Charge behavior on insulating monocrystalline surfaces by Kelvin probe force microscopy

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Introduction

Detailed knowledge about the **contact charging** behavior of **dielectric materials** is of great interest for technological applications like **tribocharging separation**[1,2] of mineral particles. The underlying **mechanisms** are still **not** well **understood**.
Here, an attempt is made to study the electric charging of well-defined surfaces (calcite monocrystals) upon contact with a conductive AFM tip. **Kelvin probe force microscopy (KPFM)**[3] was applied to verify the electrostatic characteristic of the surfaces before and after contact charging. Both, tribocharging due to **rubbing** and **static contact** charging with applied tip **bias** have been investigated.

A prototype of the coaxial triboelectrostatic separator [4]

Measurement procedure:

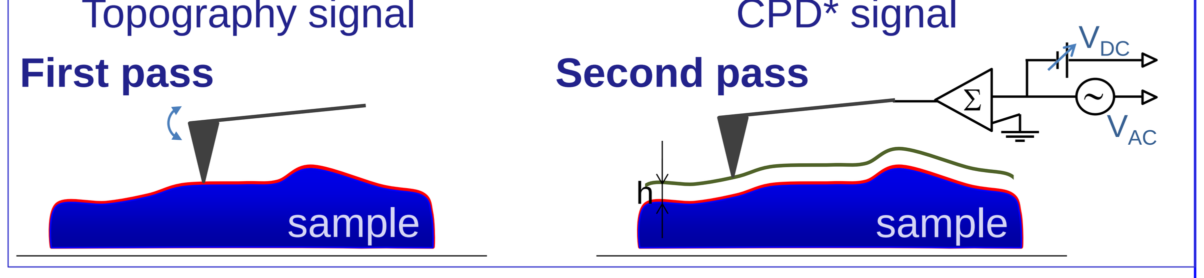
KPFM measurements → charging (rubbing or static contact) → KPFM measurements (repeating)

Experimental

Equipment:
Asylum Research
MFP-3D AFM

Probes:
TiN coated tips for noncontact AFM,
spring constant ~70 N/m,
tip curvature radius ~35 nm

KPFM measurements



*) CPD – contact potential difference

Samples:
monocrystalline **calcite**, $CaCO_3$ (100), MTI Corporation, USA

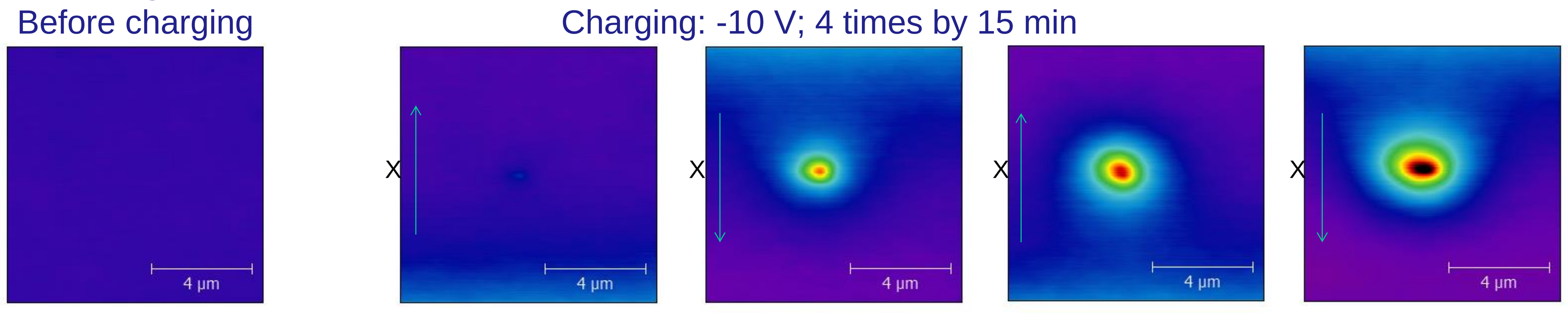
Conditions:
air, room temperature, 50 % r.H.
applied forces: 2-3 µF, applied voltage: ±10 V

