COVALENT METROLOGY

Welcome

SURFACE CHARGE ON COLLOIDS, AND BEYOND: THE COMPLEMENTARITY OF SOLID- AND SOLUTION-STATE ZETA POTENTIAL MEASUREMENT

Thomas Luxbacher, PhD
Principal Scientist,
Anton Paar

March 9, 2023 | 11am PT

COVALENT METROLOGY

Anton Paar

COVALENT METROLOGY

Silicon Valley-based analytical labs and platform delivering quality data and expert analysis for advanced materials and device innovation

Comprehensive Solutions Stack

70+ cutting-edge instruments, offering 100+ techniques

Analytical Services

Advanced Modeling

Method Development

Enterprise Metrology Solutions

Affordable and Fast

Fast Turnaround Times

Volume Savings

Instant Access to Data and Reports in Secure Portal

Flexible Business Model

Custom Consulting Solutions and Certified On-site Support

Training and Certification on Instrumentation

Co-op and Tool-Share Opportunities

Laboratory Audits

Rich Network of Partnerships

Partner to the World's Leading Instrument Manufacturers and Labs

Expanding Instrumentation, Lab Connections, and Learning

Who We Are, Who We Serve

500+ Clients, 40 – 60 Added / Quarter

60+ Employees, 25% + hold PhDs

Cutting-edge Analytical Capabilities

Silicon Valley Lab based in Sunnyvale, CA

Covalent Analytical Services

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PCBA, Semiconductor, and Electronic Device Metrology & Failure Analysis

- DPA / Mechanical Cross-section
- Dye & Pry Test
- EBIC / OBIC failure analysis
- Hot Spot Detection
- IR Imaging / Emission Microscopy
- NIR Imaging
- Root-Cause Failure Analysis

Electron Microscopy and Scanning Probe Microscopy

- AFM & Advanced AFM Modes (EFM, KPFM, MFM, PFM)
- Scanning Acoustic Microscopy (SAM)
- SEM (+ EDS)
- FIB-SEM (+ EDS)
- S/TEM (+ EDS / + EELS)
- Nano-indent / Nano-scratch

Optical Microscopy & Spectroscopy

- Chromatic Aberration
- Digital Optical Microscopy
- FTIR and ATR-FTIR
- Laser Scanning Confocal Microscopy
- Spectral Ellipsometry
- UV-Vis-NIR Spectroscopy
- White Light Interferometry

X-Ray Characterization

- X-Ray Diffraction (XRD)
- X-Ray Reflectometry (XRR)
- Micron-spot ED-XRF
- WDXRF
- Micro-computed X-ray Tomography (Micro-CT)
- 2D X-ray Inspection & X-ray Radiography

Elemental / Chemical Composition Analysis

- EPMA
- GD-OES
- GC-MS
- ICP-MS and LA-ICP-MS
- Raman Microscopy & Spectroscopy
- NMR (1D or 2D; solid / liquid)

Particle Analysis

- Dynamic Light Scattering (DLS)
- Laser Diffraction Particle Size Analysis (PSA)
- **Particle Zeta Potential**

Material Property Characterization

- DSC
- DMA & TMA
- Rheometry
- TGA
- **Solid Surface Zeta Potential**
- Porometry / Porosity
- Gas Adsorption
- Gas Pycnometry
- Foam Density
- Tap Density

Surface Spectroscopy Analysis

- Dynamic-SIMS
- ToF-SIMS (Static-SIMS)
- Ion Scattering Spectroscopy (ISS)
- Ultraviolet Photoelectron Spectroscopy (UPS)
- X-ray Photoelectron Spectroscopy (XPS)

Covalent Partners

Today's webinar is in partnership with

Anton Paar

- **Partnership with Anton Paar announced in May, 2020**
  - Established the **Anton Paar Demonstration Facility in Covalent's Silicon Valley Laboratory** with goals of
    - Expanding industry access
    - Developing new analytical applications
  - Later expanded partnership to deliver industry-leading porous materials and powders analysis
  - Partners **continue to collaborate in advanced applications development**

- **Anton Paar Instruments** at Covalent Metrology include:
  - **SurPASS 3**
  - **Litesizer 500**
  - MCR 702 Rheometer / DMA
  - STeP 6 Nanoindentation platform
  - Ultrapyc 5000 Micro
  - Autosorb iQ C-XR-XR with CryoSync accessory
  - Porometer 3G and DualAutoTap
  - NEW Upgraded Nova 800 BET (Gas Adsorption) Analyzer

Other Covalent Partners

Rigaku

JEOL Solutions for Innovation

HORIBA Scientific

ThermoFisher SCIENTIFIC

TELEDYNE CETAC TECHNOLOGIES Everywhereyoulook™

KEYENCE

Digital Surf

PVA TePla

J.A. Woollam

TA Instruments

Asylum Research an Oxford Instruments company

Toray Research Center, Inc.

COVALENT METROLOGY

Dr. Thomas Luxbacher

Principal Scientist, Anton Paar

Anton Paar

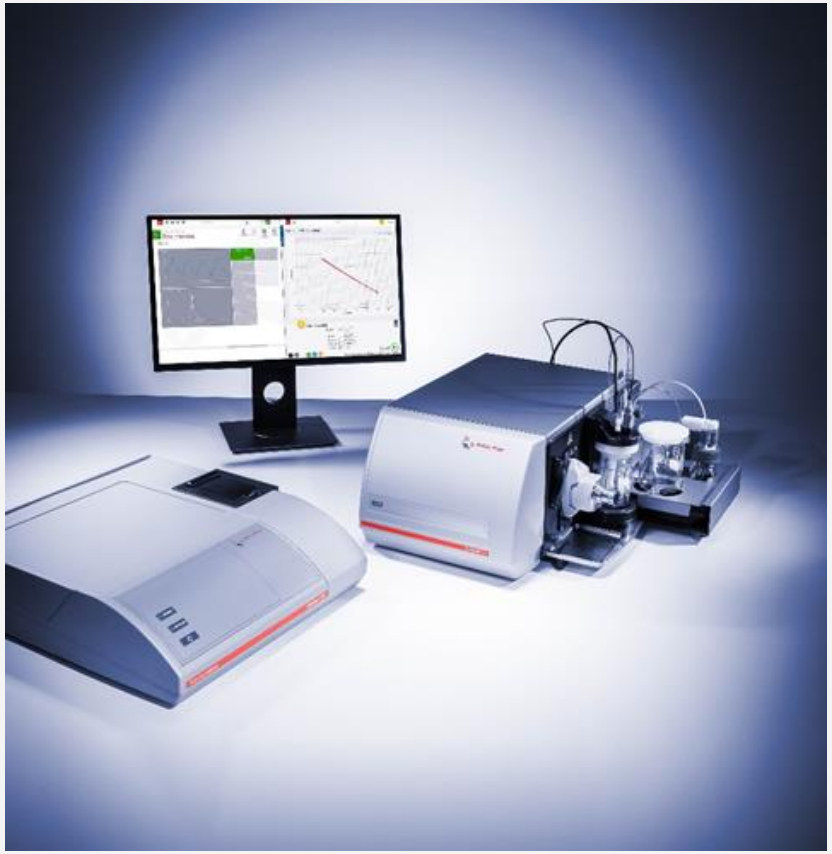
- Thomas Luxbacher has been **principal scientist for surface charge and zeta potential** at Anton Paar since 2019.
- Prior to his present role, he was a **product manager for surface zeta potential analyzers for more than 15 years.**
- Before joining Anton Paar, Thomas gained experience in product development in the **semiconductor and automotive sectors.**
- He received his **MSc and PhD degrees in Physical Chemistry** from Graz University of Technology.

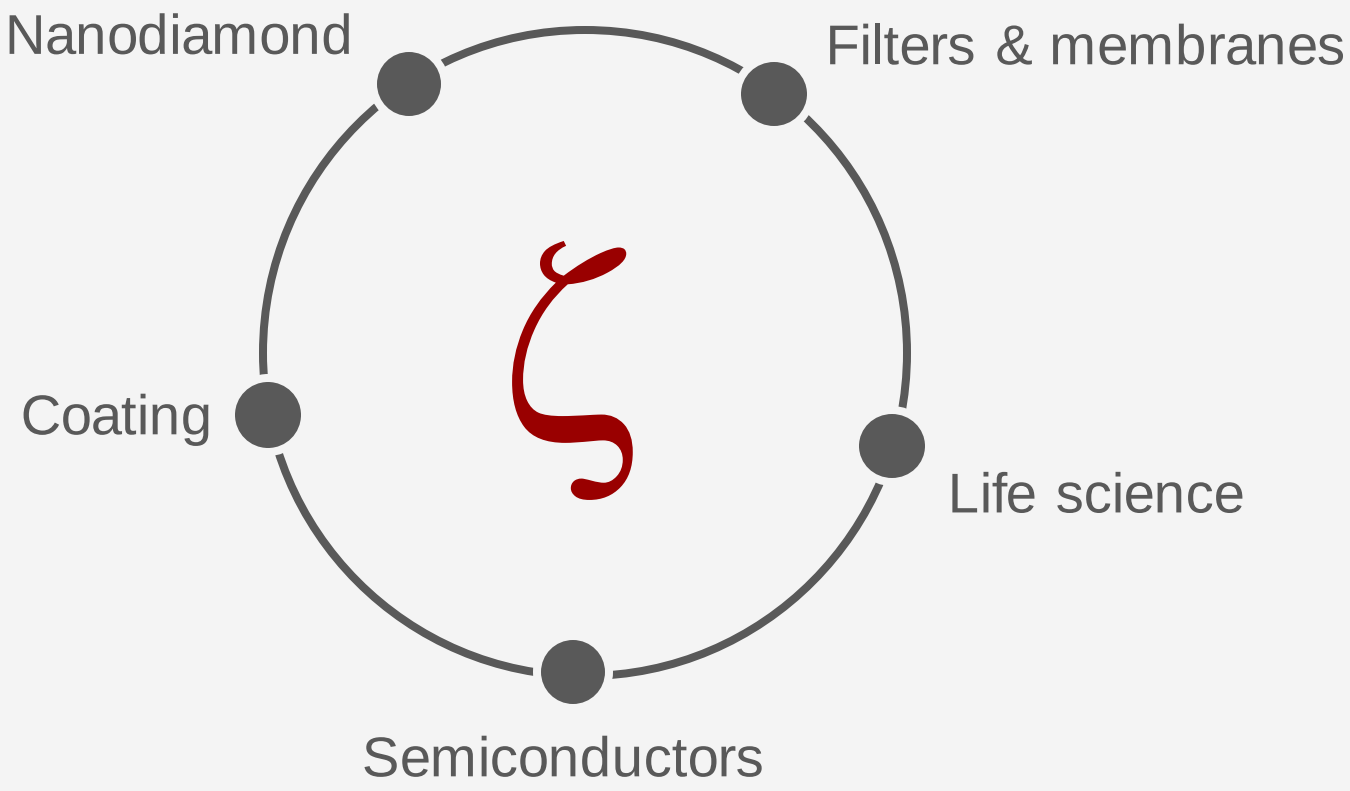
Surface charge on colloids, and beyond:
The complementarity of solid- and solution-state zeta potential measurement

