The Zeta Potential of Conductive Material Surfaces: Challenges and Solutions

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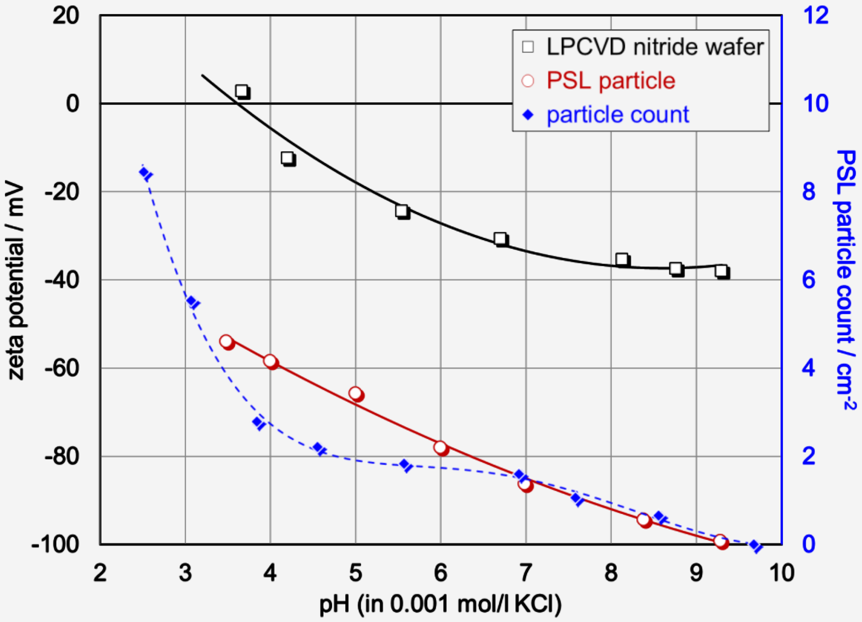
Contents

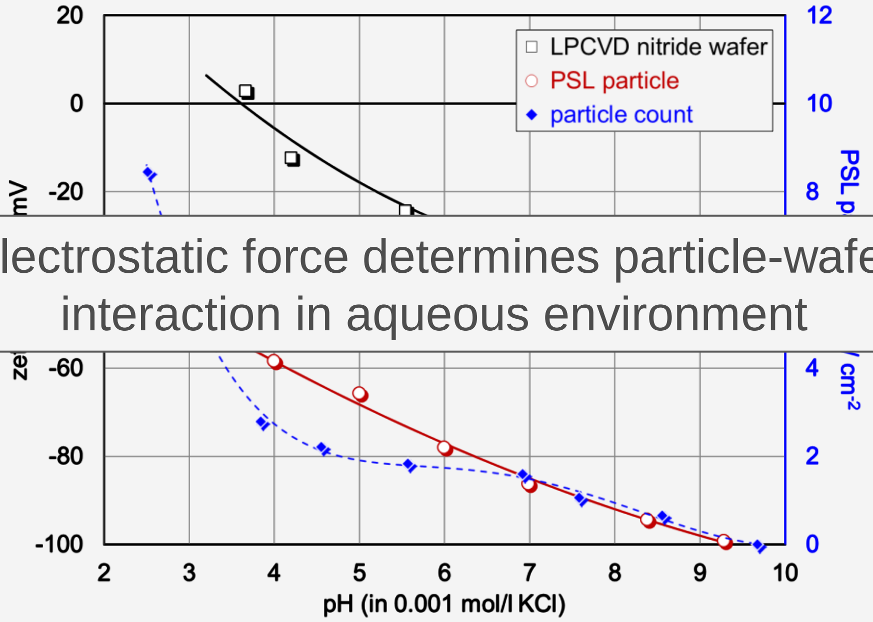
- Why zeta potential?
- Electrophoretic mobility
- Streaming potential
- Conductive coating

Why zeta potential?



D. Jan & S. Raghavan, J. Electrochem. Soc. 141 (1994) 2465

Why zeta potential?



