ElProScan SPECM System

The World’s Best
Scanning Photoelectrochemical Microscope

- Unique Matrix Scan with Microelectrode and Light Beam Remaining Confocal
- Electrochemical Signals Synchronized with Spatially Resolved Photo-Excitation
- Multi-Dimensional Data Obtained on the True Micron or Nano-Scale

www.heka.com
ElProScan - Scanning Photoelectrochemical Microscope System

- ElProScan is the World’s 1st commercial SPECM system from HEKA for microscopic study and imaging of photoelectrochemical processes on micron and sub-micron scale.

- The innovative SPECM works for a wide range of materials and applications:
  - Inorganic Semiconductors
  - Semiconducting Polymers
  - Solar to Electricity Conversion (solar cells)
  - Solar to Chemical Energy Conversion (Water splitting and CO₂ reduction)
  - Hybrid Nanostructures
  - Organic Photovoltaic Materials
  - Photosterilisation, Self-Cleaning Surfaces
  - Environmental (air and water) Remediation

- Unique system design features a Synchronized Photo-Excitation System seamlessly integrated with a Scanning Electrochemical Microscope (SECM) system.

**A general scheme for the SPECM design**

**Legend:**
1: Objective Lens  
2: Beam-Splitter  
3: 90° Mirror  
4/5/8: Special Optical Lenses  
6: C-mount Adapter  
7: Variable Field Stop  
9: Light Guide Adapter

**Illustrative cartoon shows a transparent substrate**

**Advanced SECM System from above the sample (XYZ)**

**Synchronized Photo Excitation System on the inverted bottom (F)**

- The Modular Optical Train is compatible with most excitation light sources (LED / Laser/ Xeon arc lamp).
- The incident light beam spot size may be adjusted by users, ranging from ca. 1µm – 900µm.
- The vertically mounted scanning probe remains confocal with light beam during scanning; one scan of XY-stage yields multi-channel optical, physical and electrochemical data (3D/4D/5D...) simultaneously.
PG618USB – The Perfect Bipotentiostat for Photoelectrochemical Imaging

Each HEKA SPECM system includes the best-in-class Bipotentiostat (PG618USB) for studying nanoscale electrochemical signals.

Features

- The Ultra Bipotentiostat PG618USB is designed and optimized to support cutting-edge scanning probe experiments. The **amplifier-1 channel** supports larger current ranges that’re suitable for connecting with a bulk sample electrode. The **amplifier-2** features a low noise ultra-sensitive preamplifier channel for controlling or sensing voltage and/or current of the micro-probe working electrode.

- Best-in-class current resolution of 0.15 fA in the lowest 5pA range (with current noise < 3.5 fA at 15 Hz bandwidth in 5 pA range)

- Built-in 16 bit, 200 kHz AD/DA interface with 5 µs shortest sample interval

- Additional low-current preamplifier channels can be scaled up to support triple or quadruple Working Electrodes

- Additional Auxiliary I/O ports empower the control of external equipment (such as light source, filter wheels, cameras, etc.)

- Can be used as a standalone Workstation for a wide range of traditional electroanalytical applications, including electrochemical sensing of single nanoparticles & single molecules

- Optional upgrade with high current boosters up to ±50 A range
Spatially-Resolved Photocurrent Mapping with Transparent Substrate

✓ Precise Alignment of Microelectrode Probe with Inverted Adjustable Light Beam Spot

Top 45° camera view of probe, sample and light spot

Inverted camera view with light beam on sample

Inverted camera view focusing on a Pt UME (small light spot)

Inverted camera view focusing on both UME and substrate (large light spot)

Inverted camera view focusing on optical fiber end (2 um dia.)

✓ Spatially-resolved Photocurrent Mapping from Inverted Light Illumination (individual wavelength)

Local Photocurrent of TiO₂ thin film using Full Spectrum light irradiation (90 µm dia. light spot size)

3D micrograph of Photocurrent distribution

✓ Microscopic Fast-Mapping of Photocurrent for Multiple Wavelengths within one scan

Automatic multi-wavelengths switching synchronized with ultra-fast Photocurrent recordings from BiVO₄ thin film.
Simultaneous mapping of microscopic distribution of photocurrent, IPCE/QE, photo-sensitive products or intermediates, and high-resolution surface topography within one scan.

Automatic multi-wavelengths switching synchronized with dual-channel current recordings

Innovative SPECM Imaging via Scanning Electrochemical Cell Microscopy (Microdroplet Cell Mode)

Micro-droplet of electrolyte hanging at a micropipette tip
Working with Non-transparent Substrate via Opto-Pipette

- 2018 new system supports optical fiber couplings with Opto-micropipette techniques via SICM or SECCM configurations.

