

Uses a standard Ø5 mm glassy carbon disk and supports interchangeable Au, Pt, Ag, graphite, and pyrolytic graphite disks

Operando Phase-Evolution Analysis

Enables potential- and time-dependent monitoring of crystalline phase transformations and structural evolution of electrode materials



All dimensions are in mm.

Instrument Compatibility

XRD System Compatibility

Compatible with laboratory X-ray diffractometers that accommodate external electrochemical cells. Measurement geometry, sample-stage clearance, and mounting should be confirmed before use

Potentiostat Compatibility

Compatible with commercial three-electrode potentiostats for electrochemical control during operando XRD measurements

Related Published Application

Operando XRD Tracking of $LiCoO_2$ Structural Evolution during OER

A custom-designed three-electrode operando XRD/XAFS cell was used to track $LiCoO_2$ structural evolution during OER in 0.1 M KOH. As the potential increased stepwise from 1.1 to 1.7 V versus RHE, the $LiCoO_2$ (003) peak gradually weakened. New reflections at 12.87° and 25.88° appeared above 1.50 V, indicating $K_{0.3}CoO_2(H_2O)_{0.4}$ formation associated with potential-dependent cation intercalation and structural transformation.

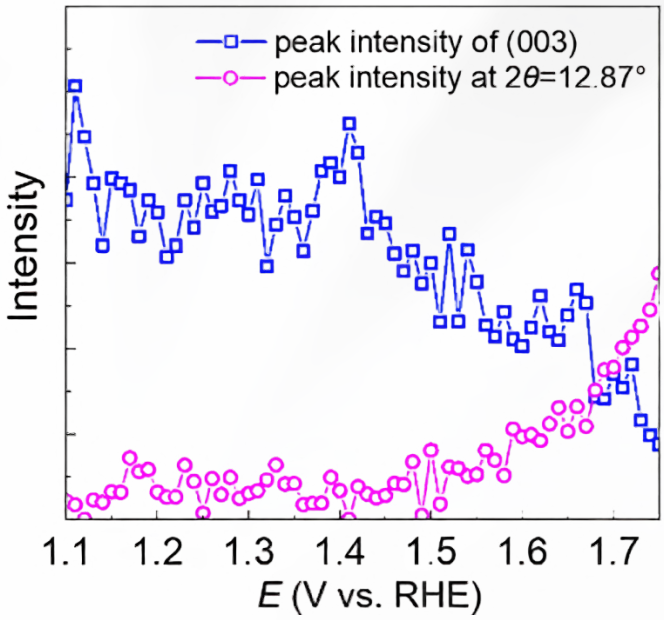
Capabilities Relevant to the EC-XRD1

- Simultaneous XRD acquisition and electrochemical control
- Detection of potential-dependent crystalline phase transformations
- Correlation of diffraction evolution with applied electrode potential

Ongoing Application Studies

Application studies using this model are currently underway.

Note: The cited publication used a custom-designed operando XRD electrochemical cell rather than the Beyond Battery EC-XRD1. The reference is included to demonstrate the relevant research methodology and should not be interpreted as describing or evaluating the EC-XRD1.



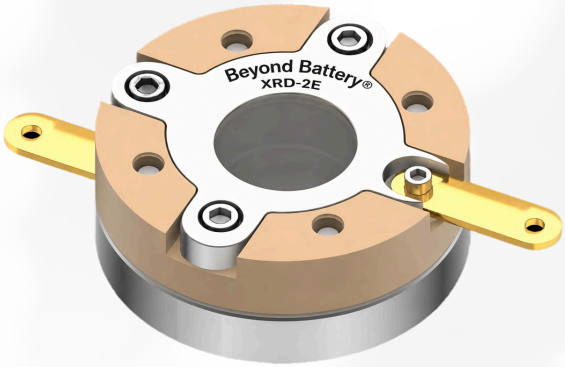
Reproduced from Chen, J. et al. J. Synchrotron Radiat. 2025, 32, 1272–1281. CC BY 4.0.