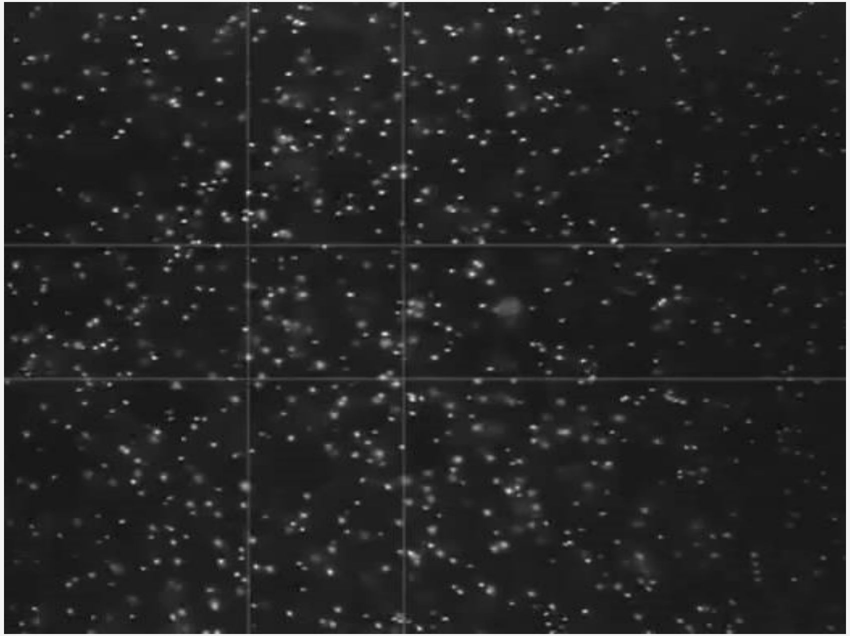
Electrostatic force determines particle-wafer interaction in aqueous environment

Electrophoretic mobility

- Electric field induces a collective motion of particles
- Highly charged particles move faster than less charged particles

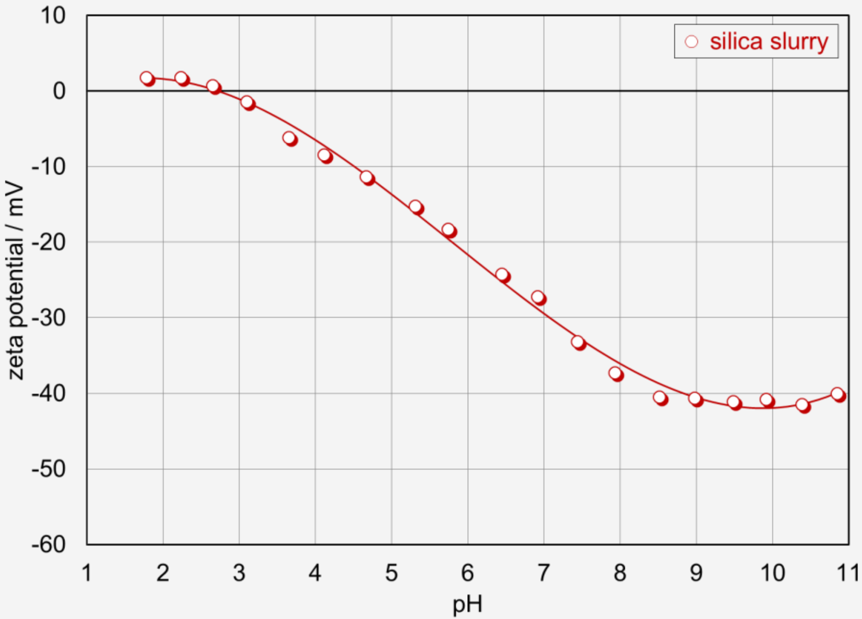
$$\zeta = \frac{v}{E} \times \frac{\eta}{\varepsilon_r \times \varepsilon_0}$$