Results

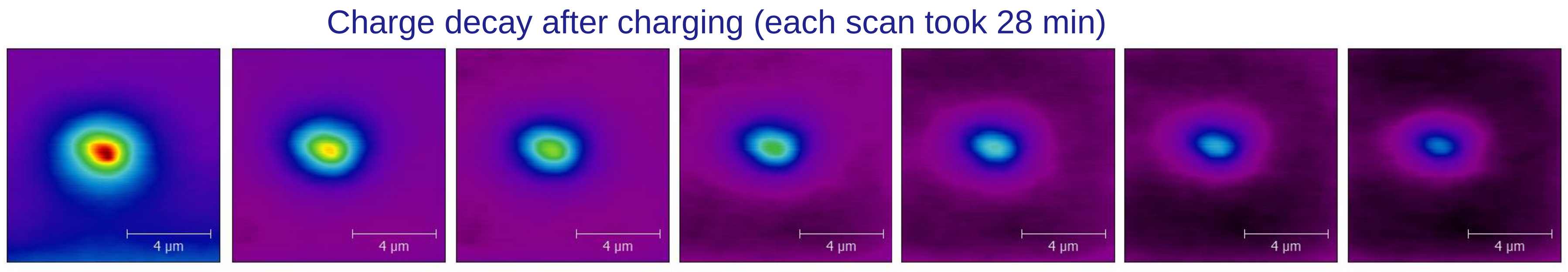
Charging by static contact

The AFM tip with applied bias (±10 V) brought into contact with defined force (~2 µN) and for defined time (15 min).