In Situ & Operando Battery Test Cells

XRD-2E

In Situ XRD Battery Test Cell

A sealed two-electrode battery test cell for operando XRD monitoring during electrochemical cycling.



Product Overview

The XRD-2E is a sealed two-electrode battery test cell designed for in situ X-ray diffraction measurements during charge/discharge cycling. A low-background beryllium window provides direct X-ray access to the cell-stack, while the spring-loaded structure maintains stable interfacial contact. The high-purity titanium body, PEEK insulation, and chemically resistant O-ring sealing support repeatable assembly, glovebox preparation, and post-test sample recovery for rechargeable battery studies.

Technical Specifications

Minimum operating angle	3°
Effective optical window diameter	Ø20 mm
Applicable sample diameter	Ø20 mm
Optical window material	Beryllium (Be)
Electrode system	Two-electroder
Cell body material	Ti
Insulation material	PEEK
Current collector tab	Gold-plated copper
Sealing method	Chemically resistant O-rings
Cell body dimensions	Ø49.5 mm × H18 mm

Note: Solid beryllium is relatively stable and poses low skin-contact risk; avoid inhaling dust or aerosols and wash hands after handling.

Key Features

Bruker D8-Compatible XRD Measurement

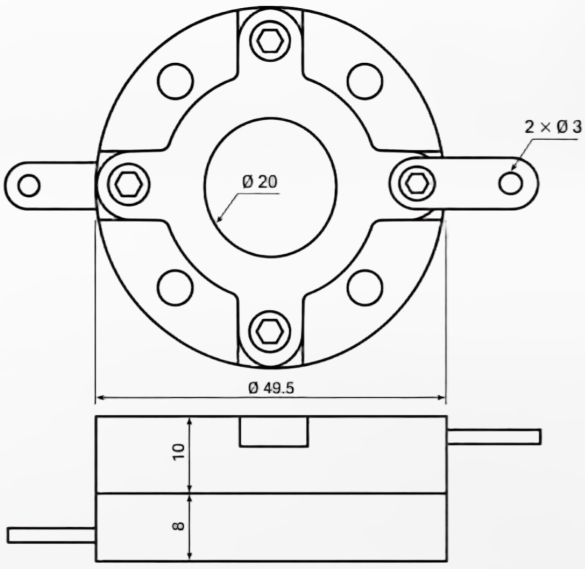
Compatible with Bruker D8 X-ray diffractometer systems for operando XRD monitoring during battery cycling

Low-Angle XRD Accessibility

Supports XRD measurements from a minimum operating angle of 3°, enabling broader low-angle access for operando configurations

Spring-Loaded, Glovebox-Compatible Design

Maintains stable cell-stack compression and enables glovebox assembly with reliable O-ring sealing for subsequent operation under ambient conditions



All dimensions are in mm.

Instrument Compatibility

XRD System Compatibility

Compatible with Bruker D8 systems and other X-ray diffractometers with suitable mounting and scan geometries. The sample holder, incident-angle range, beam path, and instrument clearance should be verified before testing

Electrochemical Testing Compatibility

Compatible with commercial electrochemical workstations and battery testing systems that support two-electrode charge/discharge testing

Related Published Application

Operando XRD Tracking of Conversion–Alloying Reactions

Alvi et al. used a Bruker D8 DISCOVER diffractometer with a Be-window operando cell to study SSBT-based anodes in lithium half-cells at C/5. Potential-dependent XRD patterns revealed lattice expansion, transient Li_2Te formation, and reversible structural evolution during cycling.