μ_e



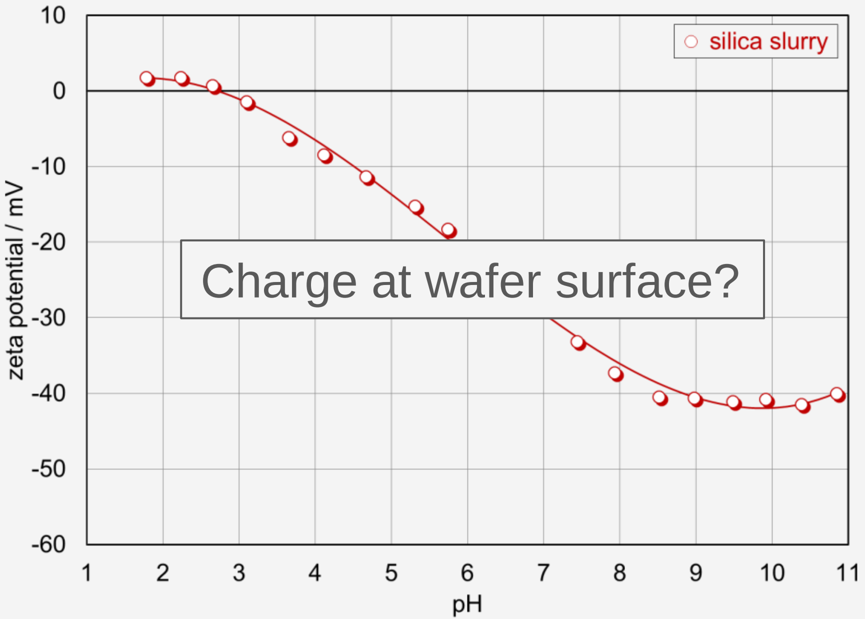
CMP slurry

Zeta potential of slurry particles



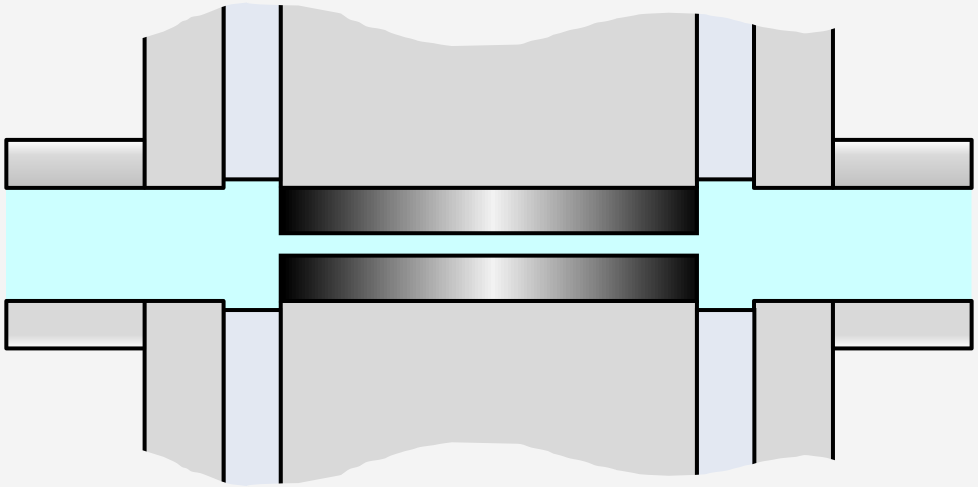
CMP slurry

Zeta potential of slurry particles



Principle of surface zeta potential

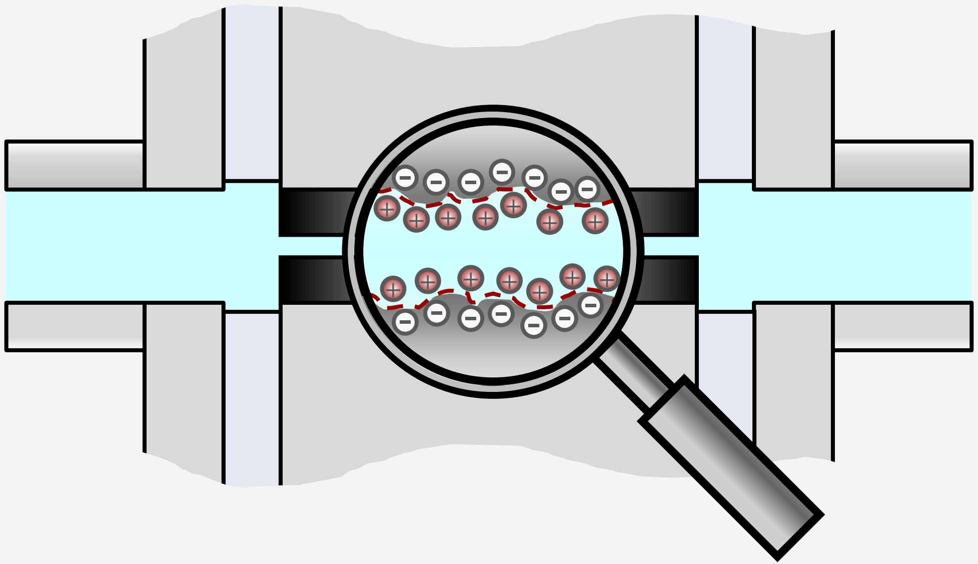
Streaming potential | Tangential mode



– Solid sample arranged to create a capillary channel

Principle of surface zeta potential

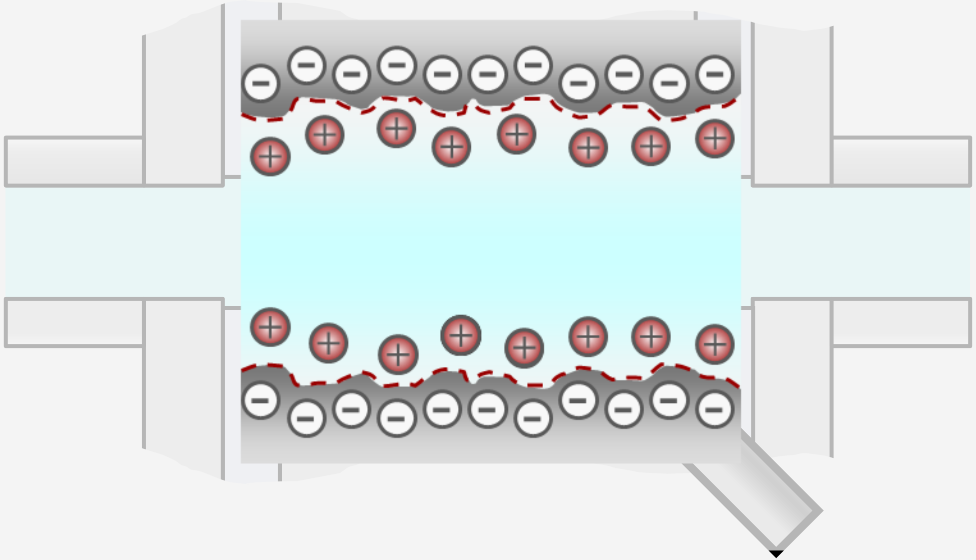