- Opto-pipette used in Scanning Ion Conductance Microscopy mode

- Opto-pipette used in Scanning Electrochemical Cell Microscopy mode

- Top camera view of Opto-micropipette tip and mirror image from a wafer sample

- Localized top-illumination mode via a quartz glass microprobe is compatible with Shear-force Topography-Sensing technique

- Localized photocurrent measurements from multi-wavelength illuminations, obtained from Synchronized Optopipette-SECCM experiments.

**Benefit & Novelty**

- Local Photocurrent (≈fA resolution) and Topography (≈nm resolution) can be mapped simultaneously within one scan
- Improved light-beam spatial resolution vs. bulk mode (e.g. 1~2 µm vs 90 µm dia. spot)
- Much improved s/n ratio and ultra-low noise in Photocurrent (e.g. pA vs. nA)
- Only a small local spot is in contact with electrolyte at a time
- Multiple wavelengths of light can be automatically switched and measured in one user-defined Matrix Scan
The Most Featured and Versatile Accessories for SPECM

- **Microelectrodes (Pt / Au / Carbon)**
  200 nm – 25 µm dia.

- **Microelectrode Polishing Machine**

- **Electrochemical Cell Stage Insert with Temperature Control and Gas Purging**

- **Various Light Sources & Filters**

- **Holders for Microelectrodes, Micropipettes and SMA-Fibers**

- **Vibration-isolation & Shielding Device**
## ElProScan SPECM System Configurations and Specifications

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<th>Components and Items</th>
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<tr>
<td><strong>Positioning System with Integrated Microscope Optics</strong></td>
<td></td>
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<tr>
<td>X/Y/Z/F 4D positioning system</td>
<td>4-Axis DC servo motors with Z-axis piezoelectric system (X/Y-axis carries sample in scanning; Z-axis carries microprobe, and F-axis drives objective lenses for precise focus).</td>
</tr>
<tr>
<td>Resolution of X/Y/Z Axis</td>
<td>Linear Encoder of each motor axis = 2.5 nm resolution (all closed-loop controlled); 1.5 nm resolution for the Z-axis piezo module; XY-scan resolution = 10 nm with 4 times oversampling algorithm to ensure accuracy</td>
</tr>
<tr>
<td>X/Y/Z/F Axis Travel Range</td>
<td>Automatic motor-scan range: X = 100 mm, Y = 75 mm, Z and F = 50 mm. Z-axis piezo range = 100 μm (closed-loop controlled) A manual translator unit extends XY range to additional 12 mm.</td>
</tr>
<tr>
<td>4D External Joystick</td>
<td>For X/Y/Z/F manual control with sub-micron accuracy; may operate in precise-slow motion and coarse-fast motion.</td>
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<tr>
<td><strong>Integrated Microscope Optics</strong></td>
<td>The inverted optical train contains a motorized focus drive, epi-fluorescence optics in Kohler configuration (with a variable field stop) and special coupling to a liquid light guide, camera port with C-mount, an optional Filter cube holder, and slide-in beam splitter and a mirror cube. Additional fixed-spot size illumination path with coupling to a FC/PC fiber is included. Optional objectives (4x up to 100x) can be mounted in a 6-position turret nose piece. Microscope optics transmits light of wavelength above 330 nm.</td>
</tr>
<tr>
<td><strong>Optional Upgrade</strong></td>
<td>Top 45° camera system may record and view the microprobe and sample surface in prepositioning, greatly facilitating Z/F-axes alignment and pre-scan preparations.</td>
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<tr>
<td><strong>Bipotentiostat WorkStation</strong></td>
<td></td>
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<tr>
<td>Voltage Range / Resolution</td>
<td>± 10V (in single amplifier mode) / 610 nV</td>
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<tr>
<td>Current Ranges</td>
<td>±20 nA to ±100 mA (Amp-1); ±5 pA to ±2 μA (Amp-2; total 18 ranges available)</td>
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<tr>
<td>Max. Current Resolution</td>
<td>0.15 fA in 5pA range (Amp-2) ; 0.61 pA in 20nA range (Amp-1)</td>
</tr>
<tr>
<td>Noise in Current</td>
<td>RMS value &lt; 3.5 fA (at 15 Hz bandwidth in 5 pA range of Amp-2)</td>
</tr>
<tr>
<td>DAC Interface</td>
<td>16-bit / 5 μs fastest pulse / 200 kHz sampling rate</td>
</tr>
<tr>
<td><strong>Optional Upgrade</strong></td>
<td>(1) Current Booster for extending max. current range to ±50 A (2) External EIS measurement module (10 μHz – 1 MHz) (3) Scanning Kelvin Probe system available as an add-on module</td>
</tr>
<tr>
<td><strong>Photo-Excitation System</strong></td>
<td></td>
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<tr>
<td>Synchronized Multi-Wavelength Excitation System</td>
<td>Standard package includes: 300W Xenon arc lamp, shuttered 10-position filter wheel, fused silica light guide, 10 bandpass filters with 10nm bandwidth in the range of 350nm to 800nm, 1 neutral density filter).</td>
</tr>
<tr>
<td>Light Guide to Fiber Coupler Kit</td>
<td>Used for connecting a light guide with 5mm OD and 20mm length fitting to a SMA type optical fiber for the fixed spot-size illumination path.</td>
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<tr>
<td>Opto-Pipette Holder Kit</td>
<td>A special pipette holder with a straight optical port (SMA type) used for coupling a HEKA Cannula to an optical fiber for combined top-illumination in SICM/SECCM experiments.</td>
</tr>
<tr>
<td><strong>Optional Upgrade</strong></td>
<td>Special customization is available for adding Synchronized Fluorescence Imaging module.</td>
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## ElProScan SPECM Supported Techniques and Applications*