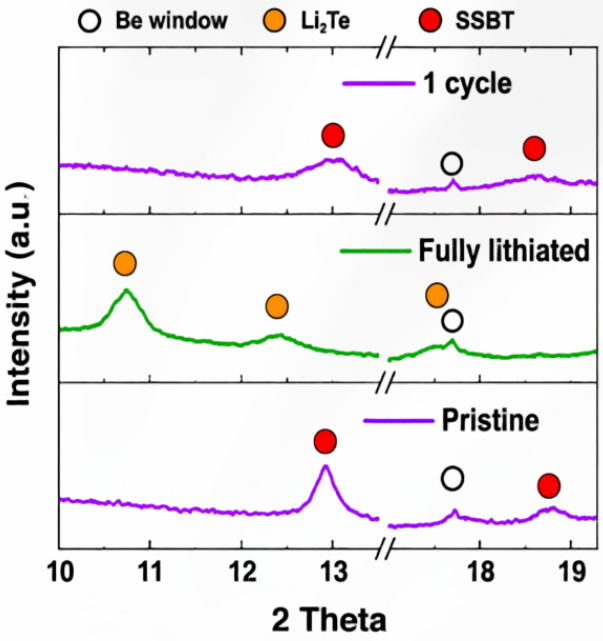
Capabilities Relevant to the XRD-2E

- Real-time tracking of phase evolution during battery cycling
- Detection of transient crystalline reaction products
- Correlation of structural changes with cell potential

Ongoing Application Studies

Application studies using this model are currently underway.

Note: The cited publication used a custom-designed operando XRD battery test cell rather than the Beyond Battery XRD-2E. The reference is included to demonstrate the relevant research methodology and should not be interpreted as describing or evaluating the XRD-2E.



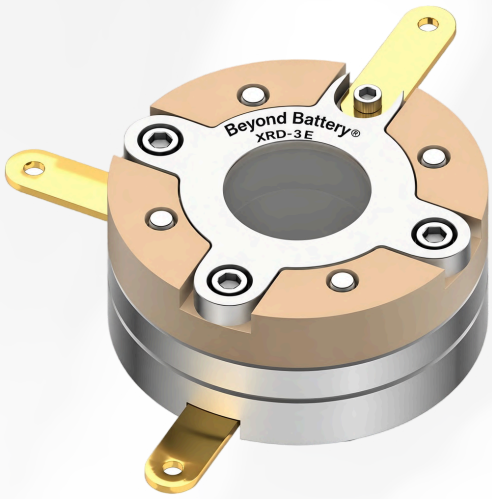
Reproduced from Alvi, S. et al. EES Batteries 2026, 2, 1003–1011. CC BY 4.0.

In Situ & Operando Battery Test Cells

XRD-3E

In Situ XRD Battery Test Cell

A three-electrode battery test cell for operando XRD monitoring with independent reference-potential measurement.



Product Overview

The XRD-3E is a three-electrode in situ XRD battery test cell upgraded from the XRD-2E platform. It enables operando structural analysis during charge/discharge cycling while an independent lithium reference electrode monitors electrode potential. A low-background beryllium window provides direct X-ray access to the electrode stack, while the high-purity titanium body, PEEK insulation, and gold-plated copper tabs support stable, repeatable electrochemical testing.

Technical Specifications

Minimum operating angle	3°
Effective optical window diameter	Ø20 mm
Applicable sample diameter	Ø20 mm
Optical window material	Beryllium (Be)
Electrode system	Three-electroder
Cell body material	Ti
Insulation material	PEEK
Current collector tab	Gold-plated copper
Reference electrode	Lithium wire
Cell body dimensions	Ø49.5 mm × H23 mm

Note: Solid beryllium is relatively stable and poses low skin-contact risk; avoid inhaling dust or aerosols and wash hands after handling.