Thomas Luxbacher, PhD

Anton Paar GmbH, Graz, Austria

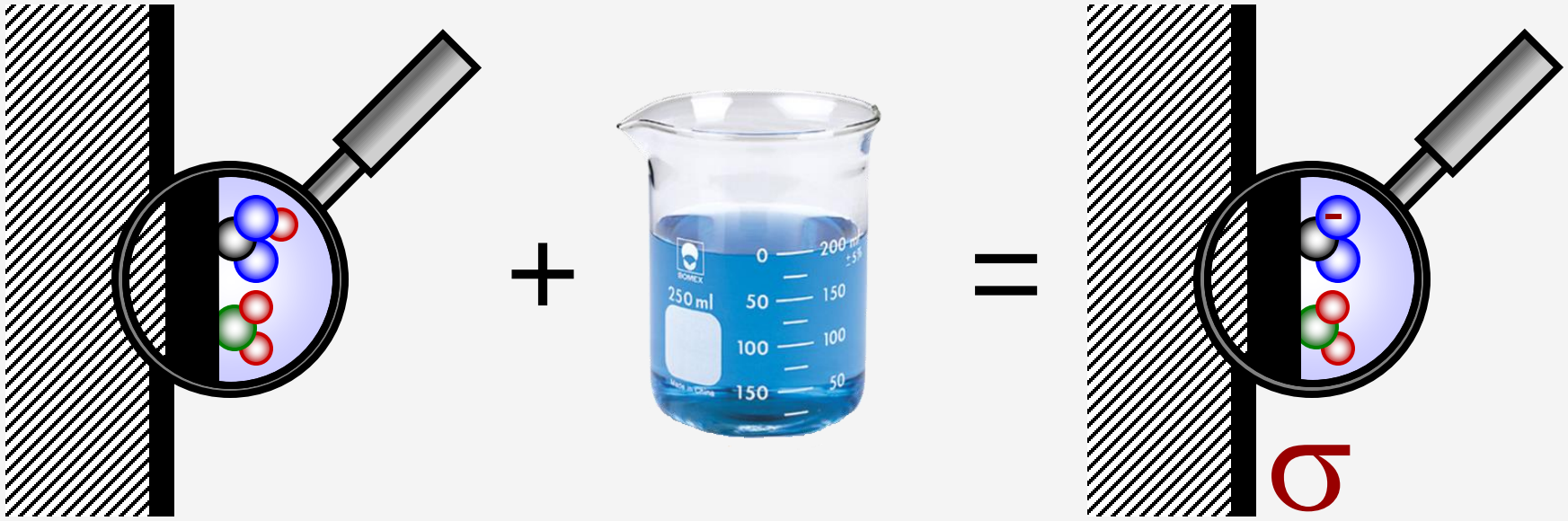
What you will learn



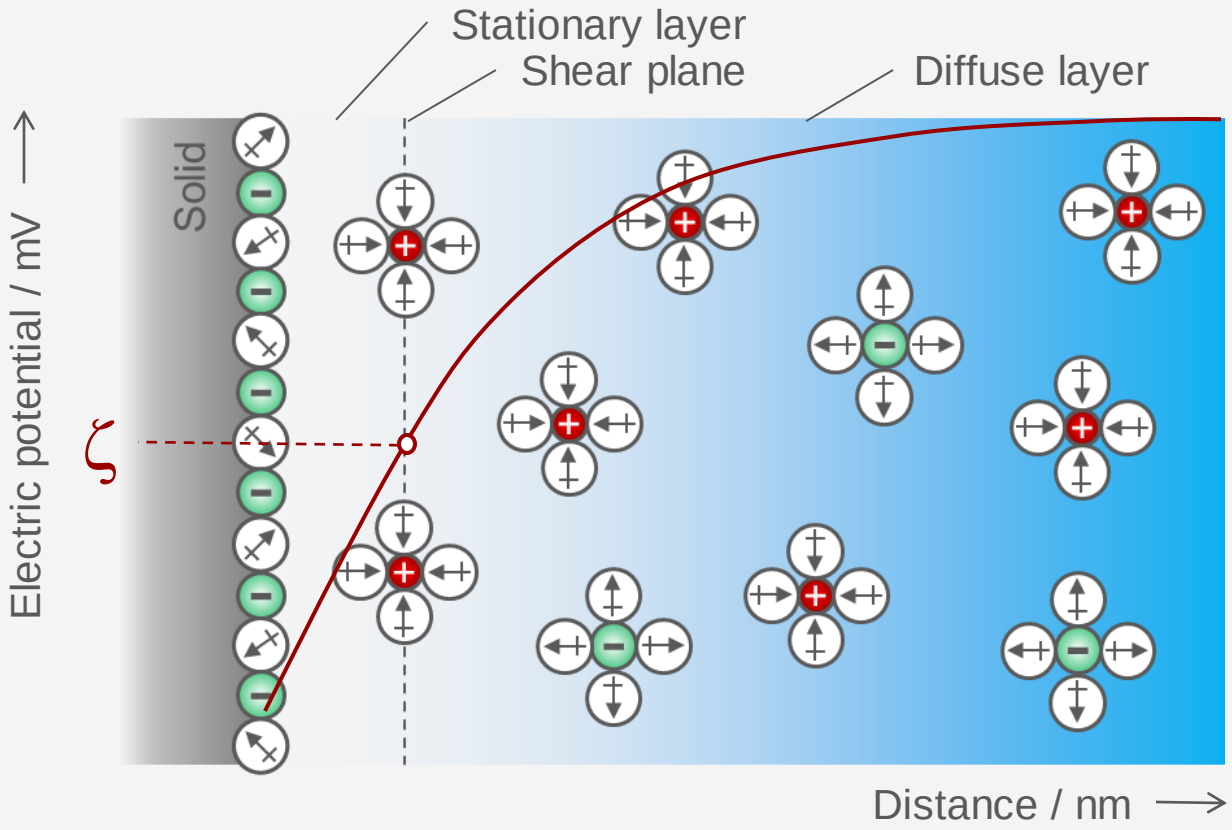


Introduction to zeta potential

Zeta potential analysis



Electric double layer



Electrophoretic mobility

Electrophoretic mobility

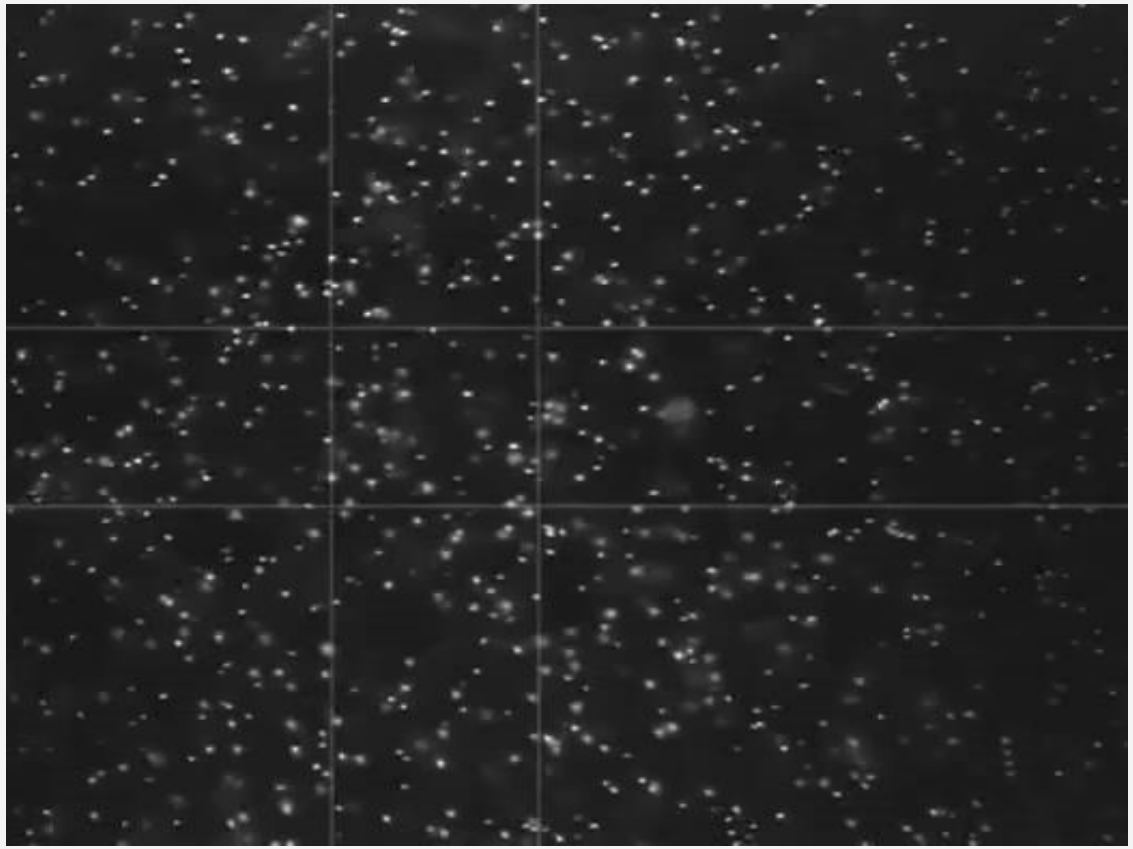
Electrophoretic light scattering (ELS)

– Electric field induces a collective movement of charged particles

$$\zeta = \frac{v}{E} \times \frac{\eta}{\varepsilon_r \times \varepsilon_0} \times f^{-1}(a\lambda^{-1})$$

μ_e

v	particle velocity
E	electric field
η	viscosity
$\varepsilon_r \times \varepsilon_0$	dielectric permittivity
f^{-1}	Henry factor
a	particle radius
λ^{-1}	Debye length
μ_e	electrophoretic mobility



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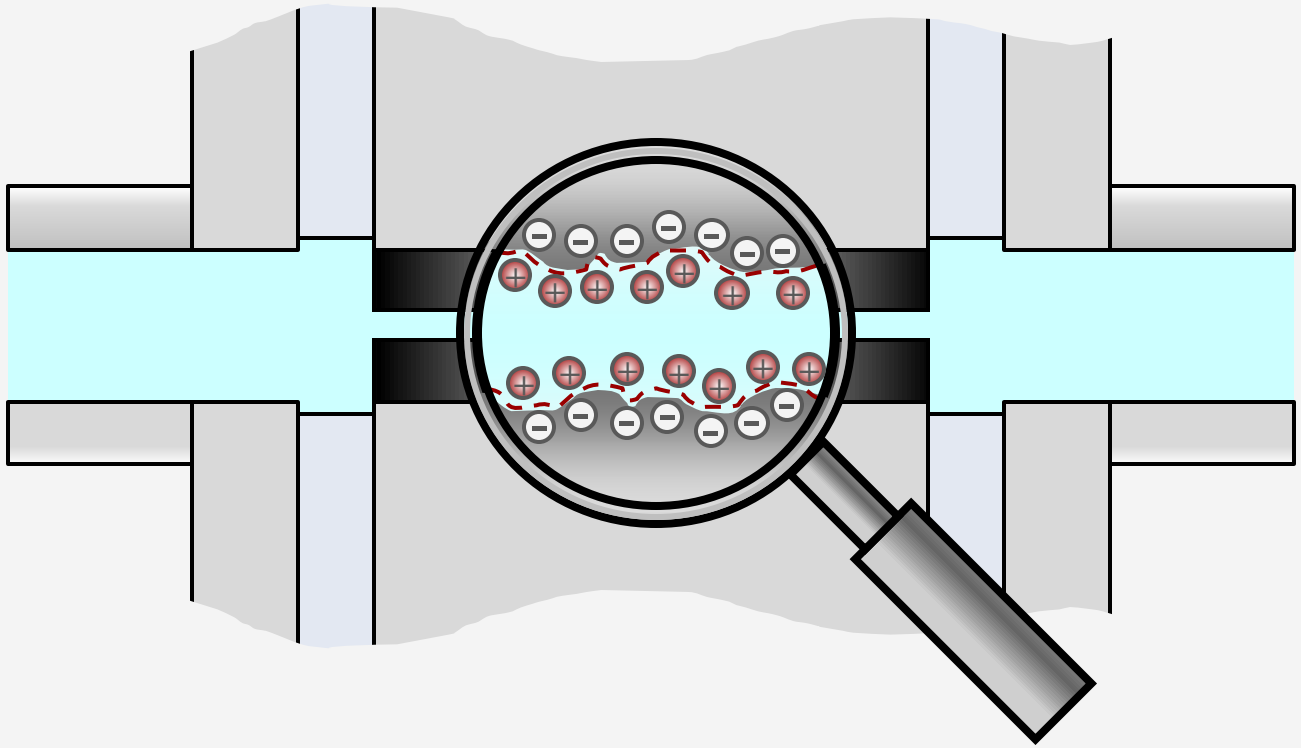
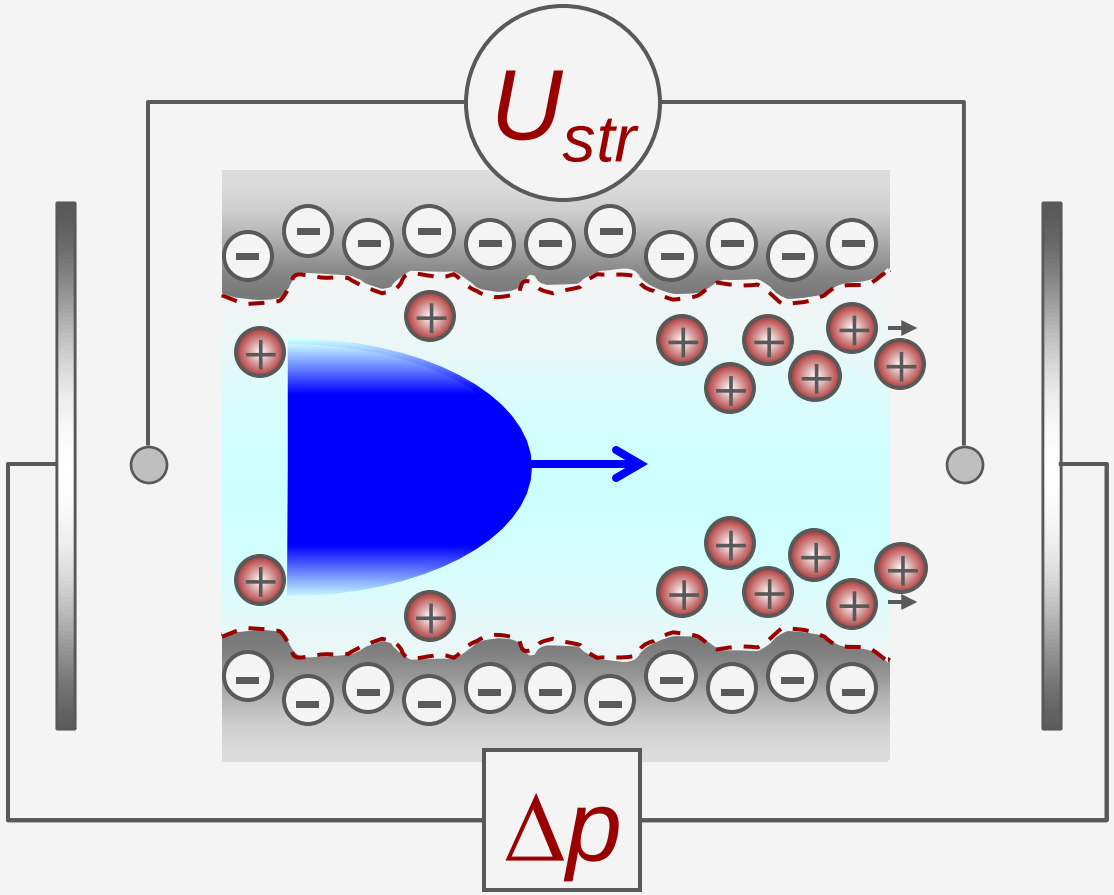
Streaming potential

Streaming potential



– Solid sample arranged to create a capillary channel

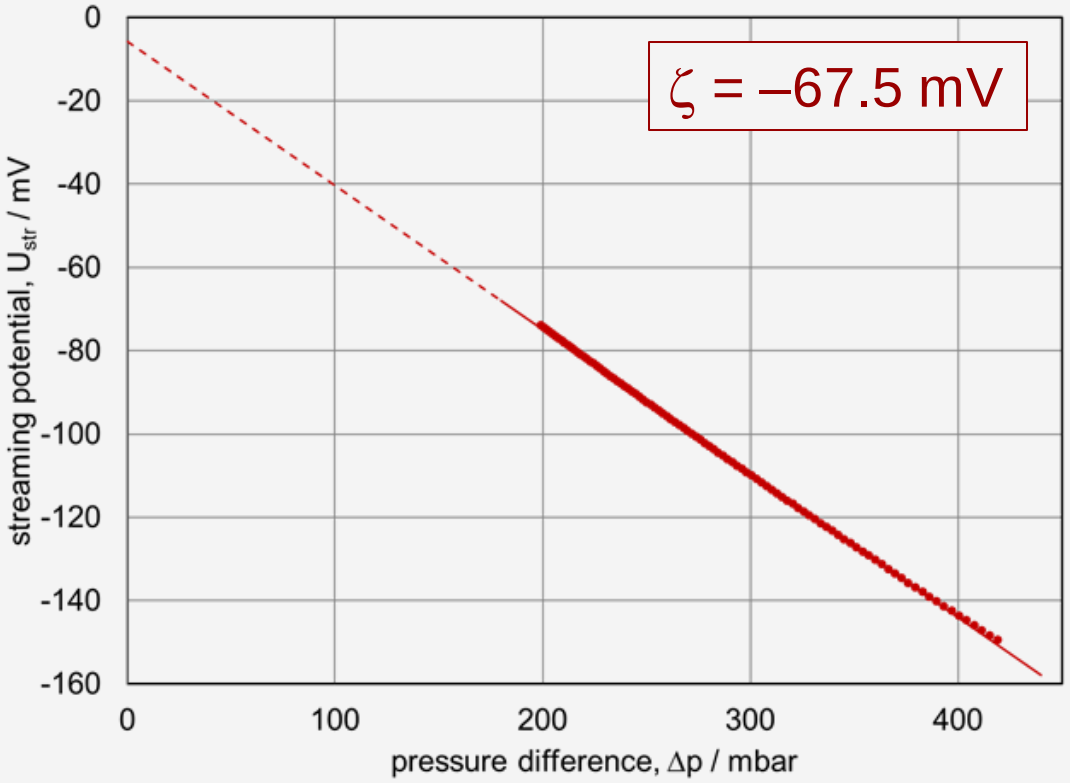
Streaming potential



$$\zeta = \frac{dU_{str}}{d\Delta p} \times \frac{\eta}{\varepsilon_r \times \varepsilon_0} \times \kappa_B$$

U_{str}	streaming potential
Δp	pressure difference
η	viscosity
$\varepsilon_r \times \varepsilon_0$	dielectric permittivity
κ_B	electrolyte conductivity

Streaming potential



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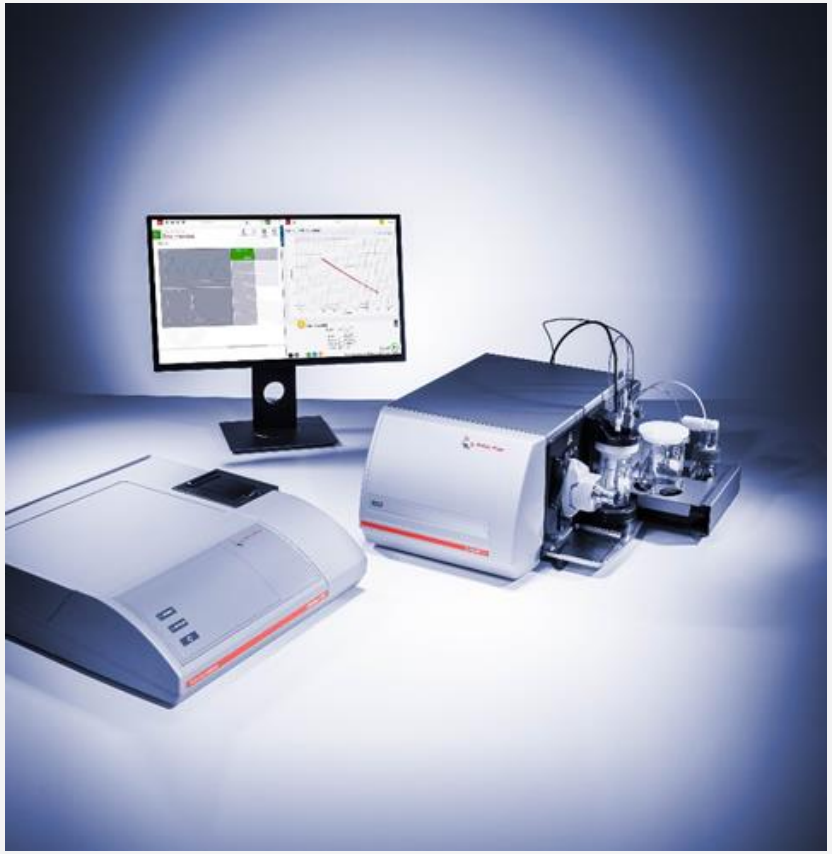
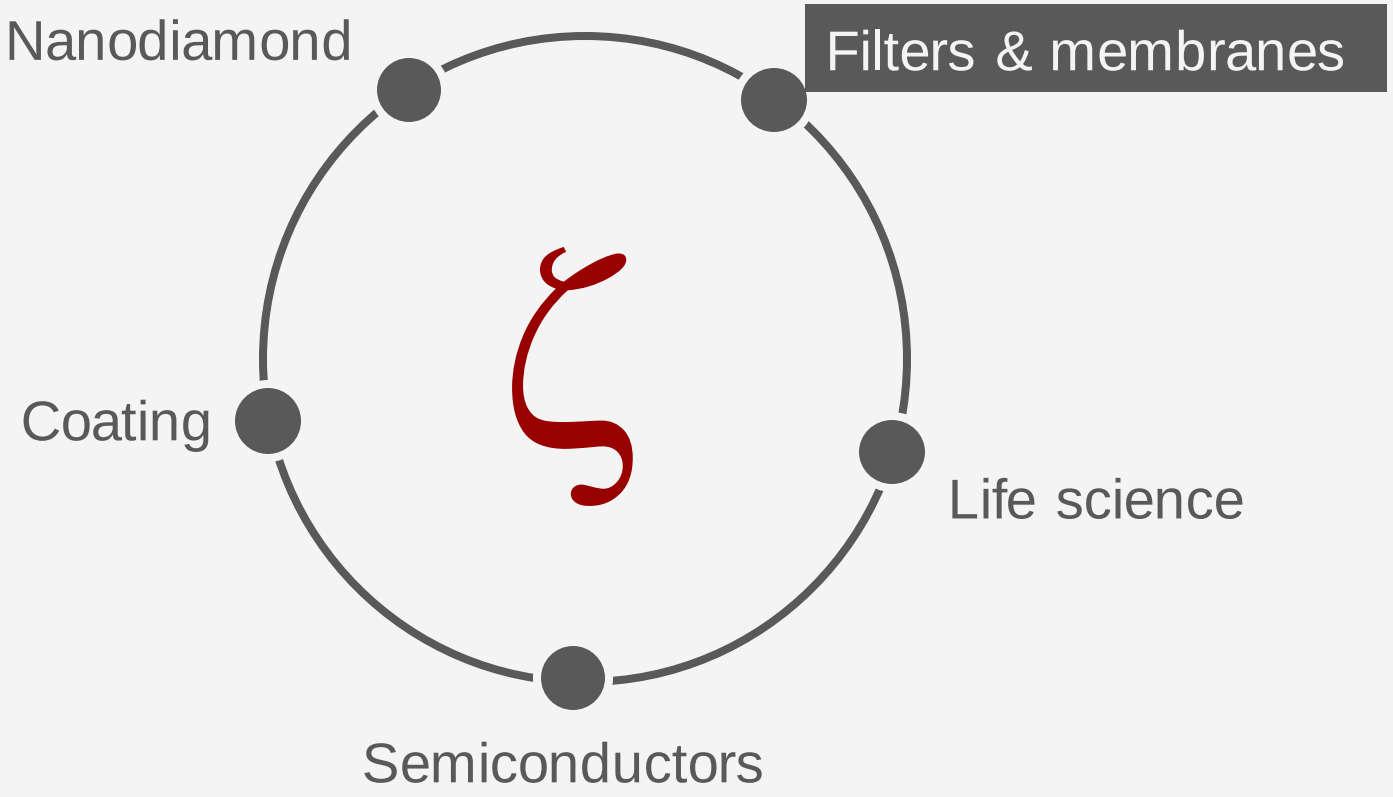
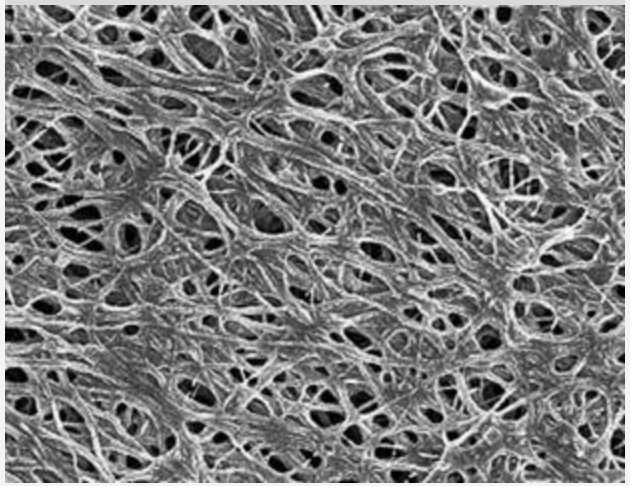
Applications