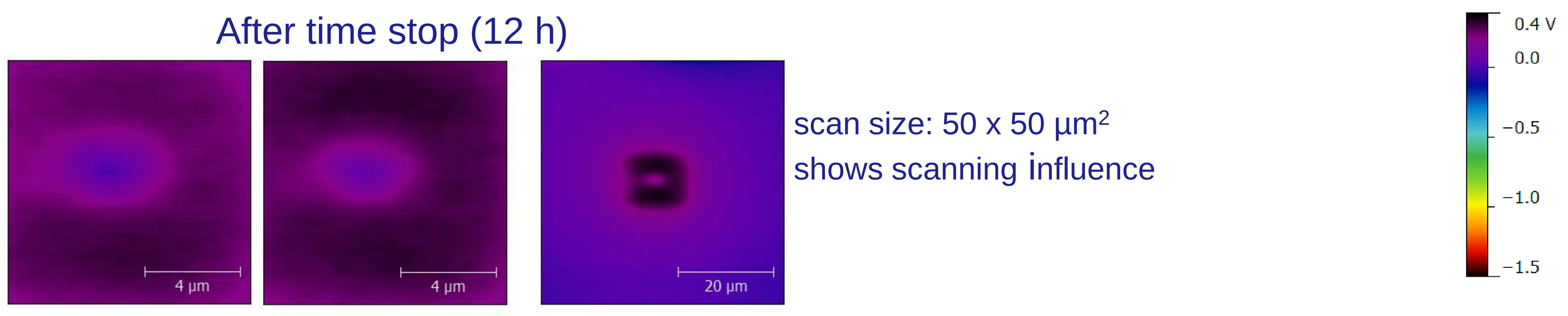
KPFM signals: scan size 10 x 10 µm²

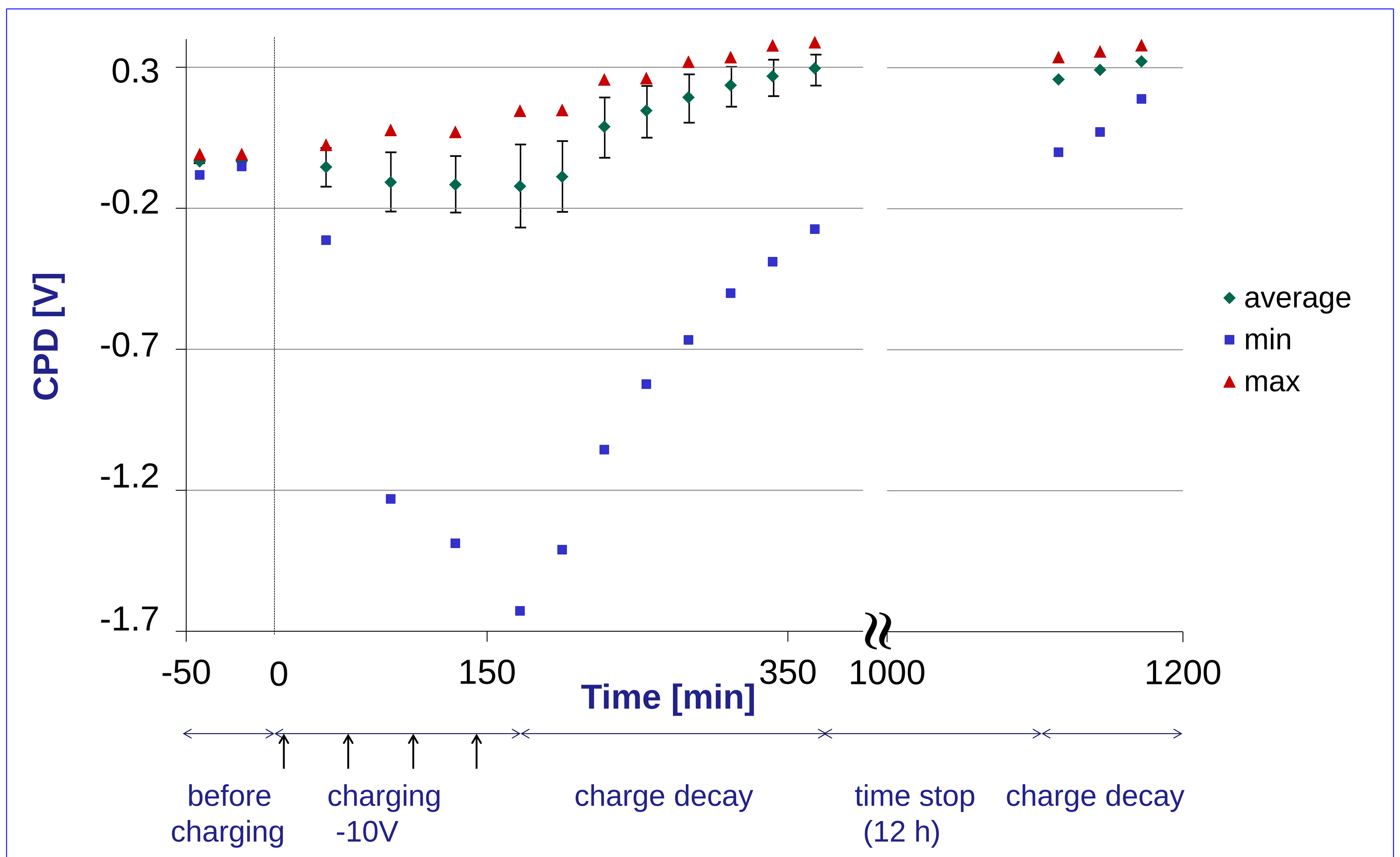


Charge decay after charging (each scan took 28 min)



After time stop (12 h)



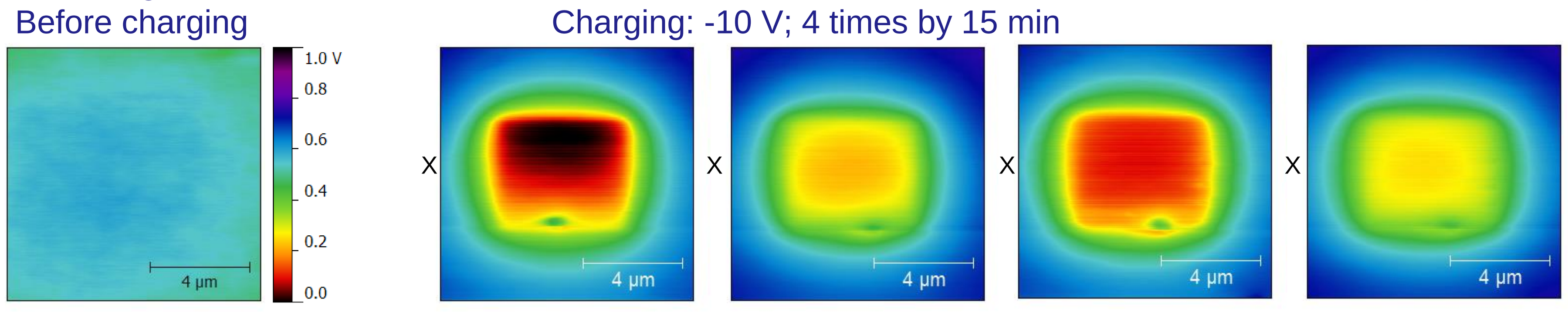


Evolution of the CPD signal with time.