Key Features

Independent Reference-Electrode Monitoring

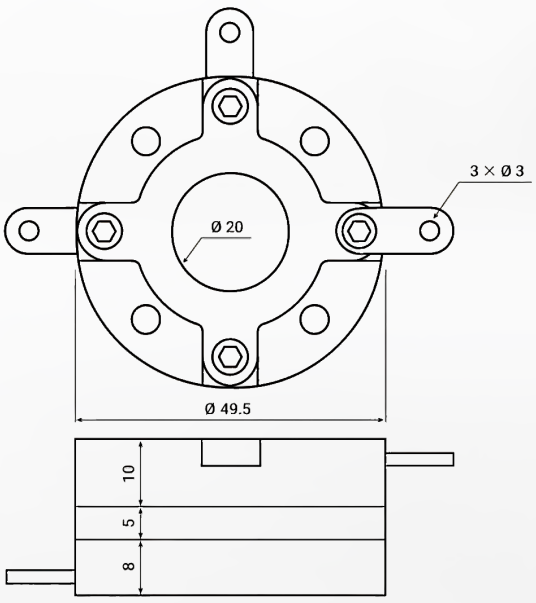
Uses a lithium reference electrode for independent working-electrode potential monitoring during cycling

Bruker D8-Compatible XRD Measurement

Designed for use with Bruker D8 X-ray diffractometer systems for operando XRD monitoring during battery cycling

Low-Angle XRD Accessibility

Supports XRD measurements from a minimum operating angle of 3°, enabling broader low-angle access for operando configurations



All dimensions are in mm.

Instrument Compatibility

XRD System Compatibility

Compatible with Bruker D8 systems and other X-ray diffractometers with suitable mounting and scan geometries. The sample holder, incident-angle range, beam path, and instrument clearance should be verified before testing

Electrochemical Testing Compatibility

Compatible with commercial electrochemical workstations and battery testing systems that support three-electrode charge/discharge testing

Related Published Application

Operando XRD Tracking of Graphite Lithiation

Olgo et al. studied a three-electrode graphite||NMC622 prismatic Li-ion cell using spatially resolved operando synchrotron XRD. The measurements tracked graphite staging transitions from graphite to LiC_{12} and LiC_6. Compared with relatively uniform lithiation at C/5, 2C charging caused delayed phase evolution and greater local heterogeneity. The stable LFP reference electrode enabled independent monitoring of graphite and NMC622 potentials while causing minimal disturbance to local lithiation behavior.

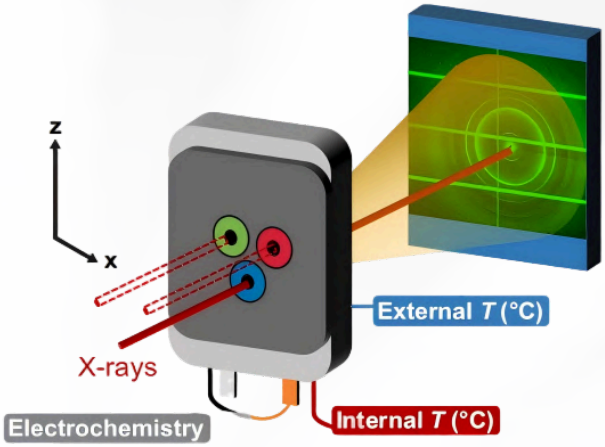
Capabilities Relevant to the XRD-3E

- Independent monitoring of electrode potentials
- Operando tracking of graphite → LiC_{12} → LiC_6 transitions
- Detection of rate-dependent lithiation heterogeneity

Ongoing Application Studies

Application studies using this model are currently underway.

Note: The cited publication used a custom-designed operando XRD battery test cell rather than the Beyond Battery XRD-3E. The reference is included to demonstrate the relevant research methodology and should not be interpreted as describing or evaluating the XRD-3E.