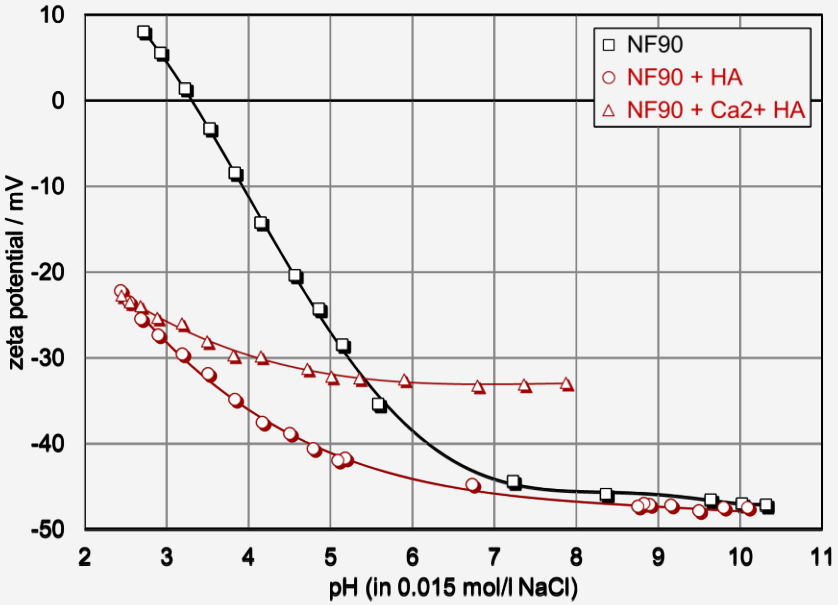


Filters and membranes

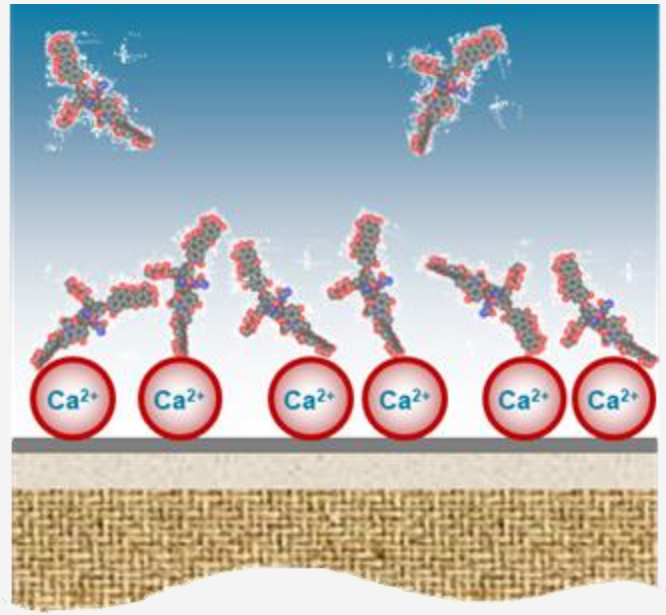
- Microfiltration
- Ultrafiltration
- Nanofiltration
- Reverse osmosis
- Forward osmosis



- Municipal and industrial wastewater
- Seawater desalination
- Separation and purification



- Solute rejection
- Membrane fouling
- Cleaning efficiency
- Surface modification

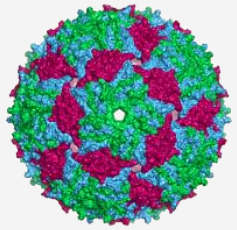


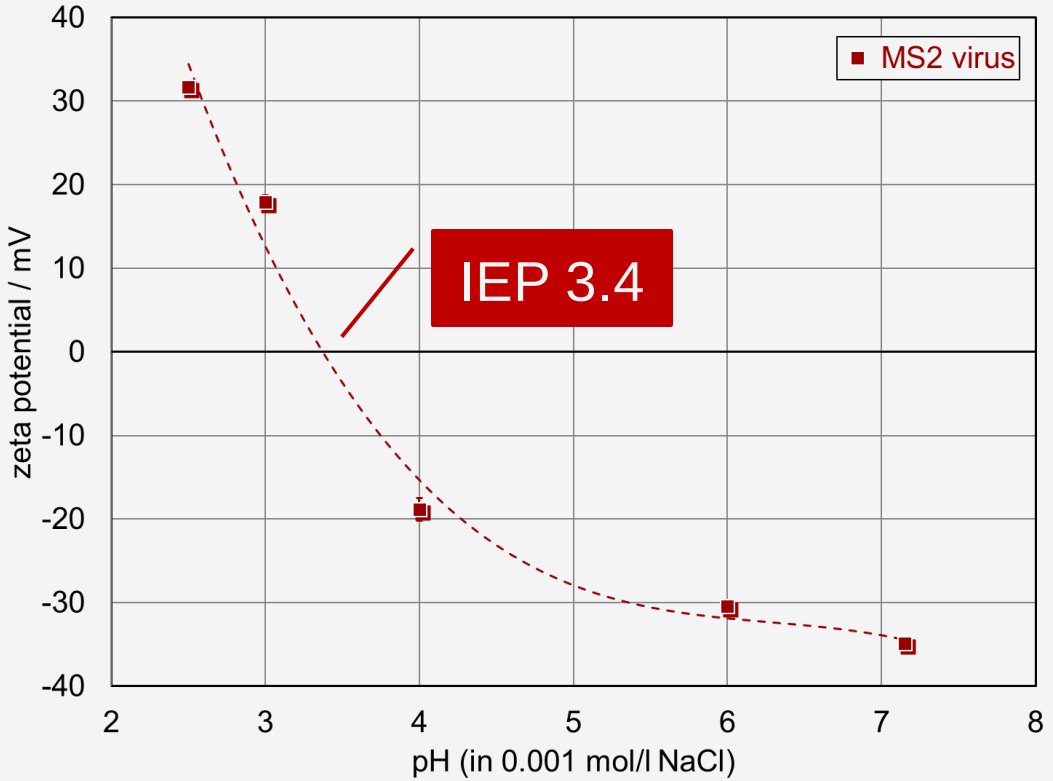
Imbrogno et al., J. Membr. Sci. 549 (2018) 474

Virus retention

MS2 bacteriophage

- Size (34 ± 2 nm), shape (icosahedral) and nucleic acid (ssRNA) similar to pathogenic viruses
- Resistant to chlorine disinfection and UV irradiation





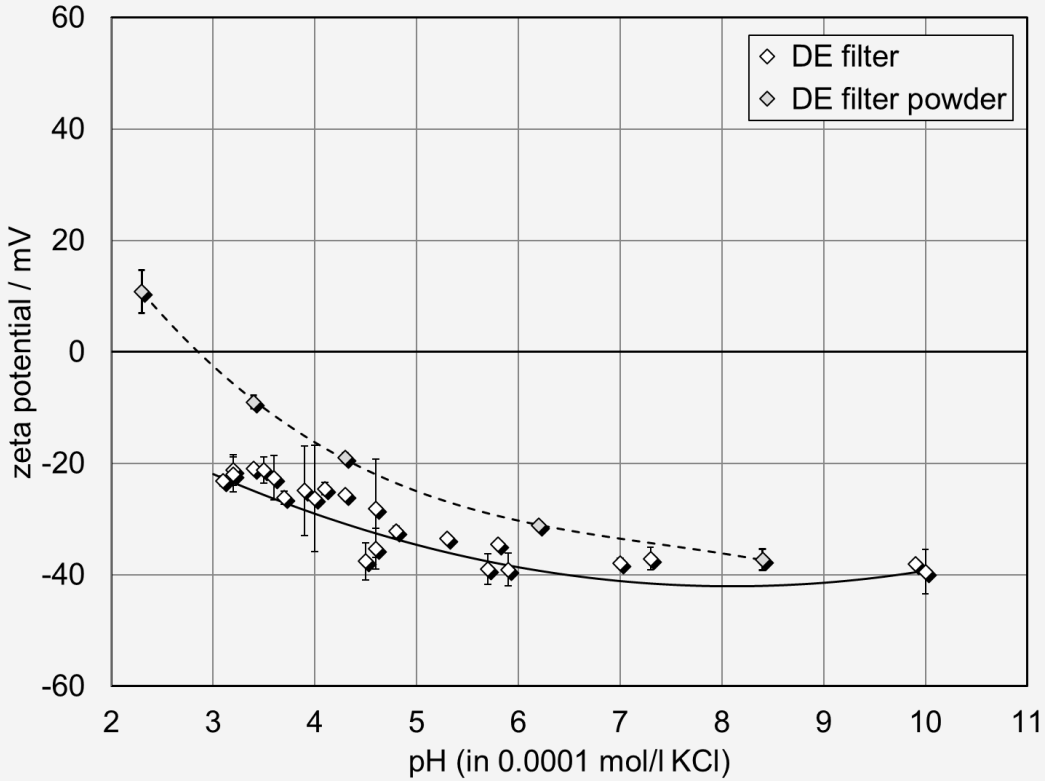
Horovitz et al., Chem. Eng. J. 354 (2018) 995

Virus retention

Diatomaceous earth filter

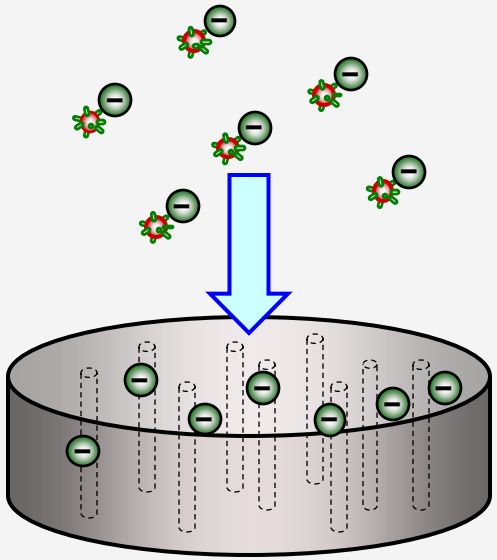
- Pore size 0.2 – 2 µm
- Specific surface area 2.2 m^2/g
- Throughput 20 l/h/bar
- Bacteria retention 99.999 %

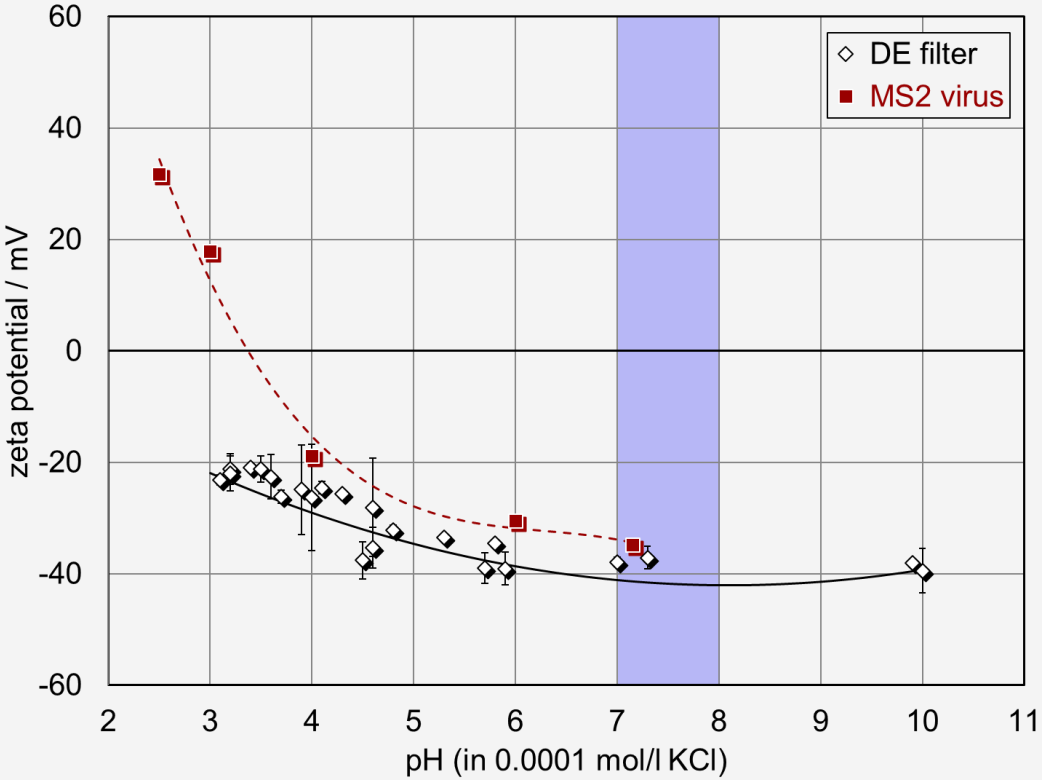
Wegmann et al., Water Res. 42 (2008) 1726