Streaming potential | Tangential mode



– Solid sample arranged to create a capillary channel

Principle of surface zeta potential

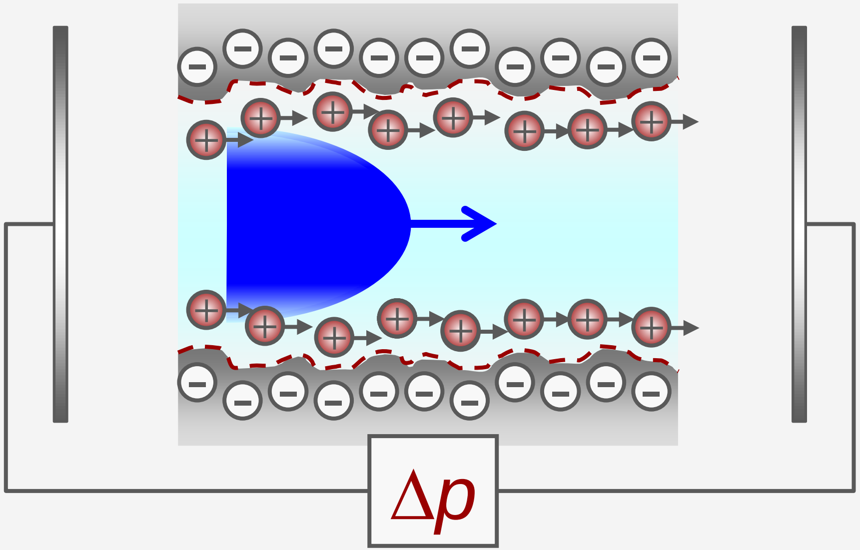
Streaming potential | Tangential mode



– Solid sample arranged to create a capillary channel

Principle of surface zeta potential

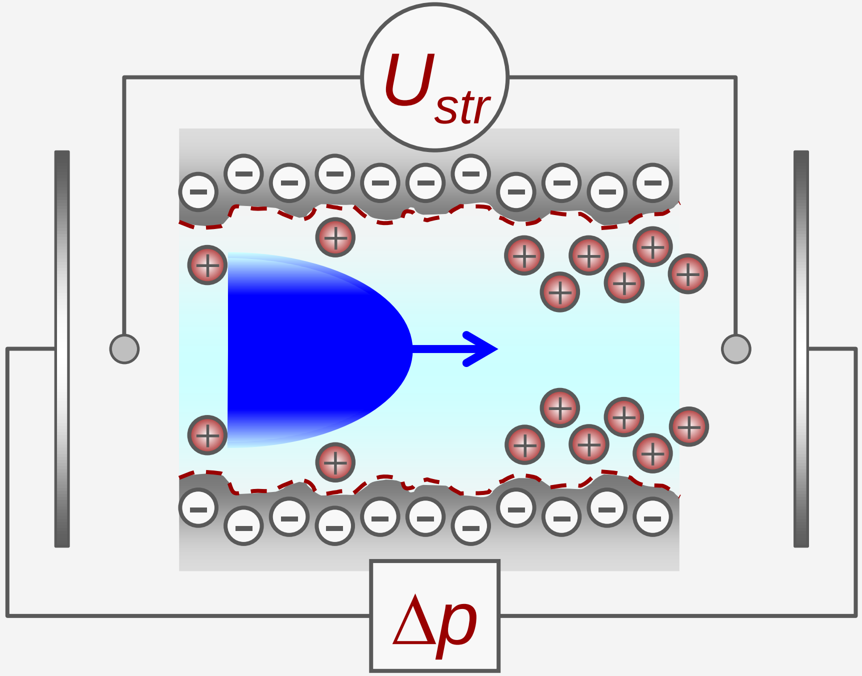
Streaming potential



- Solid sample arranged to create a capillary channel