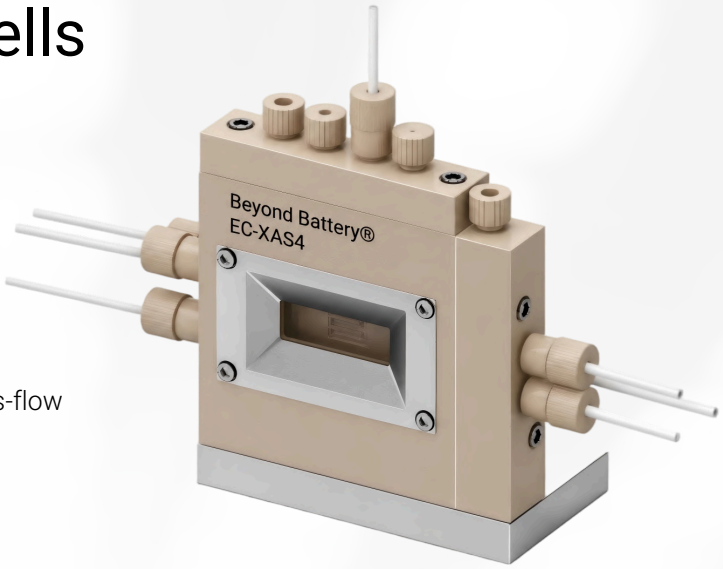
Reproduced from Olgo, A. et al. Nat. Commun. 2024, 15, 10258. CC BY 4.0.

In Situ & Operando Electrochemical Cells

EC-XAS4

In Situ X-ray Absorption Spectroscopy Cell

A modular in situ XAS cell with interchangeable gas-flow and open X-ray access back plates for gas-fed and conventional electrochemical studies.



Product Overview

The EC-XAS4 is a modular in situ XAS cell with interchangeable gas-flow and open X-ray access back plates for gas-fed and conventional electrochemical studies. The open configuration supports immersed electrodes, including porous, foil, and supported configurations, while the gas-flow back plate enables controlled reactant delivery to gas-diffusion electrodes. A wide-angle, short-path Kapton window provides efficient X-ray access and supports fluorescence and transmission XAS geometries.

Technical Specifications

Active area	1 cm² (10 × 10 mm); customizable
Chamber structure	Single-, two-, or three-chamber
Electrode system	Two- or three-electrode
Window opening angle	Up to 120°
Working electrode	Sheet-type electrode; customizable
Counter electrode	Standard Ø6.0 mm rod-type electrode; customizable
Reference electrode	Standard Ø3.8 mm rod-type electrode; customizable
X-ray window material	Kapton film; user-supplied
Cell body material	PEEK
Positioning accessory	Angular micro-adjustment stage; optional

Key Features

Modular Back-Plate Design

Interchangeable gas-flow and open X-ray access back plates enable flexible electrochemical configurations.

Wide-Angle, Short-Path Kapton Window

Provides broad X-ray access with a large access area, while the shortened distance to the working electrode enhances signal sensitivity and in situ monitoring performance.

Independent Gas and Liquid Pathways

In the gas-flow configuration, separate gas and electrolyte pathways enable controlled reactant delivery and independent liquid circulation.

Typical Applications

Gas-Fed Electrocatalysis

Operando XAS studies of CO_2/CO electrolysis, ORR, HOR, NRR, and related gas-fed reactions using gas-diffusion electrodes.

Conventional Electrochemical XAS

In situ and operando studies of immersed sheet-type, porous, or foil electrodes for OER, HER, liquid-phase NRR, and related reactions.

Catalyst Activation and Reconstruction

Tracking oxidation-state, coordination, phase, and structural changes under electrochemical control.

Time-Resolved XANES and EXAFS

Resolving dynamic electronic and local structural changes during electrochemical operation.

