Charge Transfer Between Chemically Identical Solids: Modeling and Experimental Studies

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***Abstract*—Despite its importance in many fields, electrostatic charging of solid particles and bulk solids of different size and surface roughness, but with identical composition, remains poorly understood. In a previous paper [1] we considered size effects in spherical particles under optical excitation. The spatial concentration distribution of excited electrons arises from their diffusion from the excitation site and subsequent de-excitation within the bulk or at the surface. We showed how the relative rates of bulk and surface de-excitation are size dependent and influence the concentration of excited electrons and hence the Fermi level and magnitude and direction of charge transfer between particles.**

We extend our previous studies in the light of Frenkel's insightful but neglected work [2], that pointed out that dielectric solids may act as semiconductors at hot spots, and suggested that this conductivity enabled the tribo-electric effect. Our modeling shows that enhanced surface de-excitation gives lower concentrations and higher concentration gradients of excited charge carriers in rougher than in smoother surfaces during contact. This asymmetry gives rise to charge carrier transfer from smoother to rougher surfaces. We also discuss the effect of the internal electric field arising from the mobile and trapped electrons, and show the effect of the trapped, un-neutralized electrons that are the source of the observed tribo-charge.

We measured charge transfer on small rough and smooth wafers of high resistivity N and P-type silicon using a Faraday cup. Rough N-type silicon became negative against smooth N-type silicon; however, rough P-type silicon became positive against smooth P-type silicon. This reversal of charge transfer direction is consistent with the modeling and with charge transfer by electronic rather than ionic charge carriers. Other studies were performed on glass microscope slides of varying roughness. Especially significant is the observation that the glass surface results can be put in a tribo-electric series with the glass surface of intermediate roughness negative with respect to the smoothest glass surface, but positive with respect to the roughest glass surface.

REFERENCES

[1] John C. Angus, Isaac Greber, Kathleen Kash, "Size-dependent electron chemical potential: Effect on particle charging," Journal of Electrostatics 71 (2013) 1055-1060

[2] J. Frenkel, "On the electrification of dielectrics by friction," Journal of Physics, USSR, (1941) 5, 25-29