Virus retention

Diatomaceous earth filter

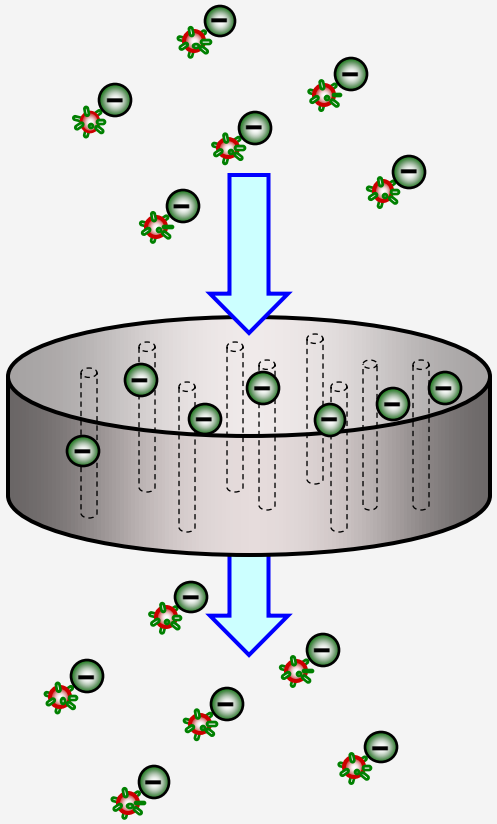


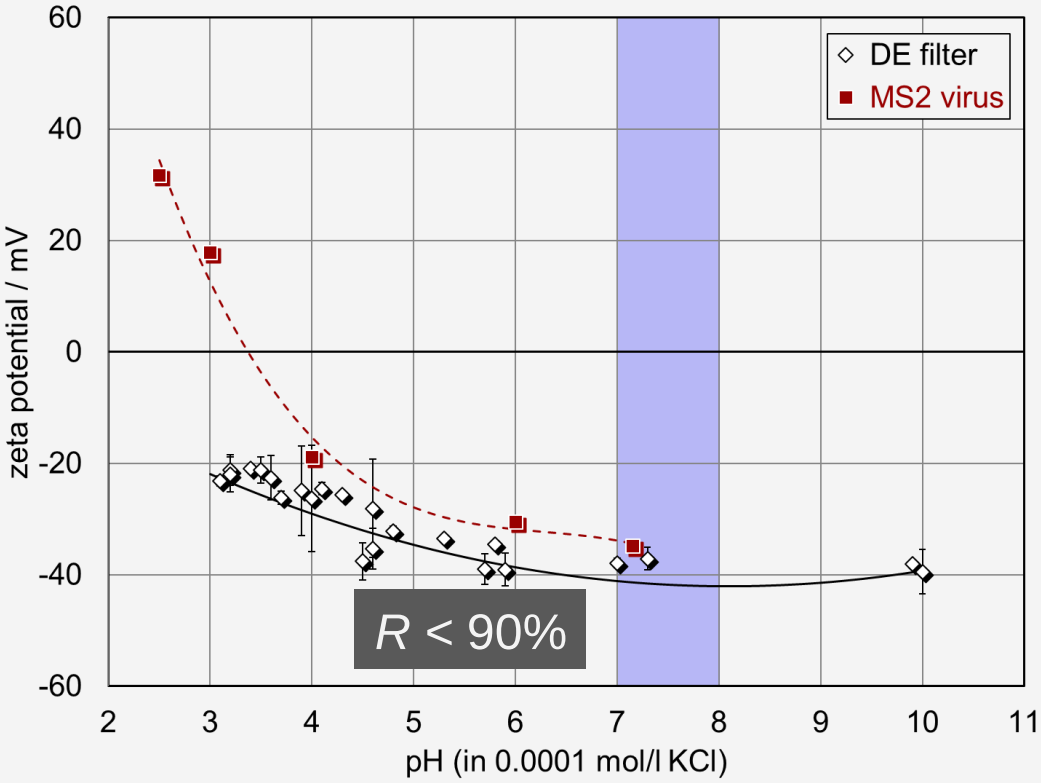


Wegmann et al., Water Res. 42 (2008) 1726

Virus retention

Diatomaceous earth filter

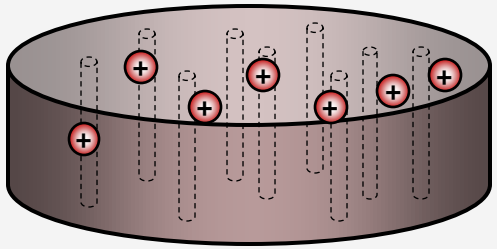


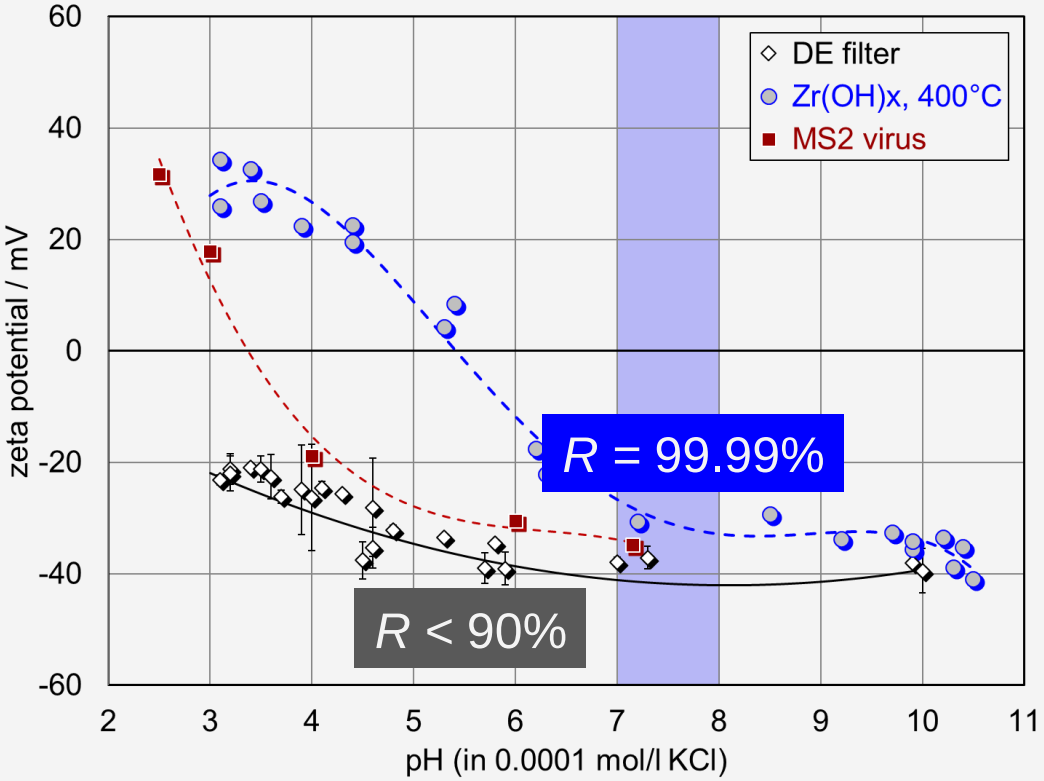


Wegmann et al., Water Res. 42 (2008) 1726

Virus retention

Modified filter





Wegmann et al., Water Res. 42 (2008) 1726

Virus retention

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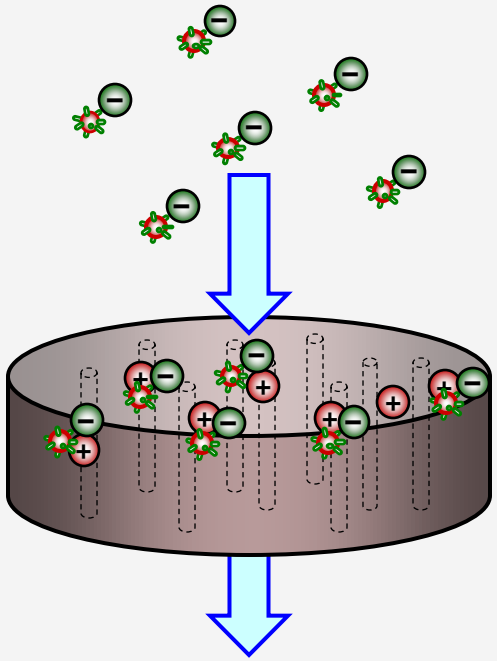

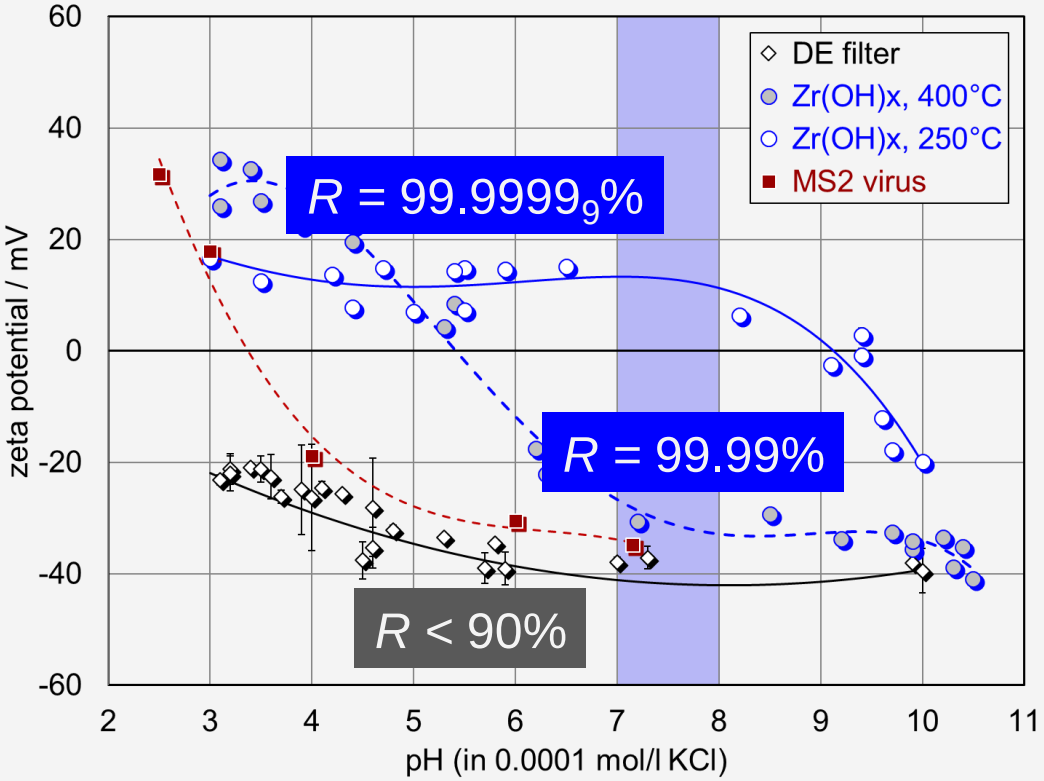

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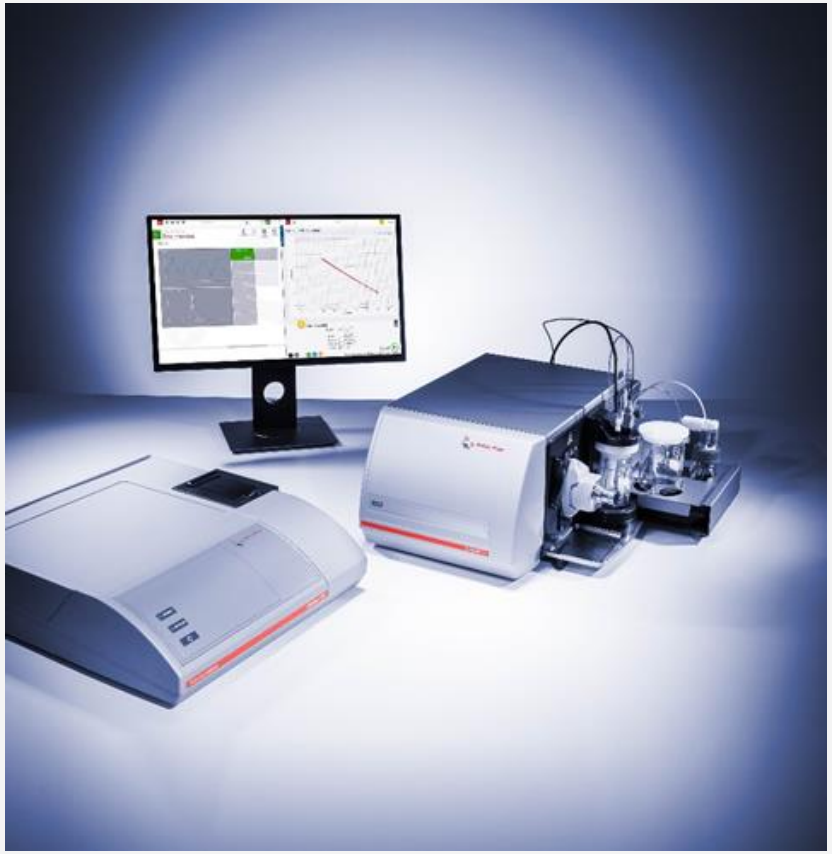
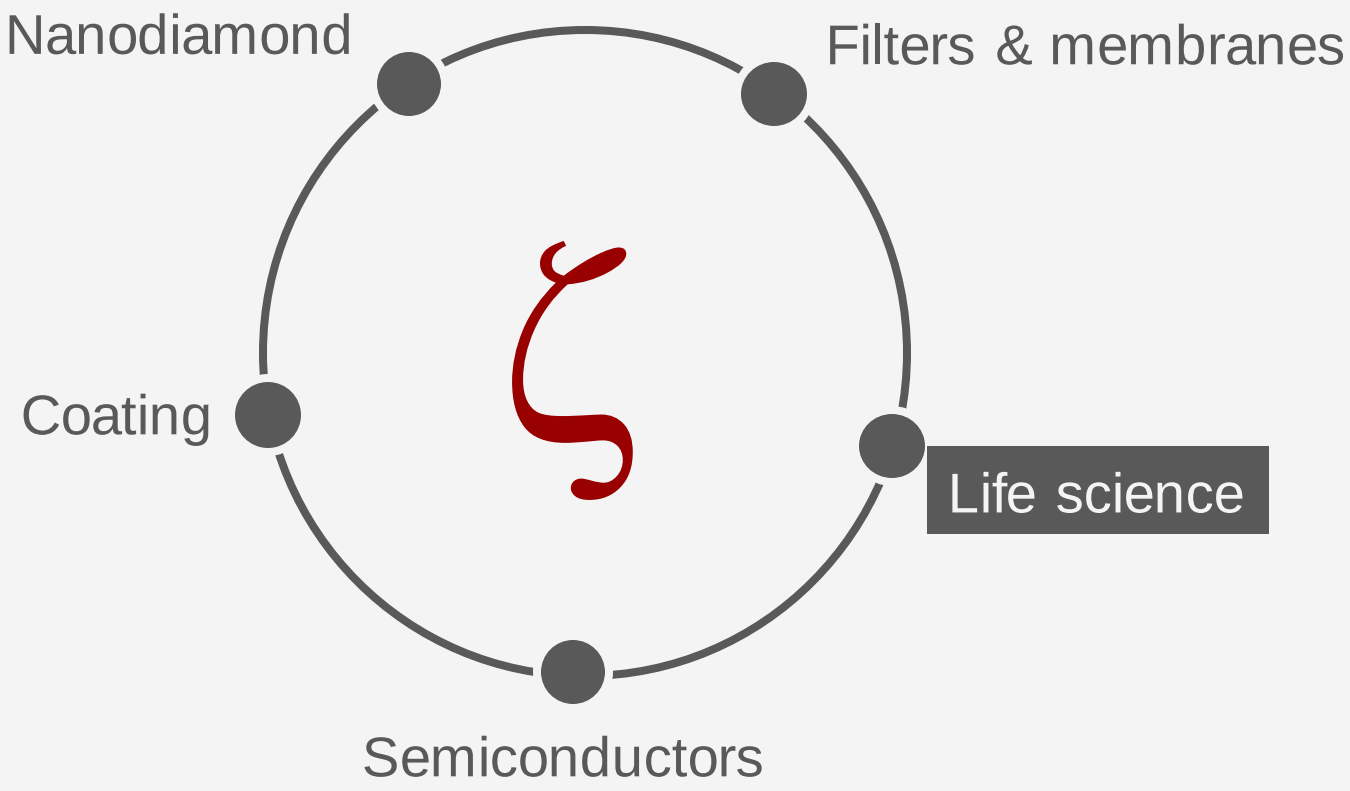
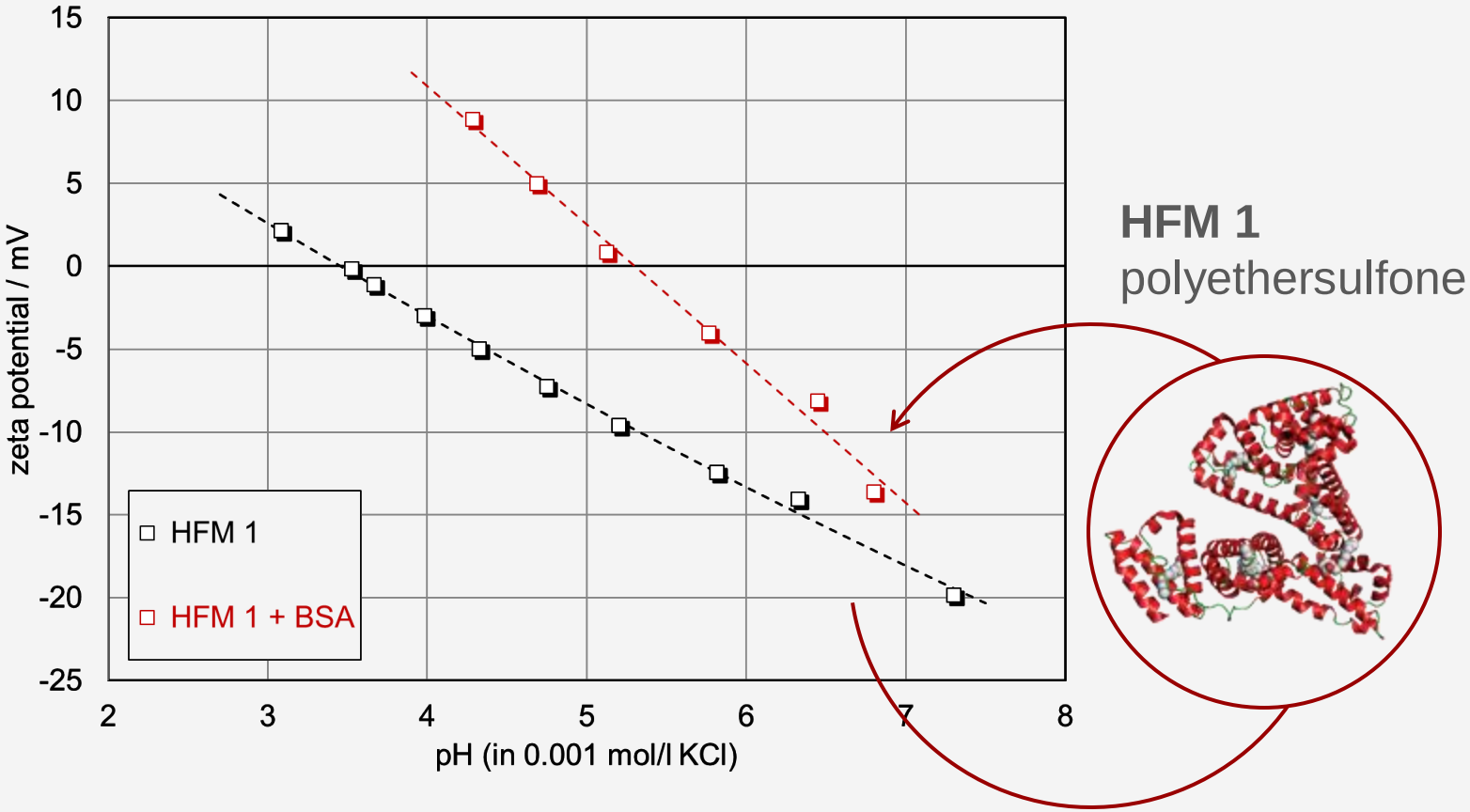
Applications