Instrument Compatibility

Synchrotron XAS Beamline Compatibility

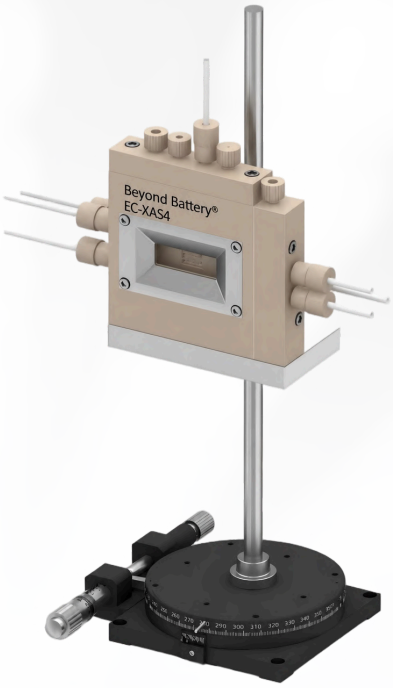
Compatible with synchrotron XAS beamlines for in situ measurements. Beamline geometry, detector clearance, stage mounting, and alignment should be confirmed before use.

Potentiostat Compatibility

Compatible with commercial potentiostats for two- or three-electrode measurements. Electrode connections should be confirmed before use.

Optional Accessory

The angular micro-adjustment stage is an optional accessory supplied separately. It enables fine positioning of the EC-XAS4 and precise adjustment of the X-ray incidence angle, facilitating beam alignment with the Kapton window and working-electrode region for consistent in situ XAS measurements.



Back-Plate Selection Guide

Gas-Flow Back Plate

A gas-flow configuration for controlled reactant delivery to the backside of a gas-diffusion electrode. Recommended for gas-fed electrocatalysis, including CO_2/CO electrolysis, ORR, HOR, NRR, and related reactions. Select this back plate when direct gas supply to a GDE is required.

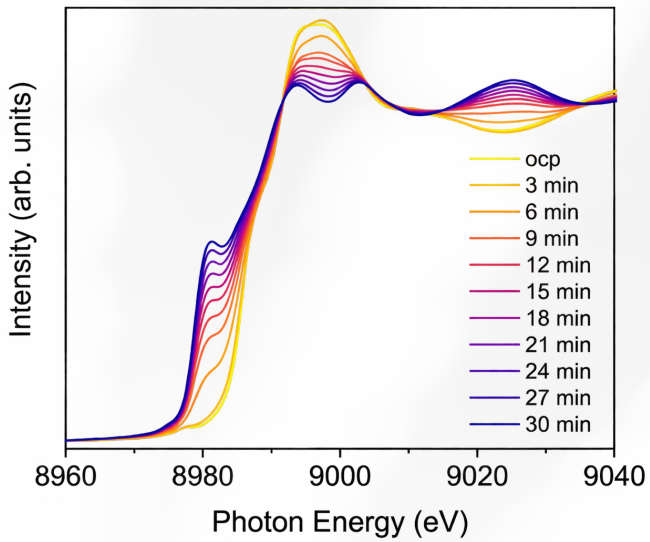
Open X-ray Access Back Plate

An open configuration providing unobstructed X-ray access for conventional electrochemical XAS measurements. Recommended for immersed sheet-type, porous, foil, and supported electrodes, with fluorescence or transmission detection selected according to the sample and beamline geometry. Select this back plate when backside gas delivery is not required.

Related Published Application

Time-Resolved In Situ XAS of Cu Catalyst Reconstruction

Yao et al. used fluorescence-mode, time-resolved Cu K-edge XAS at the BL11B beamline of the Shanghai Synchrotron Radiation Facility and the SuperXAS beamline of the Swiss Light Source to monitor Cu catalyst reconstruction during CO_2 electroreduction. The membrane-separated flow cell circulated 0.1 M $KHCO_3$ through both electrode compartments and employed a carbon-paper-supported Cu working electrode. At −1.1 V versus RHE, spectra acquired with a time resolution of 1 s tracked the loss of Cu–O coordination and formation of metallic Cu–Cu bonds, with linear-combination analysis indicating 99.2% metallic Cu after 30 min.



Reproduced from Yao, K. et al. Nat. Commun. 2024, 15, 1749. CC BY 4.0.

Capabilities Relevant to the EC-XAS4

- Enables time-resolved XANES and EXAFS measurements under electrochemical control.
- Supports membrane-separated anolyte and catholyte circulation with a carbon-paper-supported working electrode.
- Tracks oxidation-state and coordination changes during catalyst activation and reconstruction.