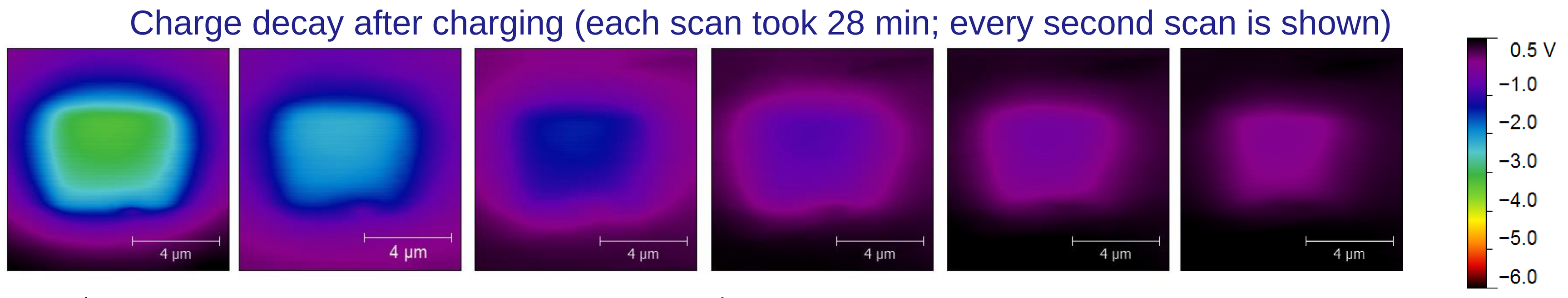
Charging by rubbing

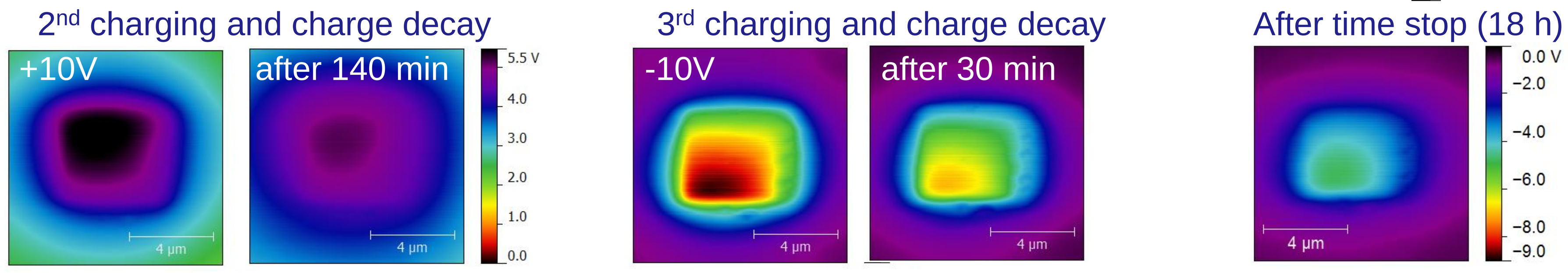
The AFM tip with or without applied bias (0 V or ±10 V) is dragged on chosen surface area (4 x 4 µm²) with defined force (~3 µN) and speed (0.30 Hz).