- Pressure gradient provokes liquid flow
- Charge distribution at solid | liquid interface distorted

Principle of surface zeta potential

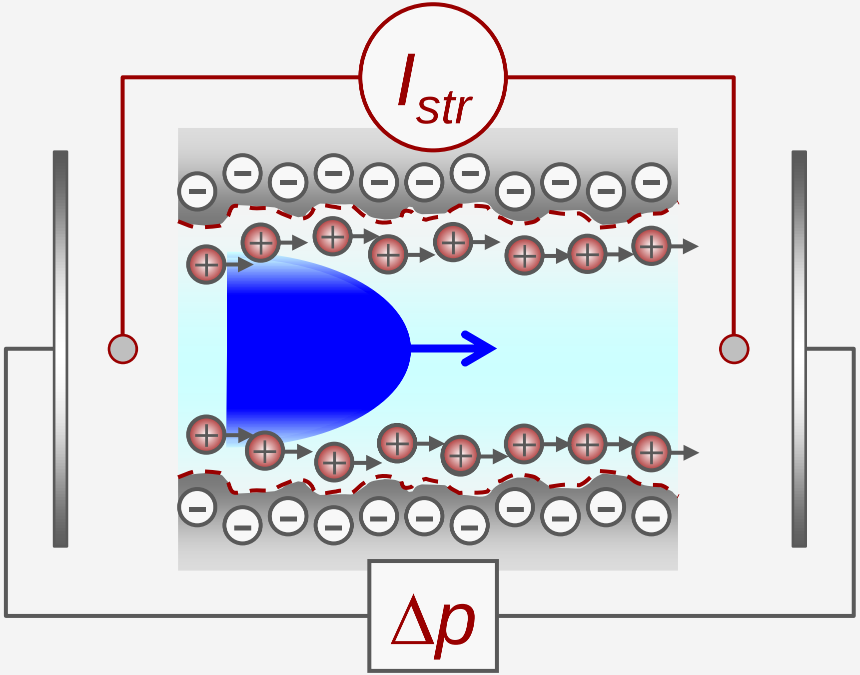
Streaming potential



- Solid sample arranged to create a capillary channel
- Pressure gradient provokes liquid flow
- Charge distribution at solid | liquid interface distorted
- Streaming potential (d.c. voltage) generated along the capillary