Ongoing Application Studies

Application studies using this model are currently underway.

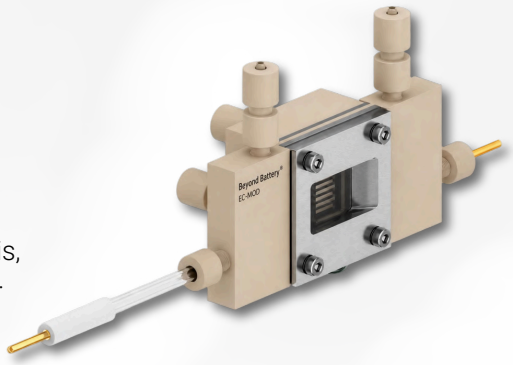
Note: The referenced study used a membrane-separated in situ XAS flow cell with a configuration comparable to the EC-XAS4 and is included solely as a related application example.

In Situ & Operando Electrochemical Cells

EC-MOD

Modular In Situ Electrochemical Cell

A modular, multi-technique flow cell for in situ Raman, FTIR, UV–Vis, XRD, and XAS studies under controlled electrochemical conditions.



Product Overview

The EC-MOD is a modular flow-through electrochemical cell designed to couple three-electrode control with in situ spectroscopy and diffraction. Interchangeable optical and X-ray window assemblies configure the same base cell for Raman, FTIR, UV–Vis, XRD, or XAS measurements. Standard plate-electrode and gas-diffusion configurations support liquid-phase interfacial studies, spectroelectrochemical analysis, and gas-fed electrocatalytic reactions.

Technical Specifications

Cell configuration	< 1.5 mm
Optical window size	15 × 15 mm
Chamber structure	Single-chamber (standard configuration); Two-chamber (gas-diffusion configuration)
Working electrode	Sheet-type electrode
Reference electrode	Ag/AgCl electrode (standard)
Counter electrode	Platinum wire electrode
Cell body material	PEEK + Ti
Raman/UV–Vis windows	Sapphire (standard) or quartz (optional)
XAFS window	Kapton film (optional)
XRD window	Beryllium (optional)
IR window	CaF_2 (ZnSe optional)

Key Features

Multi-technique Window Platform

Interchangeable quartz, sapphire, CaF_2, Kapton-film and beryllium windows configure the cell for different in situ analytical methods.

Dual Working Electrode Configurations

Standard plate-electrode and gas-diffusion assemblies support conventional liquid-phase studies and gas-fed electrocatalysis.

Flow-Through Electrolyte Circulation

Dedicated inlet and outlet ports support external electrolyte circulation and controlled flow during electrochemical measurements.

Typical Applications

In Situ Raman/UV–Vis Measurements

Monitoring interfacial species and reaction intermediates

In Situ IR Measurements

Monitoring adsorbed species and reaction pathways

In Situ XAFS Measurements

Probing oxidation states and coordination structures

In Situ XRD Measurements

Tracking phase and structural evolution

Gas-Diffusion Electrode Studies

Suitable for CO_2RR, ORR, and NRR

Instrument Compatibility

Spectroscopy and X-ray Compatibility

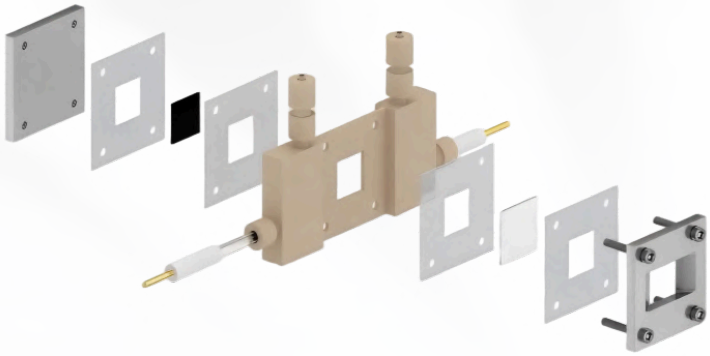
Configurable for Raman, UV–Vis, and IR optical systems, synchrotron XAFS beamlines, and laboratory or synchrotron XRD instruments, subject to instrument geometry, beam size, incidence angle, optical access, and working-distance requirements.

