# Nanoscale modulation of friction and triboelectrification with application to electrohydrodynamic nanolithography

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**Abstract**

Triboelectrification, or contact electrification (CE), is a common phenomenon in our daily life and has been studied for more than 2600 years, with its first observation dating back to the amber/wool rubbing experiment by Thales of Miletus. However, the underlying mechanism of CE remains elusive, although many researchers suggest the transfer of electrons, ions, or charged materials. Recently, CE is gaining popularity as a facile method to generate nanopatterned surface charge, with widespread applications in nanoxerography, thin film self-organization, and data storage. Of special interest is the CE induced by stamping nanotextured elastomer poly(dimethylsiloxane) (PDMS) masters onto the target surface because it can facilely achieve high-fidelity charge generation and nanopatterning thanks to the excellent flexibility of PDMS.

Here, we developed a simple charge patterning technique by replicating nanotextured molds with PDMS. It was found that the demolding action induced charges on the PDMS surface in a pattern closely correlated with the nanotexture. This new technique not only enables facile fabrication of nanoscale charge patterns on insulator surfaces but provide more specific targets for modeling and analysis of CE. By combining a variety of scanning probe microscopy technique (AFM/KPFM/EFM), electrostatic modelling, and finite element analysis (FEM), we developed a universal mechano-electric model than can explain how the generated nanopatterns are formed and affected by the interfacial nanotexture’s morphology, as well as different material combinations. It turns out that the cumulative distance of the elastomer’s tangential sliding during the interfacial separation plays the key role in shaping the charge distribution pattern. As an exemplary application, we configured the generated nanopatterned surface charge into a electrohydrodynamic lithography (EHDL) process, leading to nanovolcanos with 10 nm-scale craters. This EHDL process can be potentially used for fabricating functional material and metasurfaces.