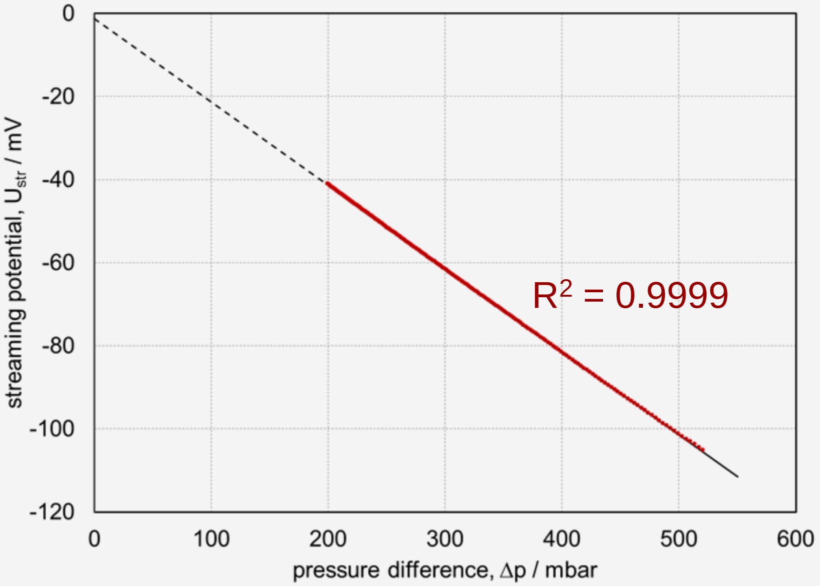
Principle of surface zeta potential

Streaming current



- Solid sample arranged to create a capillary channel
- Pressure gradient provokes liquid flow
- Charge distribution at solid | liquid interface distorted
- Streaming current (d.c. current) generated along the flow channel

Principle of surface zeta potential



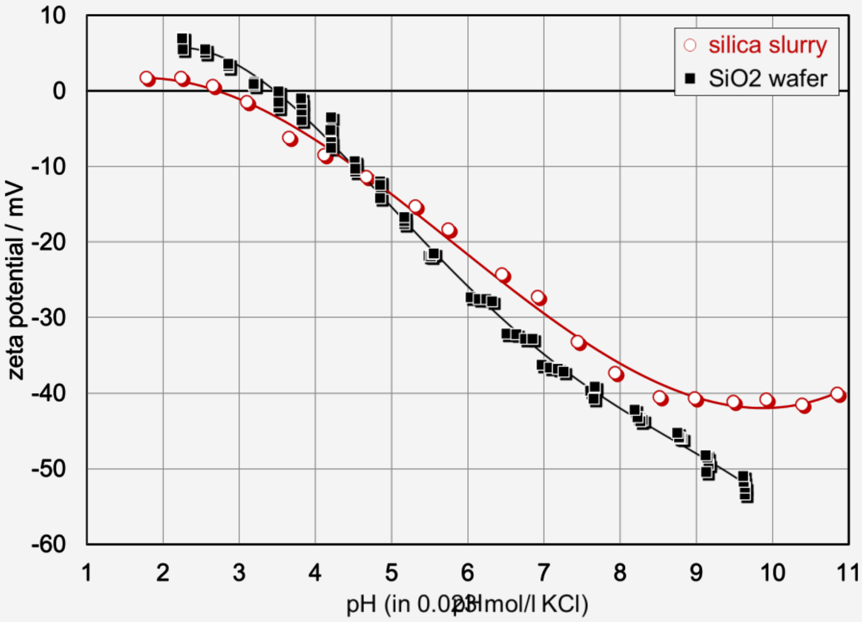
$$\zeta = \frac{dU_{str}}{d\Delta p} \times \frac{\eta}{\varepsilon_r \times \varepsilon_0} \times \kappa_B$$

$$\zeta = \frac{dI_{str}}{d\Delta p} \times \frac{\eta}{\varepsilon_r \times \varepsilon_0} \times \frac{L}{A}$$

U_{str} .... streaming potential
I_{str} .... streaming current
Δp .... pressure difference
η .... viscosity
$\varepsilon_r \times \varepsilon_0$ .... dielectric permittivity
κ_B .... electrolyte conductivity
L/A .... cell constant