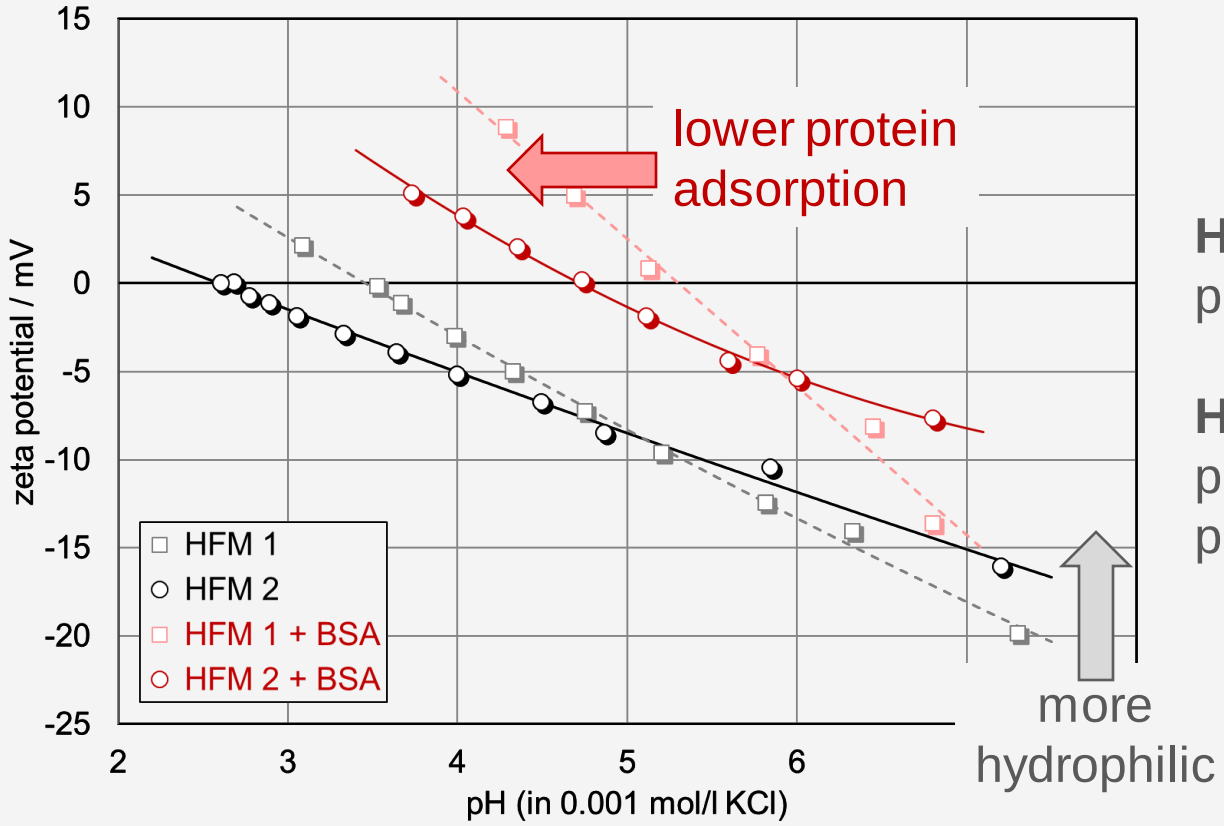


Dialysis membrane



HFM 1
polyethersulfone

Dialysis membrane



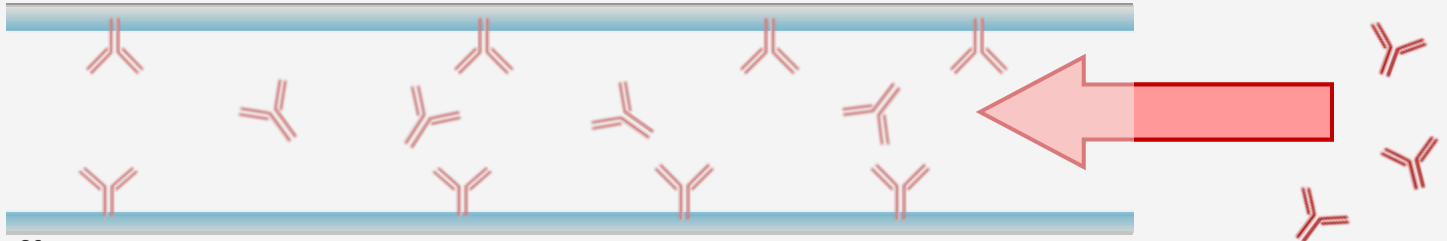
HFM 1
polyethersulfone

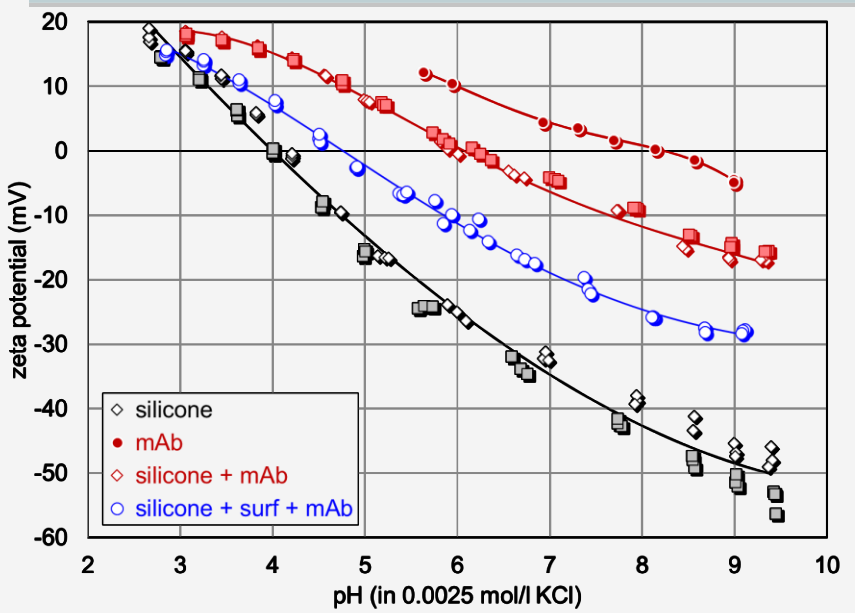
HFM 2
polyethersulfone + polyvinylpyrrolidone

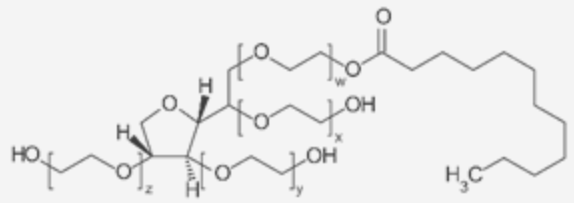
Life science

Medical devices, biomaterials

- Medical tubes
- Pre-filled syringes
- Cardiovascular implants
- Dental implants
- Contact lenses



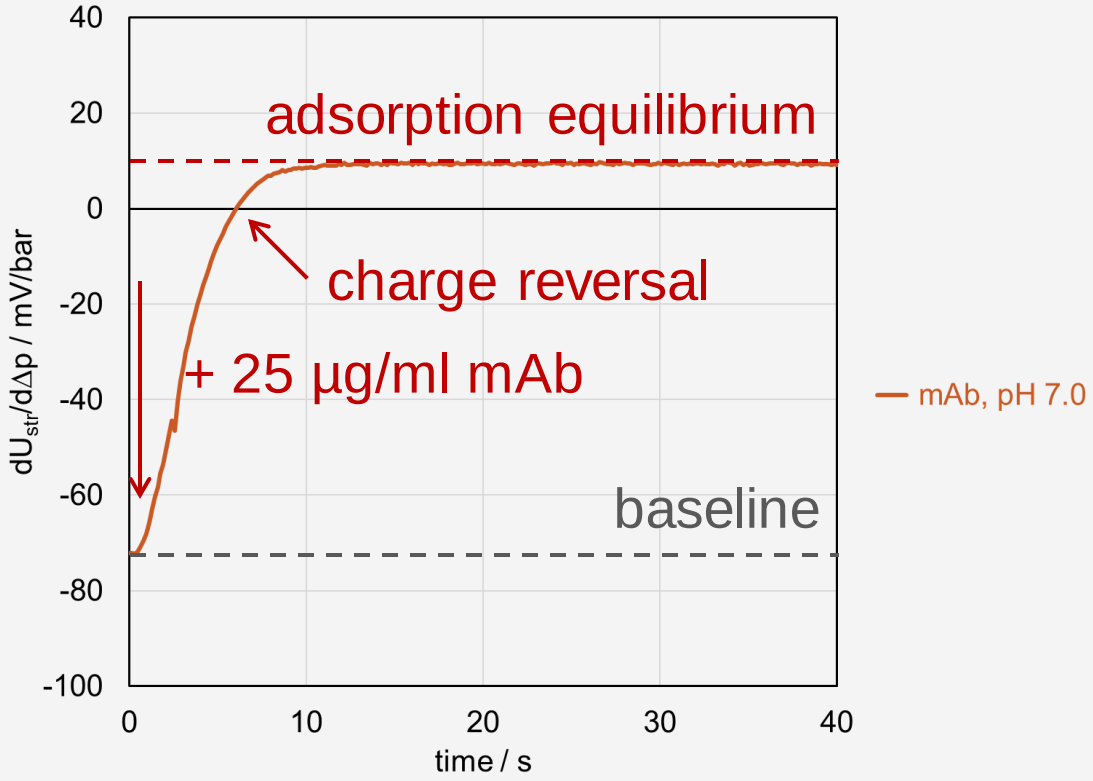




Deiringer et al., J. Pharm. Sci. 111 (2022) P1577

Dynamic streaming potential

Adsorption kinetics



Dynamic streaming potential

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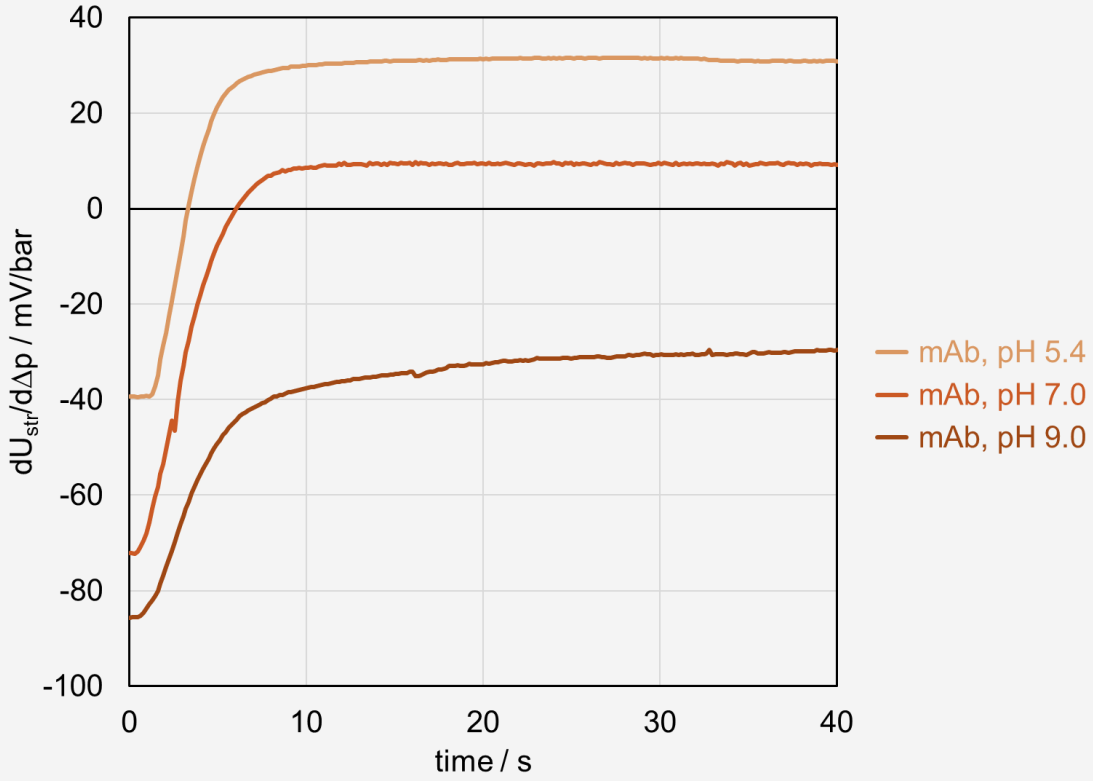
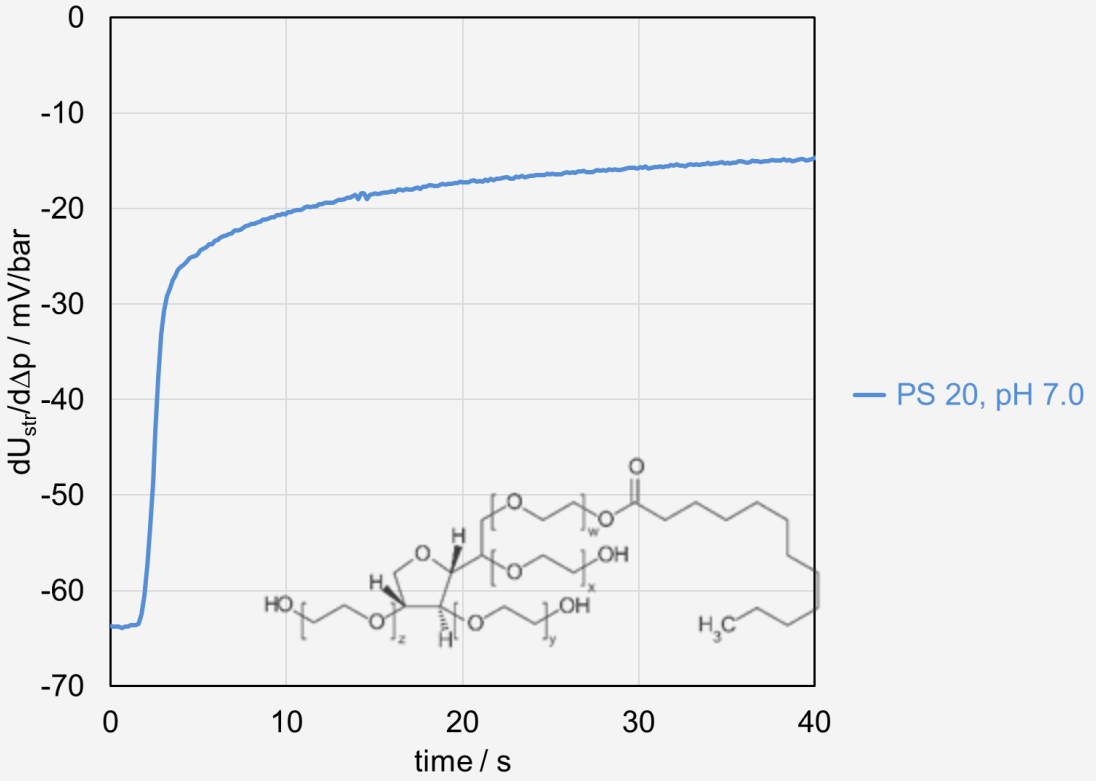
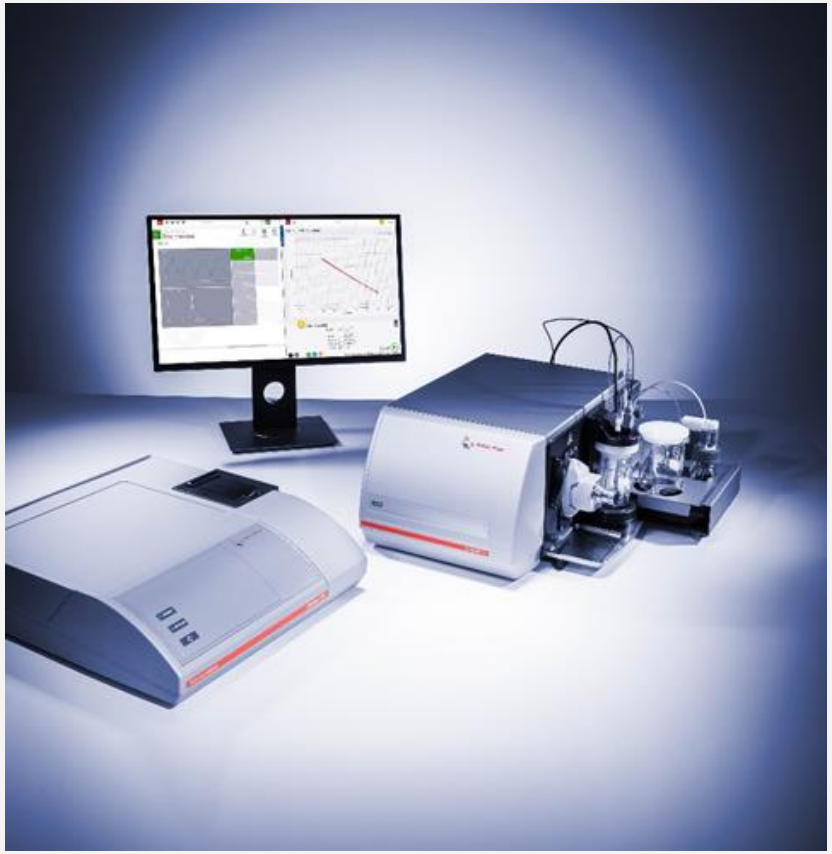
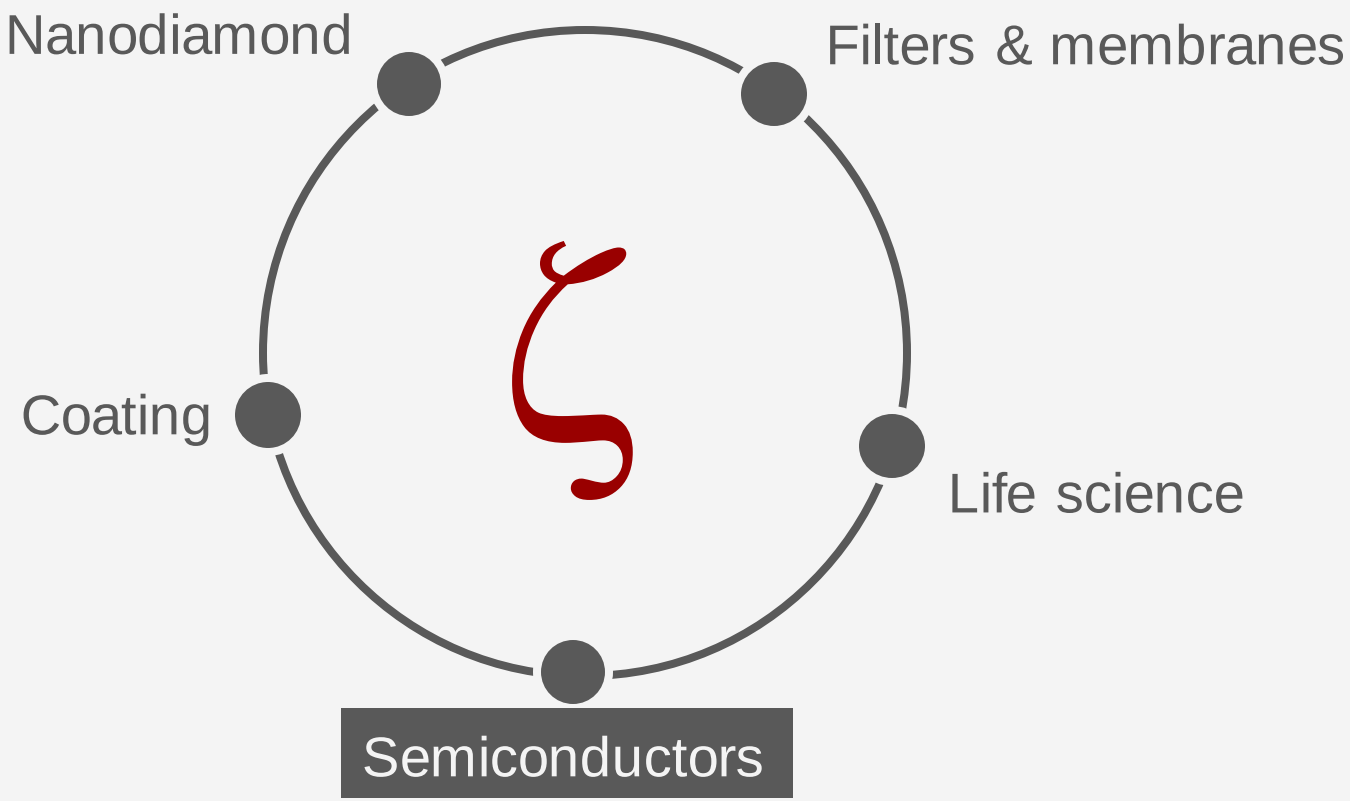




