

Graduate School Event

Thesis Defense: Experimental probing of nanoscale charge features and surface morphology changes during tribocharging

Felix Pertl
Waitukaitis Group

Host: Georgios Katsaros

Contact electrification (CE) is a simple yet elusive phenomenon that occurs when two materials come into contact and separate, leaving behind net electrical charge. Despite its ubiquity, the microscopic origin of CE remains unclear. In this thesis, we investigate CE from three complementary perspectives: developing a quantitative method to measure charge at the nanoscale, exploring the dynamic behavior of charge on insulating surfaces, and uncovering the role of mechanical history in forming a triboelectric series.In the first part, we establish a rigorous framework for converting qualitative Kelvin probe force microscopy (KPFM) voltage maps into quantitative charge density distributions. Using finite element method (FEM) simulations, we determine the point-spread function of the KPFM tip–sample geometry and demonstrate that the true surface charge can be reconstructed by numerical deconvolution. This procedure enables the recovery of both the magnitude and sign of charge density with high fidelity, resolving nanoscale features that are otherwise obscured. Applying the method to contact-charged SiO$_2$ surfaces, we show that existing analytical approximations, such as parallel plate or spherical models, can miscalculate charge magnitude by orders of magnitude. Our hybrid FEM/KPFM approach therefore provides a fast and general method to convert qualitative KPFM signals into quantitative charge data, enabling nanoscale charge mapping under realistic experimental conditions.In the second part, we study the temporal stability of CE-induced charges and identify the key material factors that determine whether KPFM can capture meaningful charge patterns. Through time-resolved experiments combining a custom-built transfer system with both microscopic and macroscopic measurements, we demonstrate that only the best insulators, such as SiO$_2$, preserve CE charge long enough for stationary imaging. For less conductive polymers, such as PDMS, charge decays within the duration of a single KPFM scan due to bulk conduction. Using a simple capacitor-based model, we reproduce the observed decay dynamics and confirm that the transferred charge decays characteristic to the sample's bulk conductivity. Further, we always observe homogeneous charge transfer.In the third part, we address the question: can we form a triboelectric series with identical materials? Using controlled repetitive contact experiments, we show that nominally identical materials can progressively order themselves into a triboelectric series, where surfaces with more contact history charge negatively relative to fresher ones. By constructing a minimal

model based on this contact bias'', we replicate the evolution from random to ordered charging observed in experiments. Supporting surface analyses, including atomic force microscopy, reveal that repeated contact induces nanoscale morphological changes, suggesting a mechanism tightly coupled to mechanical strain. These results highlight the crucial role of surface history and nanoscale mechanics in dictating charge transfer, motivating further exploration of mechanisms such as mechanochemical bond cleavage and flexoelectric polarization.

Monday, August 3, 2026 10:00am - 11:00am

Sunstone Bldg / Ground floor / Big Seminar Room B (I23.EG.102)

This invitation is valid as a ticket for the ISTA Shuttle from and to Heiligenstadt Station. Please find a schedule of the ISTA Shuttle on our webpage: https://ista.ac.at/en/campus/how-to-get-here/ The ISTA Shuttle bus is marked ISTA Shuttle (#142) and has the Institute Logo printed on the side.