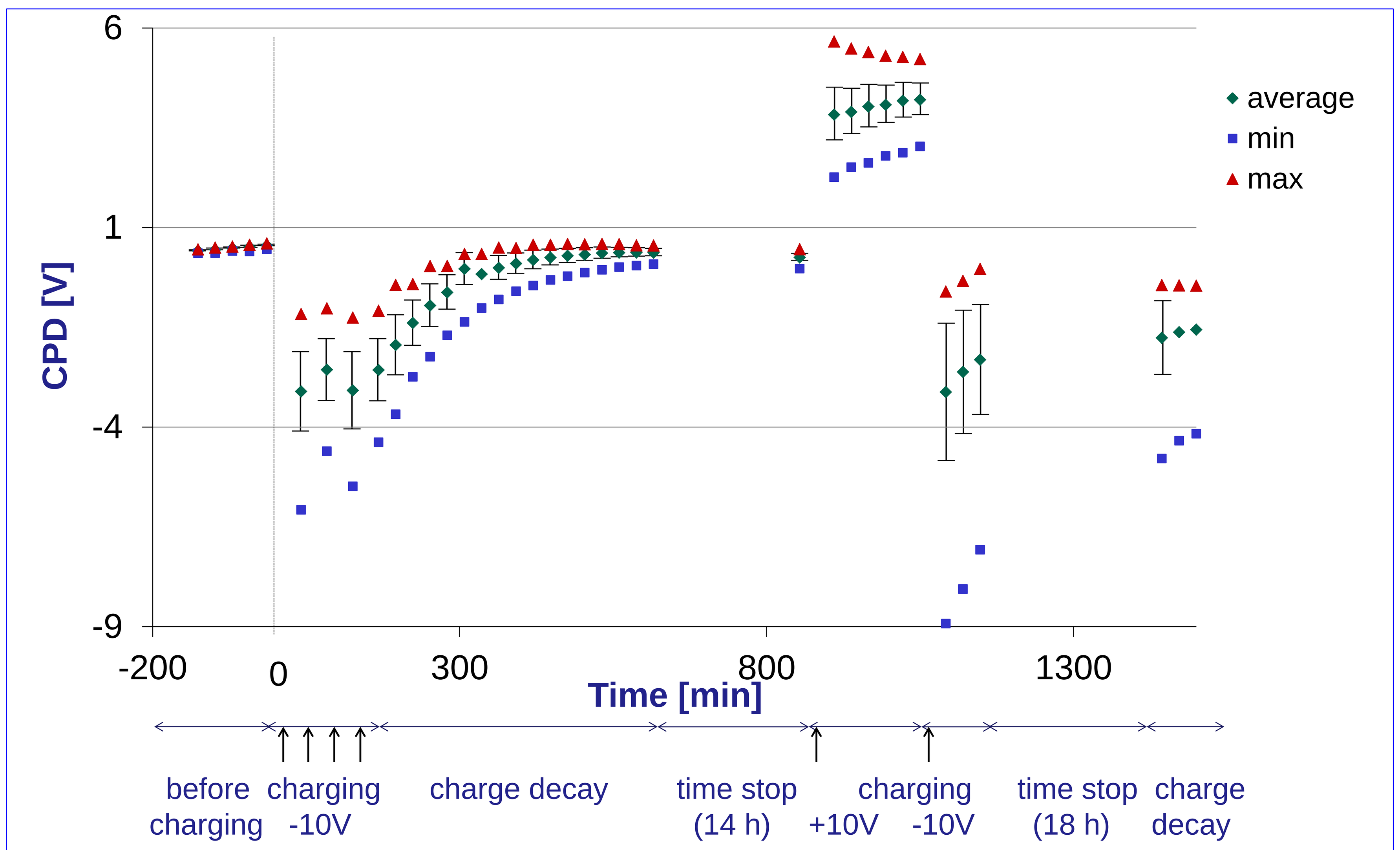
KPFM signals: scan size 10 x 10 µm²



Charge decay after charging (each scan took 28 min; every second scan is shown)







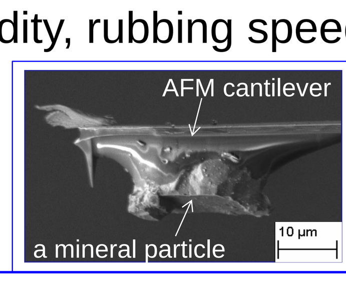
Evolution of the CPD signal with time.

Summary

- Successful charging by static contact as well as by rubbing confirmed by CPD change (static contact: ΔCPD ~-1.5 V , rubbing : ΔCPD ~-6.5 V).
- Charging by rubbing appears to be more effective than charging with static contact (correction procedure for different geometry of charged regions has to be developed).
- Charging can be reversed by application of opposite tip bias.
- For rubbing, a CPD „saturation“ level is observed which is not the case for static contact charging.
- Charge decays roughly exponentially with time.

Outlook

- Investigation of the influence of parameters like contact force, humidity, rubbing speed, and temperature.
- Performing contact charging with crystal particle attached to the AFM cantilever.



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Literature

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