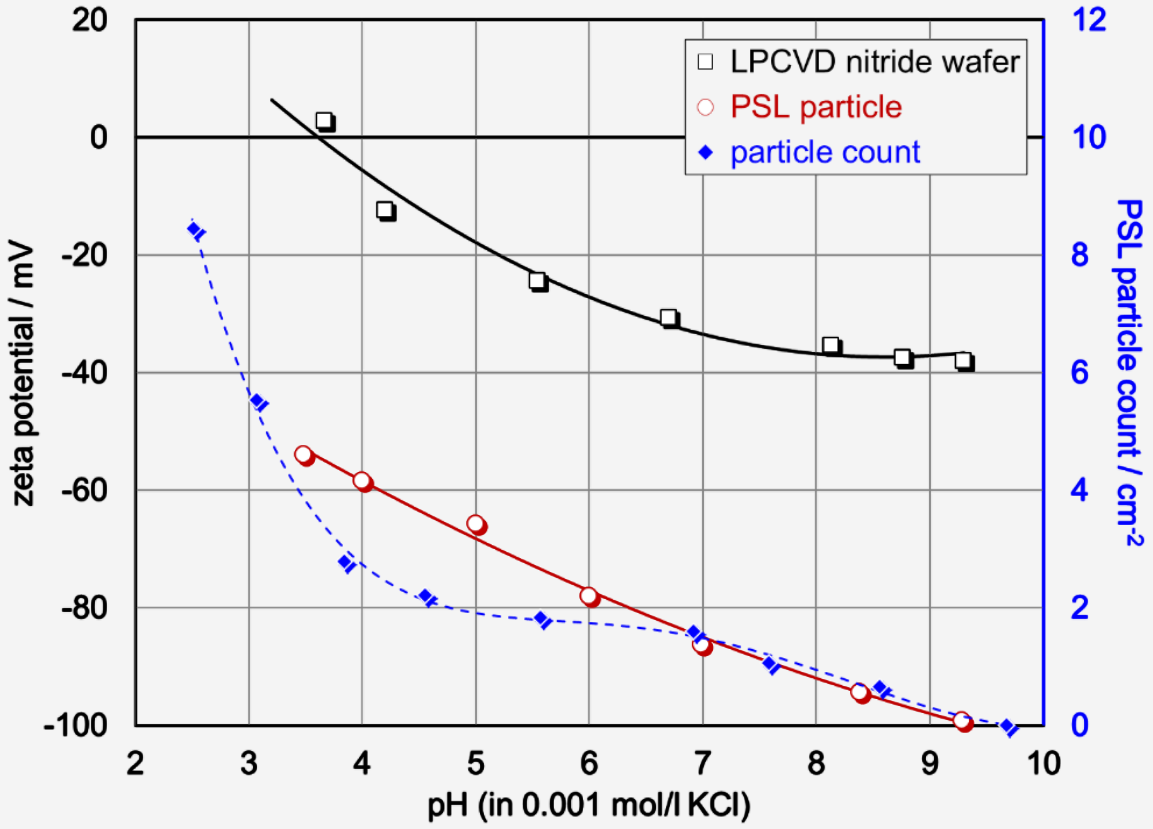
Applications





Wafer-particle interaction

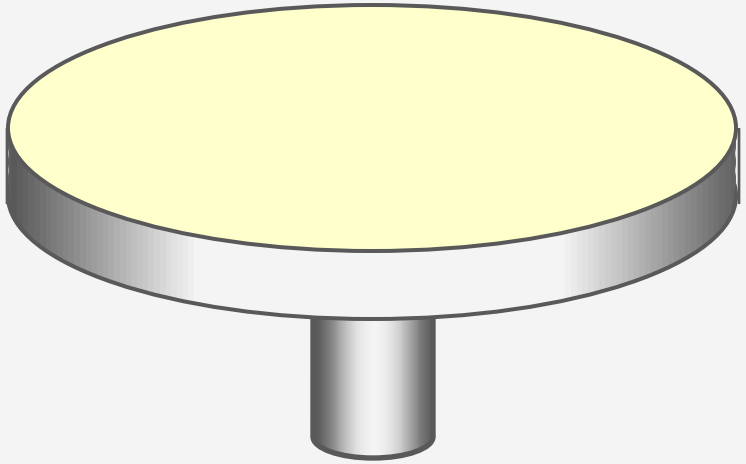
- Electrostatic force determines wafer-particle interaction in an aqueous environment
- Important for CMP process