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<tr>
<th>Supported Techniques</th>
<th>Key Features</th>
<th>Main Application Examples</th>
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<tr>
<td>SECM for localized 2D/3D imaging and spectroscopic measurements</td>
<td>Supports all existing SECM operation modes (Feedback; Generation-Collection; Redox-Competition, AC-SECM, etc.)</td>
<td>Mapping surface electrochemical activities of various samples and systems (e.g. biological sensors, live cells, molecular transport at porous membranes, electro- &amp; photo-catalysts, local corrosion processes, liquid/liquid charge transfer, micro-fabrication &amp; micro-patterning of surface)</td>
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<tr>
<td>Simultaneous Surface Topography Mapping</td>
<td>Shear-force based Constant Distance scan in synchronization within SECM or AC-SECM scans (via advanced non-contact hopping mode)</td>
<td>(i) In situ imaging of sample's height profiles and topography. (ii) Real-time surface-tracking of height/volume for thin-films.</td>
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</table>
| Scanning Photoelectrochemical Microscopy (SPECM) | (a) Precise synchronization of SECM with multi-wavelength photo-illumination at variable controlled spot-sizes.  
(b) Multi-dimensional data recordings via automated Protocol-controlled Matrix Scan.  
(c) Flexible optical designs are suited for both transparent and non-transparent samples.   
(d) Spatially-resolved optical and electrochemical probe coupling reaches sub-micron resolution.  
(e) Versatile optical configurations support the addition of a UV-VIS-IR spectrometer via optical fiber coupling. | (i) Simultaneous microscopic imaging of localized photocurrents, IPCE/QE distribution, and photoactive intermediates or products within a single 2D/3D SECM scan. (ii) High throughput screening of Photocatalysts via synchronized multi-wavelength excitations and multi-channel data recordings.  
(iii) Localized studies of photoelectrochemistry (e.g. Localized Photocurrent Spectroscopy; kinetics study of electron-hole recombination; Spectral Resolved Transmittance / Absorbance Spectroscopy* vs. Voltage, Current, or Time)  
* requires fiber-coupled spectrometers |
| Scanning Ion Conductance Microscopy (SICM) | (a) Three modern operation modes of SICM are supported: AC- and DC- hopping mode, and Bias-Modulated SICM.  
(b) Unique probe design allows the use of Opto-pipette to combine photo-excitations with SICM. | (i) Non-destructive high-resolution topography imaging is widely suited for all delicate and soft sample surfaces in electrolyte. (ii) Simultaneous in situ mapping of surface charge and topography via Bias-Modulated SICM.  
(iii) *Simultaneous microscopic mapping of topography and photocurrents/IPCE/QE for photoactive materials.  
* Requires Opto-pipette kit and light illumination controls. |
| Scanning Electrochemical Cell Microscopy (SECCM) and Scanning Microcapillary Contact Method (SMCM) | (a) Users may control the probe size and the spatial resolution of the scanned area (i.e. nano-/micro-pipette tip can be prepared by users).  
(b) User-defined protocol script may automate a highly complex Matrix Scan with multi-dimensional data recorded.  
(c) SECCM and SMCM set-up is fully compatible with photo-illumination from top and inverted optics, thus extending the schemes of experimenting in SPECM.  
(d) Unique Opto-pipette holder supports the use of various combinations of bi-functional probes: such as SECM-SICM probes; Optical illumination-SICM probes; Optical illumination-SECM probes, etc. | (i) Spatially-resolved local electrochemical analysis of photo-catalysts, electro-catalysts and conductive polymers. (ii) Simultaneous mapping of depth profiles and localized corrosion potentials.  
(iii) Nanoscale mapping of redox activity of Li-ion battery cathodes materials.  
(iv) Combined SPECM imaging* with simultaneous topography mapping  
* Requires Opto-pipette kit and light illumination controls. |

* Please also refer to HEKA’s Full ElProScan Brochure for more technical details.
Engineered in Germany
Supported at Your Doorstep

Please contact HEKA for ElProScan SPECM at:

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