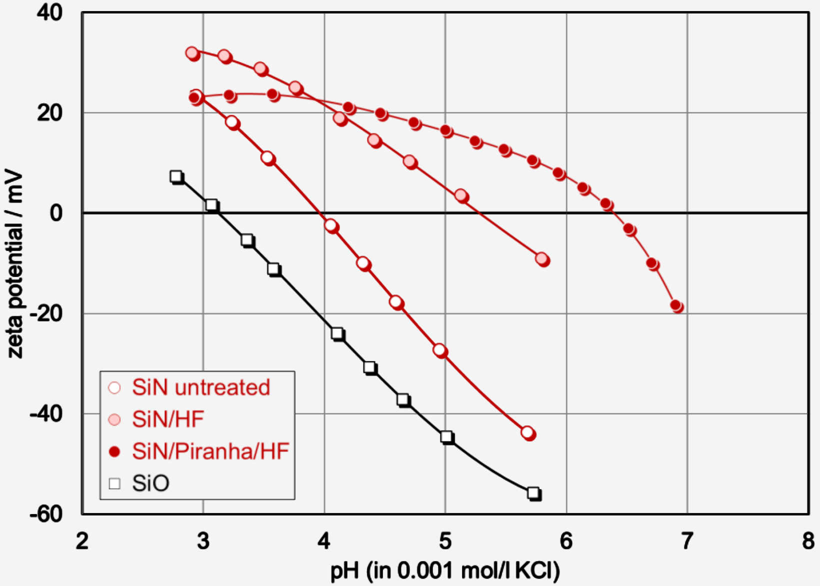
CMP slurry

Zeta potential of wafer surface



Streaming potential

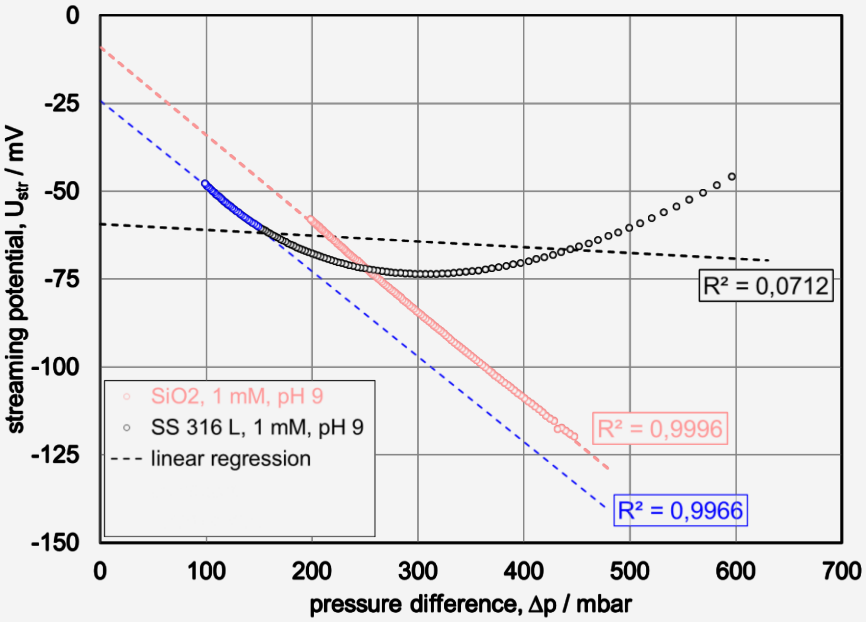
Surface modification of top coating



- **SiN**
  Si wafer with Si_3N_4 top layer
- SiO
  Si wafer with SiO_2 top layer
- **SiN/HF**
  Si_3N_4 after HF dip
  removal of silicon oxide
- **SiN/Piranha/HF**
  Si_3N_4 after Piranha etch and HF dip
  removal of organic contaminant

Conductive material surface

Non-linear pressure ramp



ζ = – 3.45 mV

ζ = – 51.0 mV

Conductive material surface

Electric interference of material with streaming potential

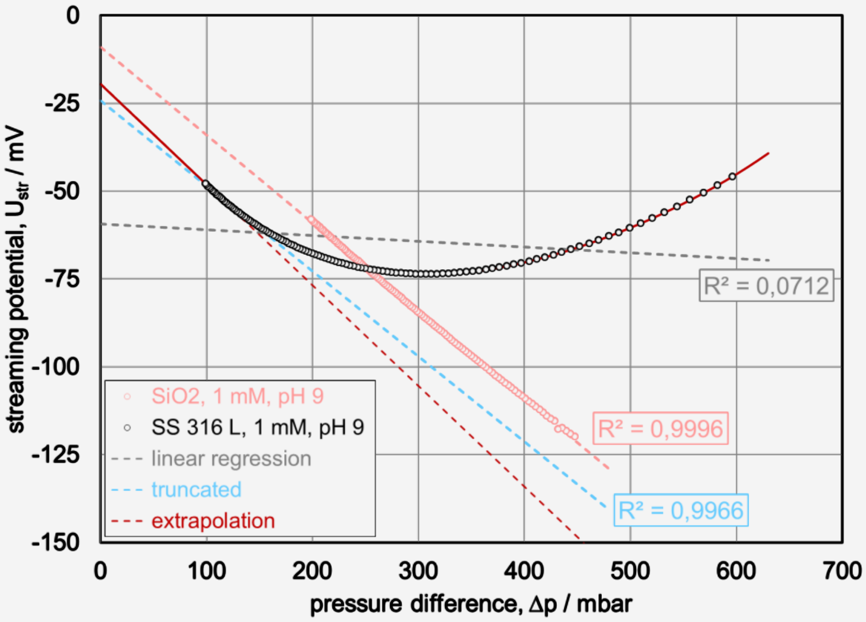
- Conductive material behaves like electrode
- Charging of material surface by streaming potential (d.c. voltage)