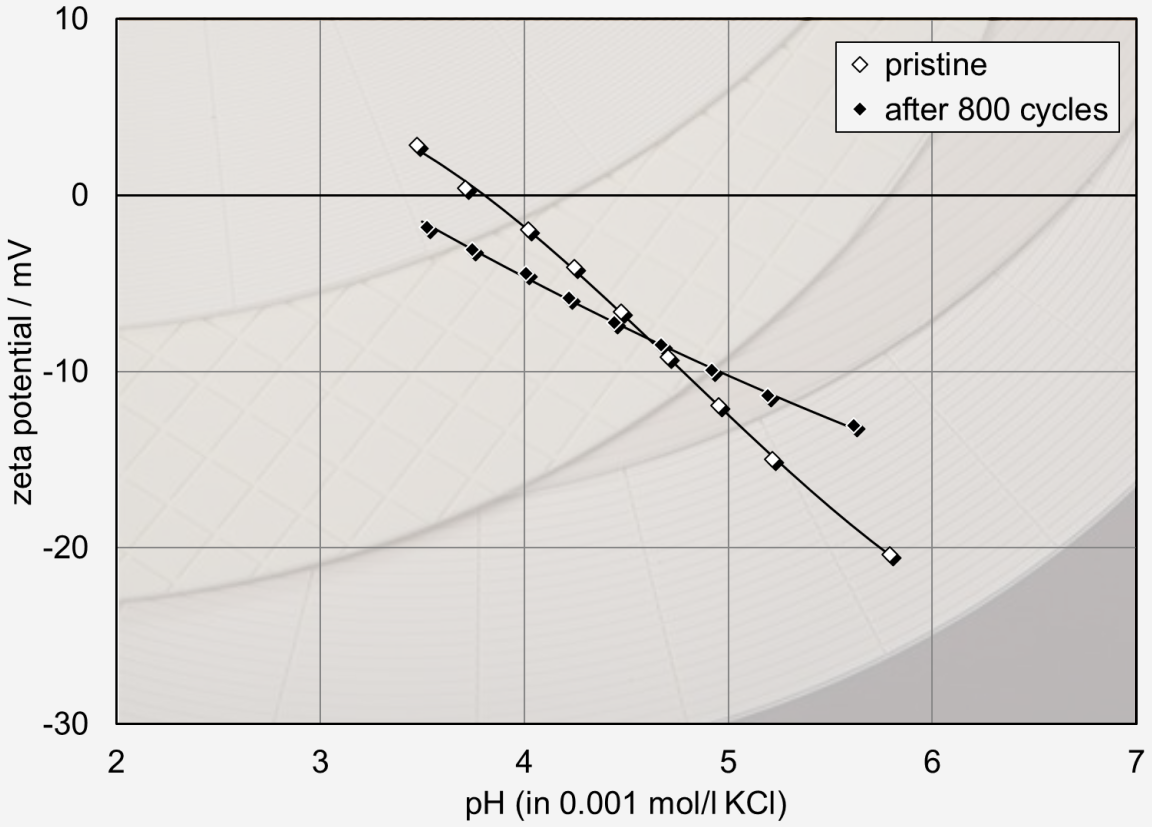


Jan et al., J. Electrochem. Sci. 141 (1994) 2465

Wafer polishing process

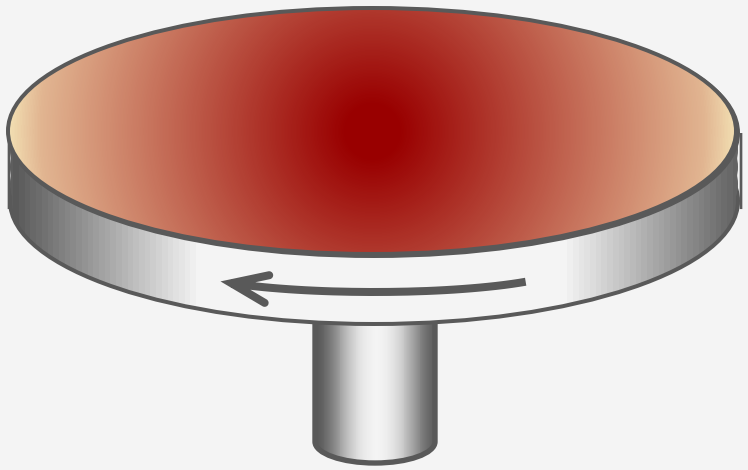
Polishing pad

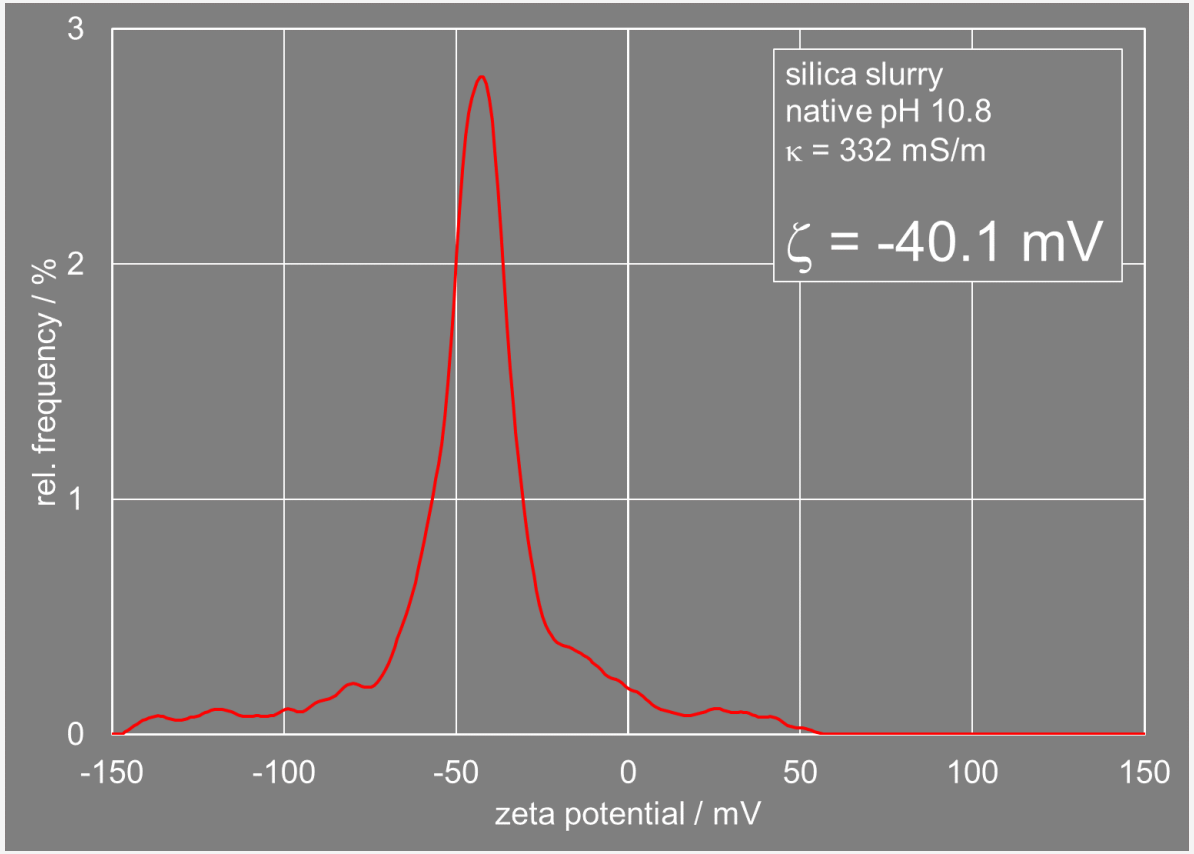




Wafer polishing process

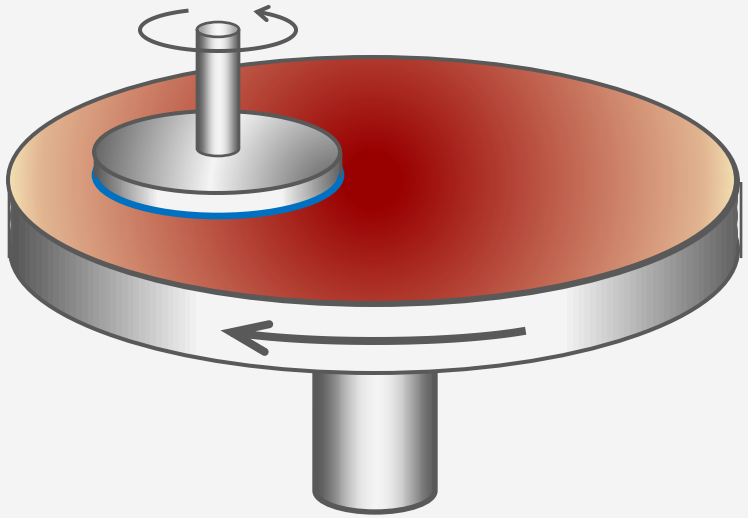
CMP slurry

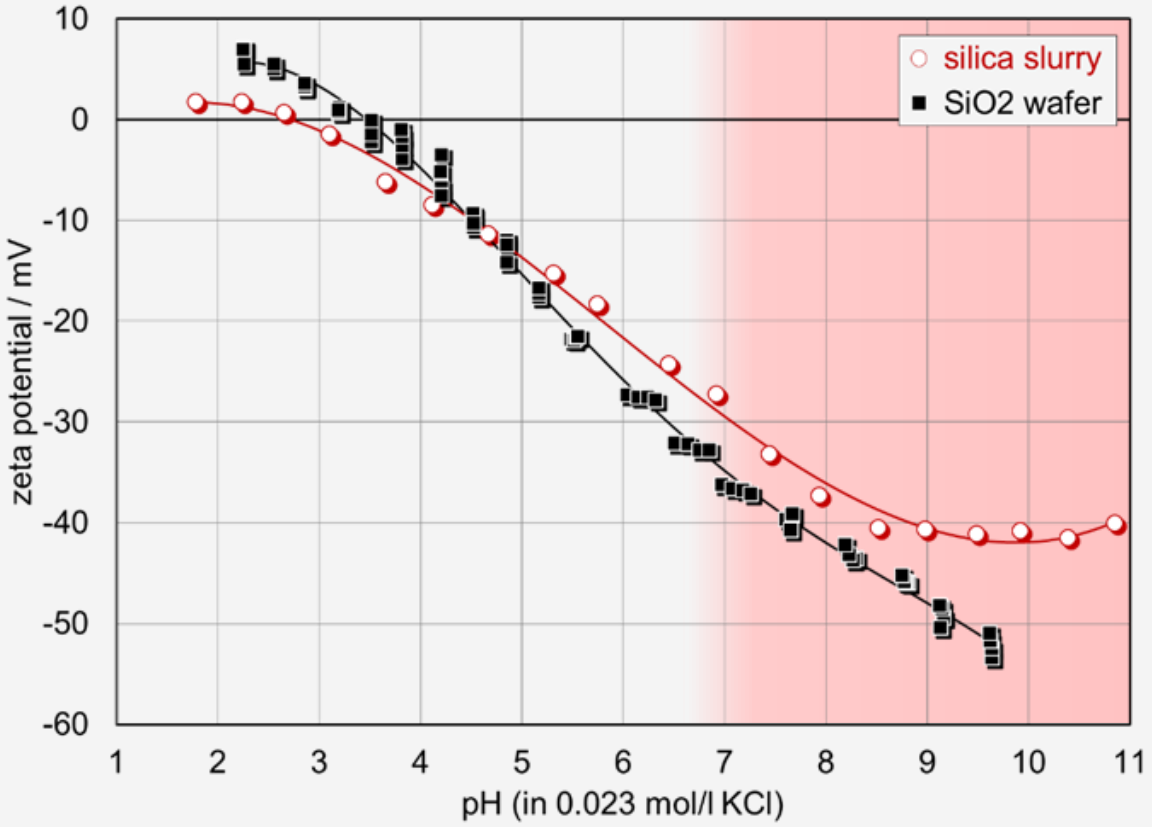




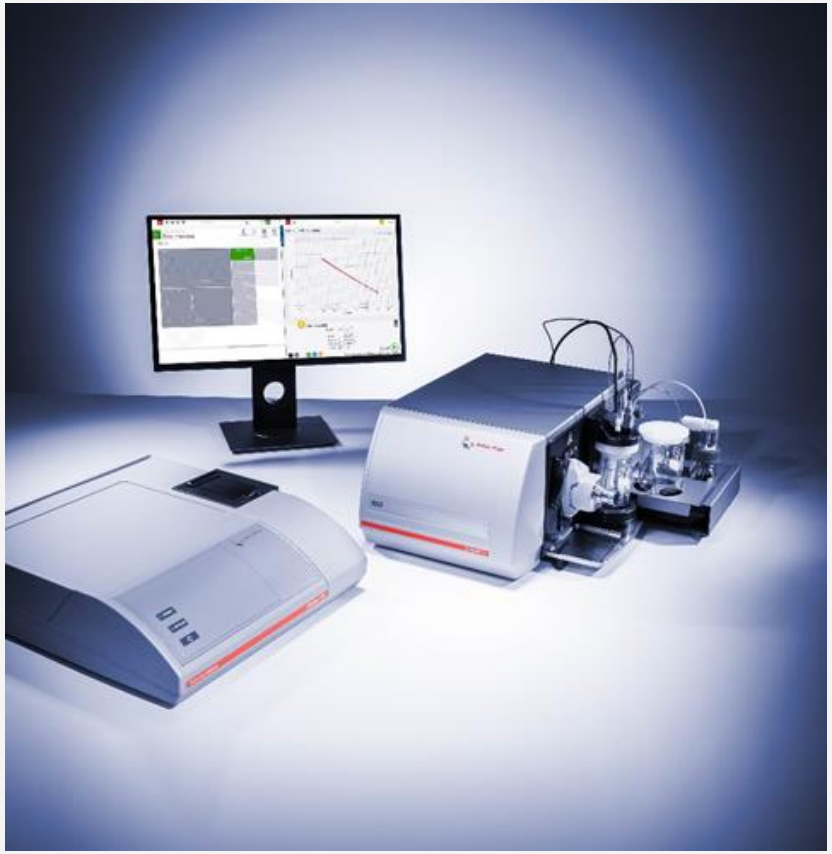
Wafer polishing process

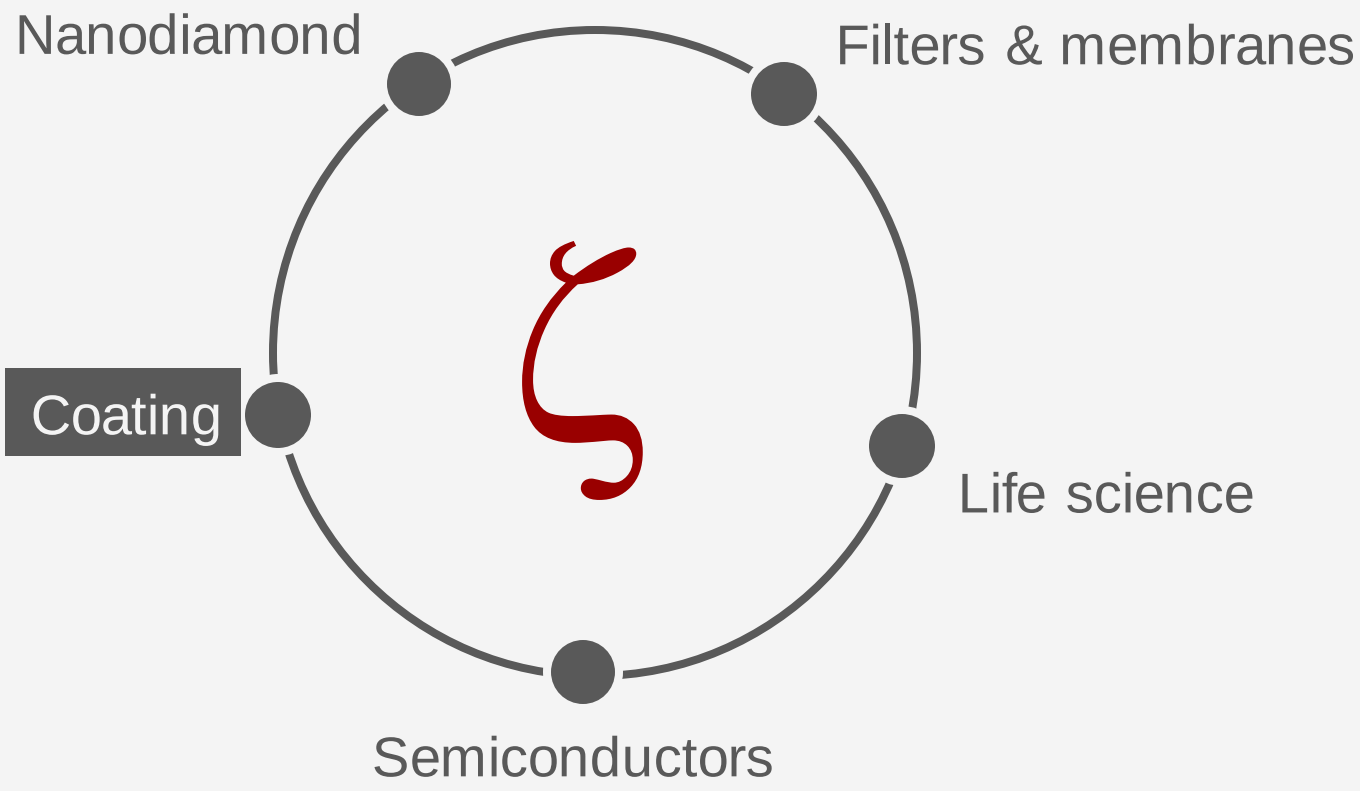
Wafer surface





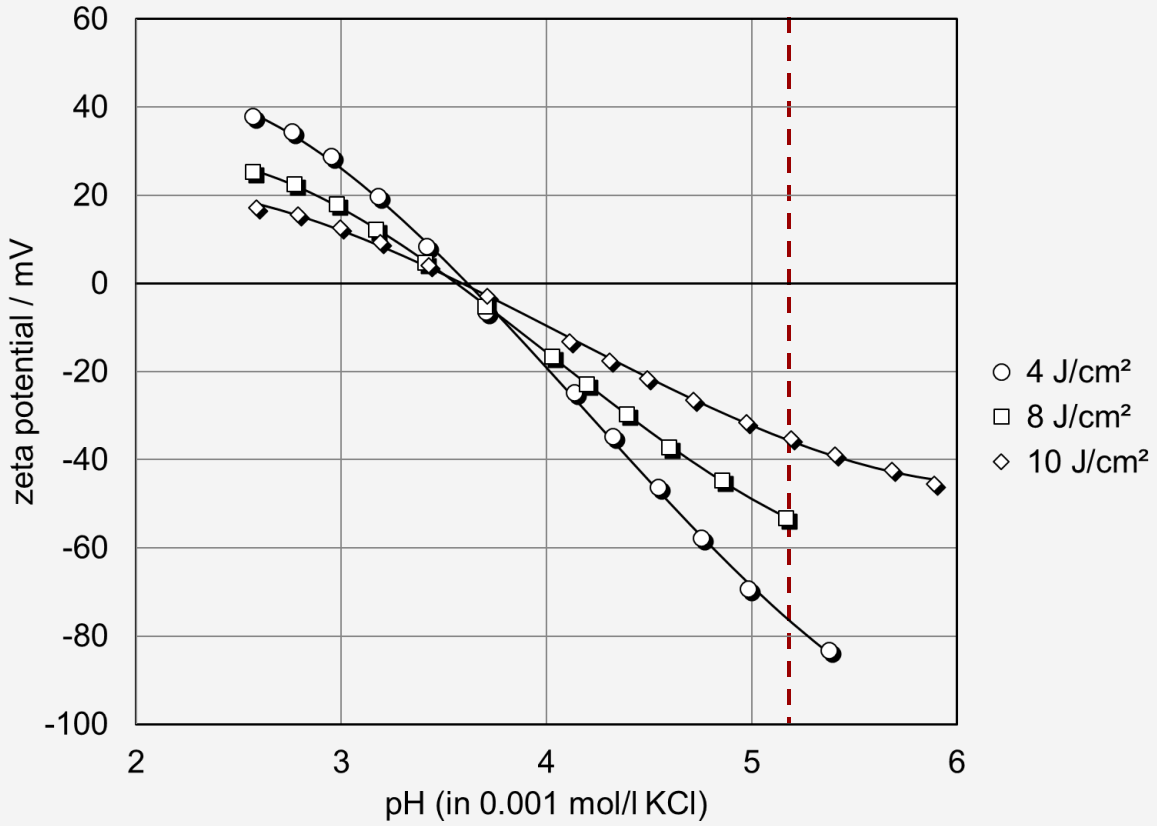
Applications

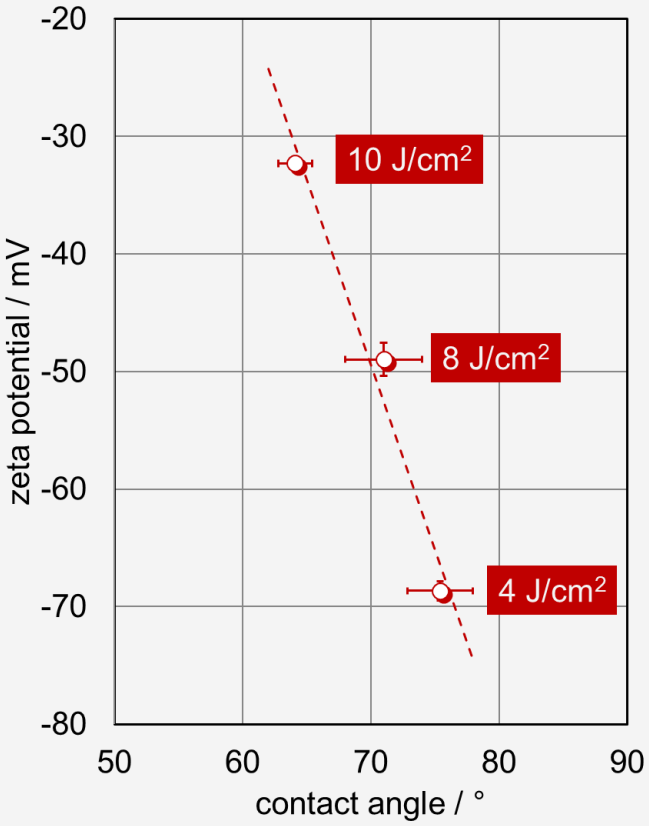




Thin-film coating

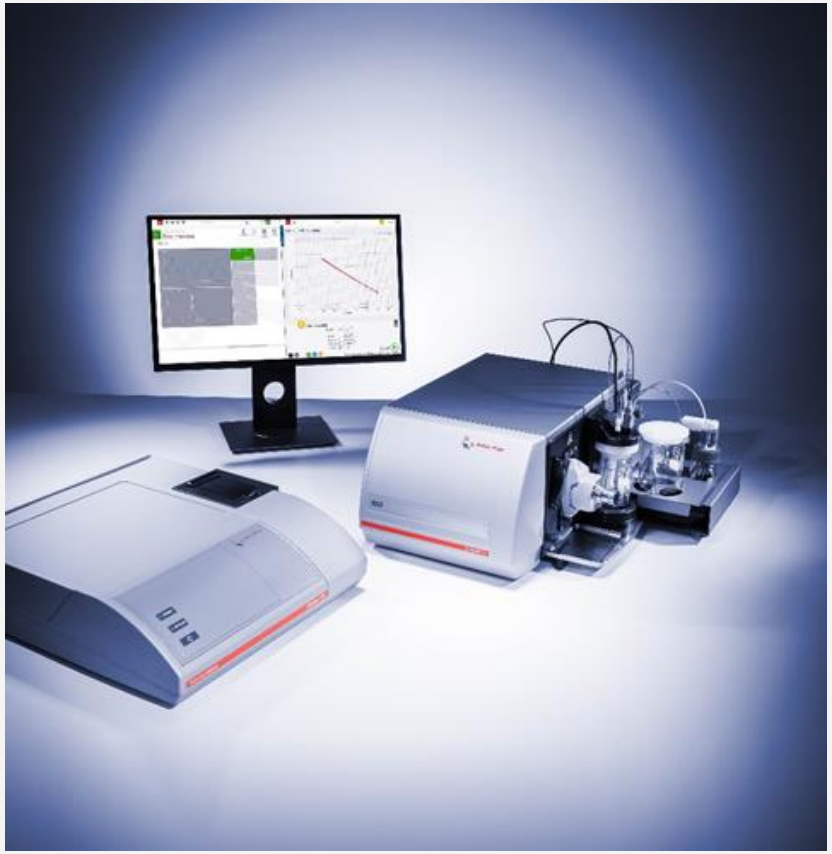
DLC diamond-like Carbon

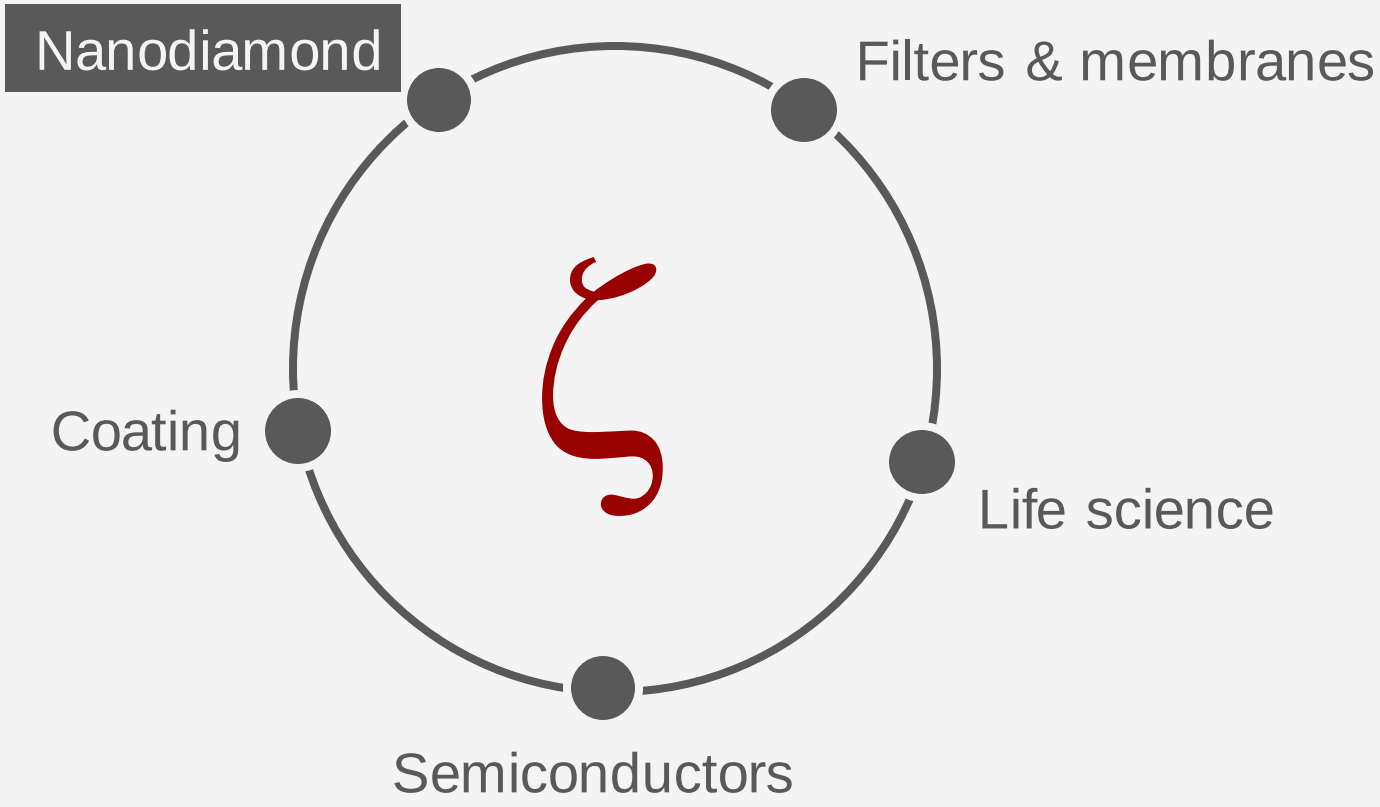




Jelinek et al., Mat. Sci. Eng. B 169 (2010) 89; Jelinek et al., Appl. Phys. A 101 (2010) 579

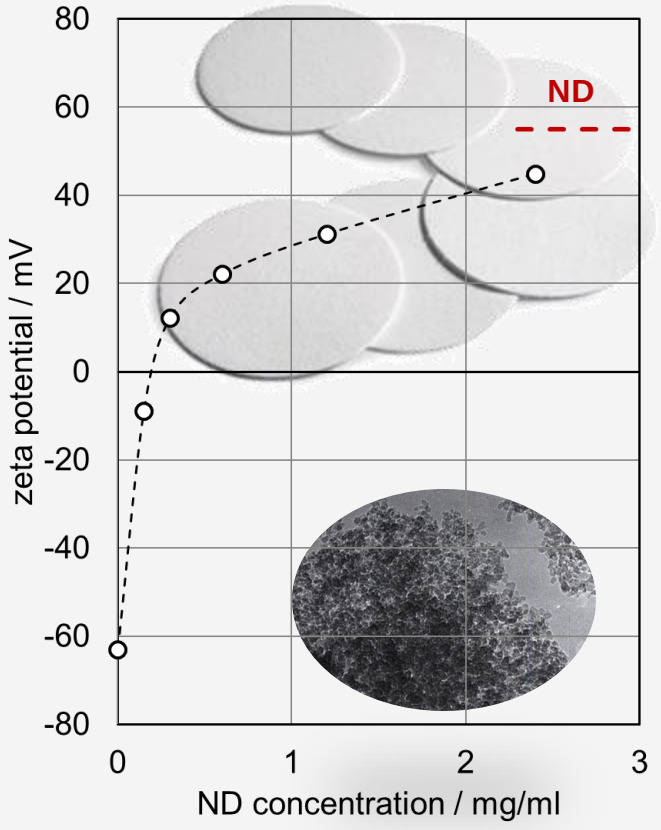