Electrochemical and Flow System Compatibility

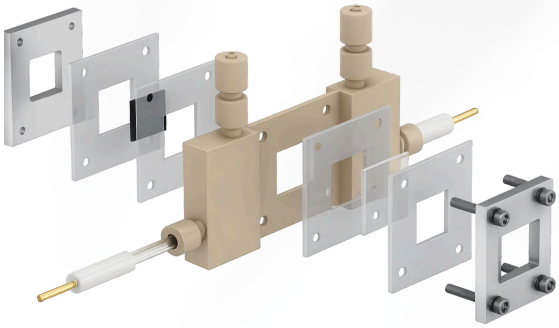
Compatible with standard three-electrode potentiostats, external electrolyte pumps, PTFE tubing, gas-supply systems and downstream product-collection equipment

Standard and Gas-Diffusion Configurations

Standard Configuration (single-chamber)

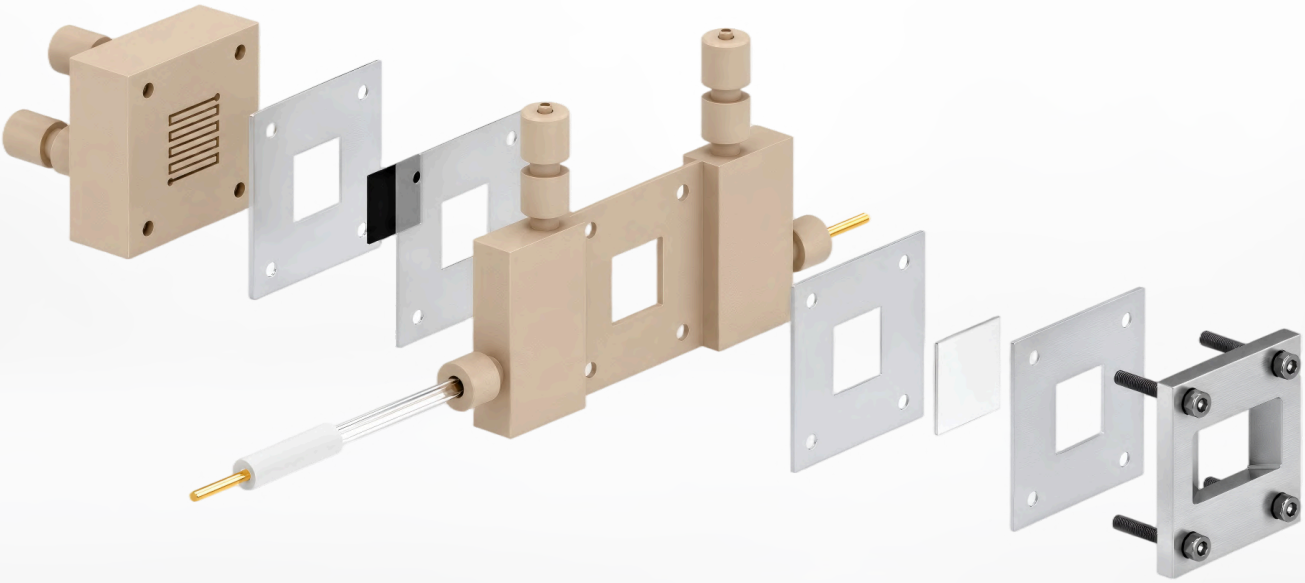


General Test Configuration



IR Test Configuration

Gas-diffusion Configuration (two-chamber)



Ongoing Application Studies

Application studies using this model are currently underway.