Prediction

- Correct $dU_{str}/d\Delta p$ at zero flow
- Effect decreases with increasing ionic strength

Conductive material surface

Non-linear pressure ramp



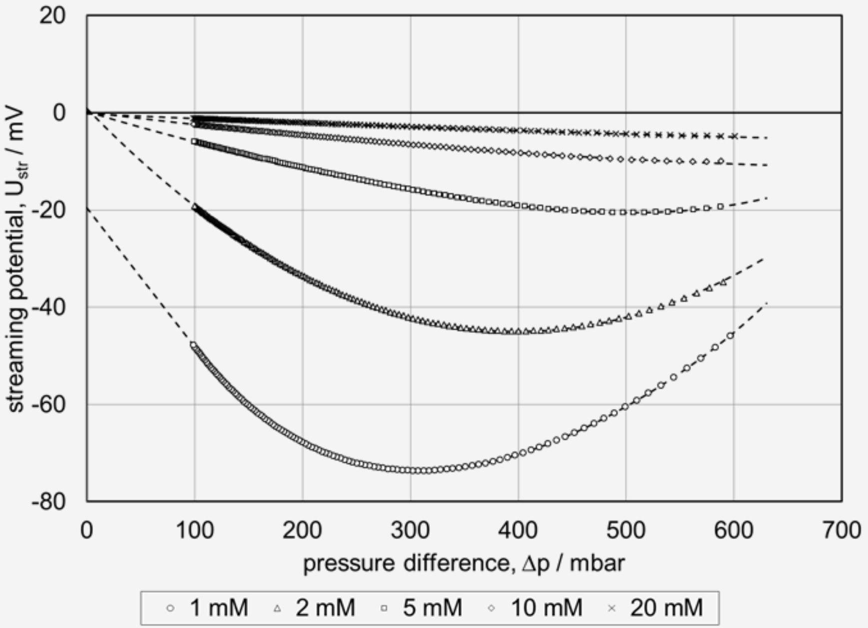
ζ = – 3.45 mV

ζ = – 51.0 mV

ζ = – 60.2 mV

Conductive material surface

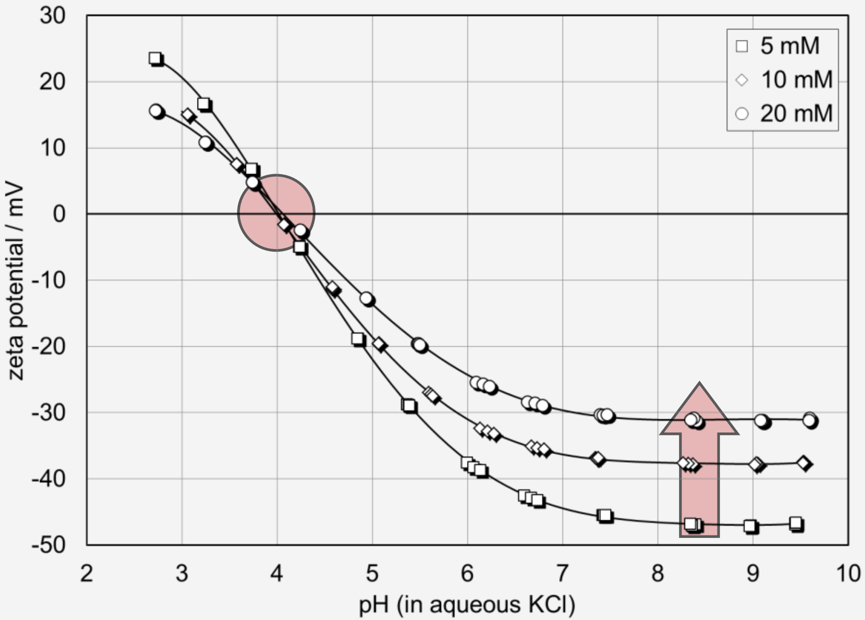
Non-linear pressure ramp



Ionic strength	R^2_{linear}
20 mM	0.996
10 mM	0.986
5 mM	0.934
2 mM	0.663
1 mM	0.071

Conductive material surface

Reliable zeta potential results



Thank you for your attention!