Applications

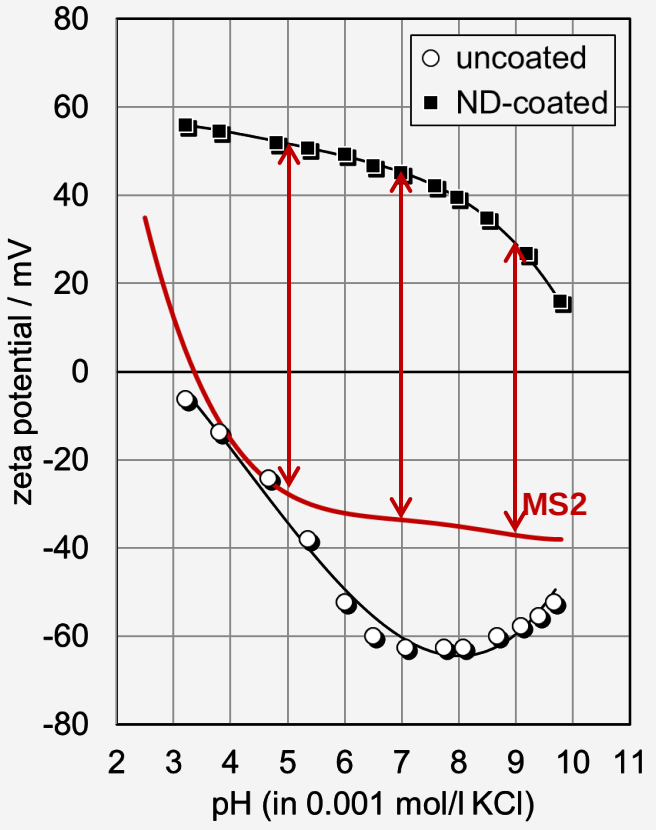


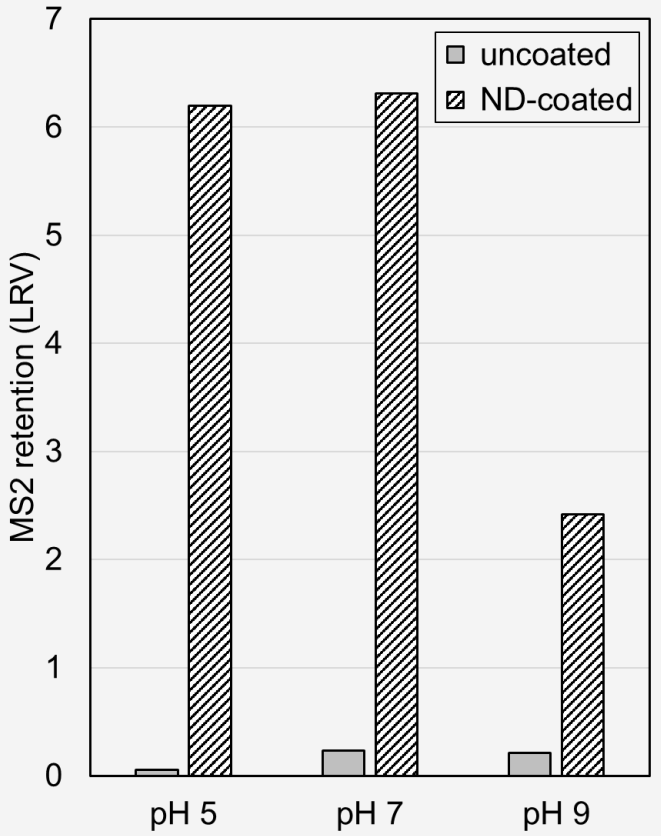


Nanodiamond meets quartz filter

ND-coated quartz filter for virus retention



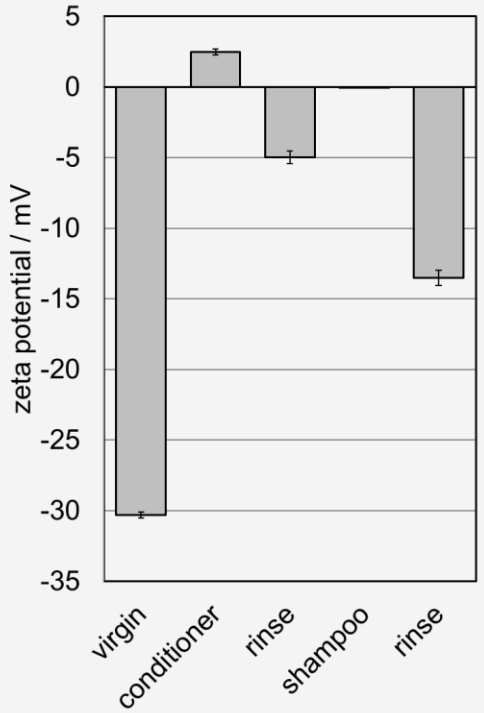




Bland et al., ACS Appl. Nano Mater. 4 (2021) 3252

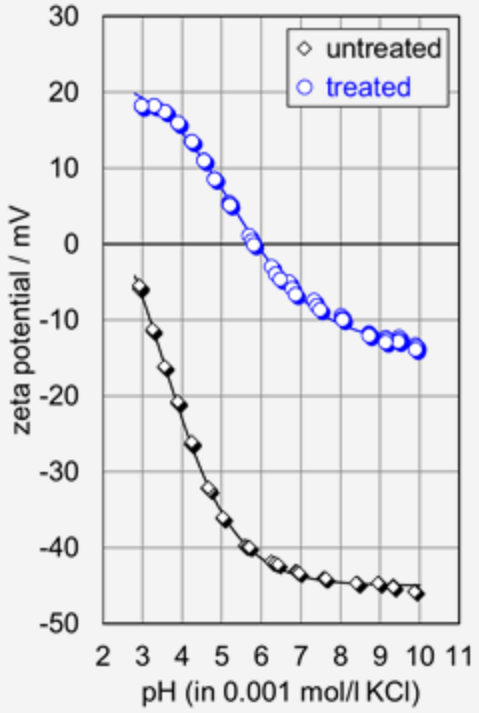
Summary

single



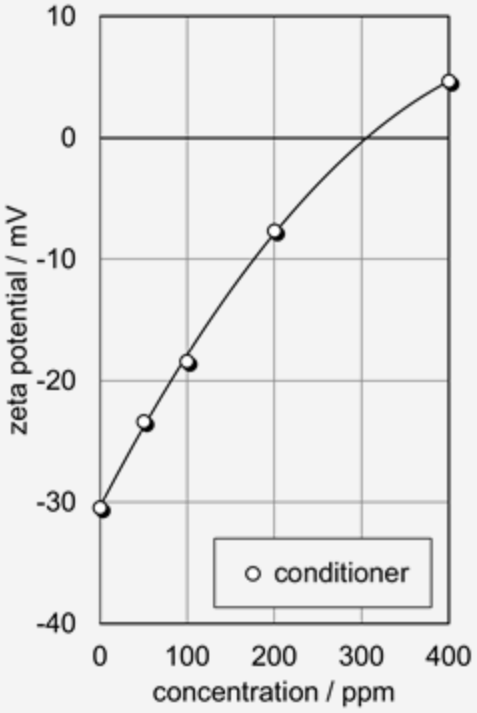
human hair

pH



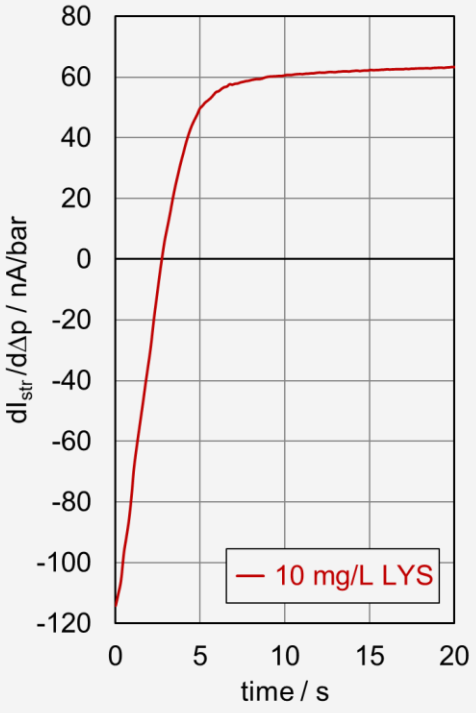
glass fiber

concentration



human hair

kinetics



CoCr alloy

Thank you for your attention!

Some Quick Housekeeping...

COVALENT METROLOGY

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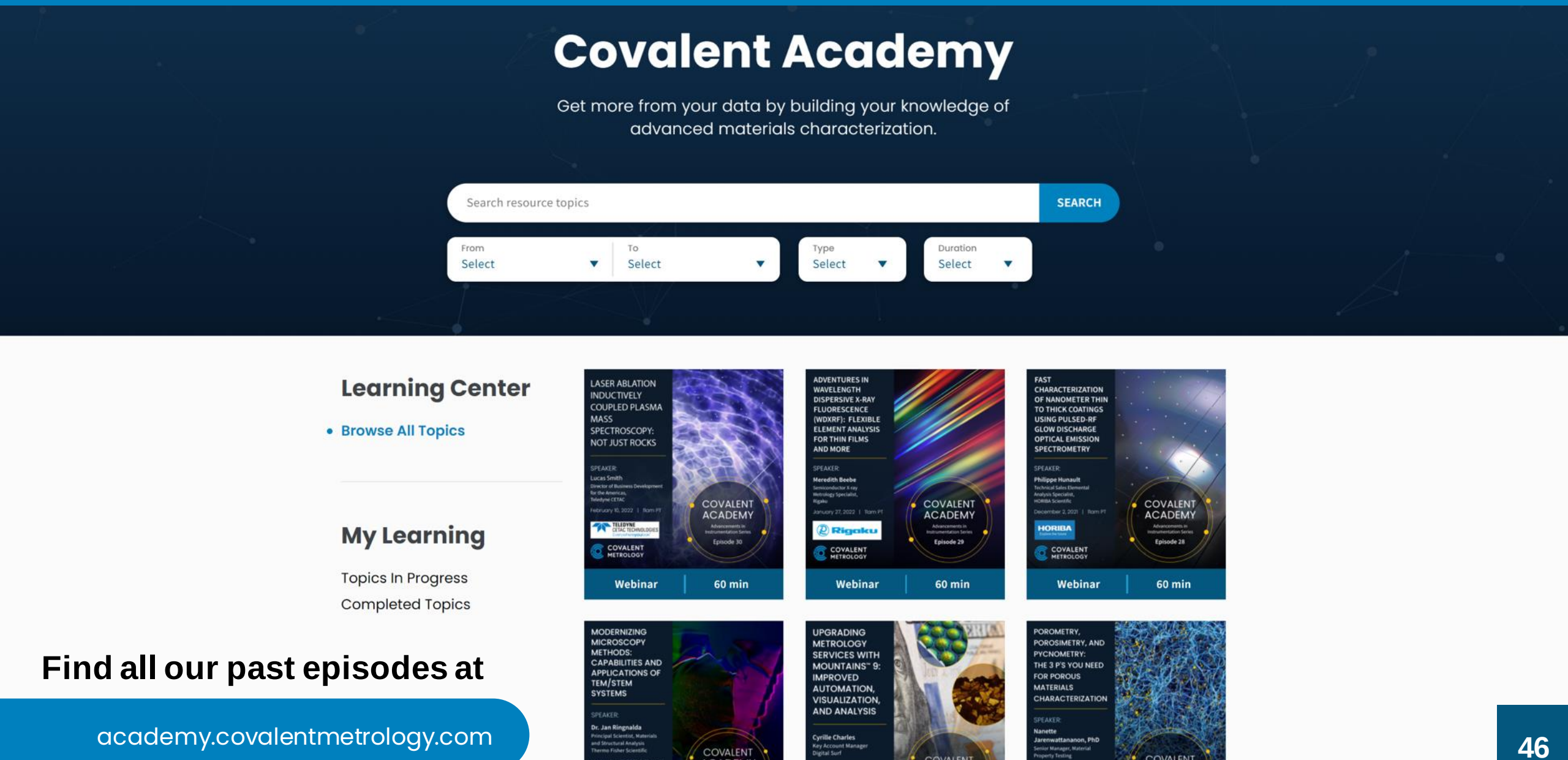

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Q & A Session

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Thank You