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IT-14-P-1892 Conduction and Dissipation of Electrostatic Charges: Fundamental Study by Scanning Probe Microscopy

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Static electricity is a well-known and often observed physical phenomenon. It can cause dangerous problems in many applications, such as dust filters, chemistry, sophisticated electronics, cable insulation, charge based data storage, etc. Although many contributions have been done, the understanding of conduction and dissipation behaviors, charge transfer to, and retention on, surface or charges leakage over surfaces is far from being completed. Since most of studies are at the macroscopic scale, a microscopic and systematic study is of importance to understand these phenomena. Thanks to the development of scanning probe microscopy, a number of new electrical modes using a conductive probe have been developed and used to characterize the different microscopic electrical properties, such as Current-Sensing AFM (CS-AFM), Kelvin Probe Force Microscopy (KPFM). The objective of our project is to make a microscopic, detailed and systematic study of the phenomena of electrification, charge, discharge, conduction and dissipation mechanisms of electrostatic charges. The materials studied are two different kinds of fibers used in antistatic filters: polyester fiber and stainless steel conductive fiber commercially named Bekinox® fiber.

Surface properties of stainless steel conductive fiber are first studied (Fig.1). The surface topography and surface roughness are studied by standard AFM, the surface electrical resistance distribution is measured by CS-AFM, and the surface potential distribution is measured by KPFM. I-V spectroscopy is performed statistically to investigate the different charge transport mechanisms from different surface states. Second, the mechanisms responsible for charge conduction and dissipation between two fibers are studied. It can be noted that when a conductive fiber is put in non-galvanic contact with an other polarized conductive fiber, a dynamic behavior of surface potential variation can be measured by KPFM on the first conductive fiber (Fig.2). The quantified charging and discharging curves can be fitted to obtain relaxation times. Different contact systems, including different types of fibers, galvanic and non-galvanic contacts, are investigated systematically in order to deeply understand the mechanisms of conduction and dissipation.

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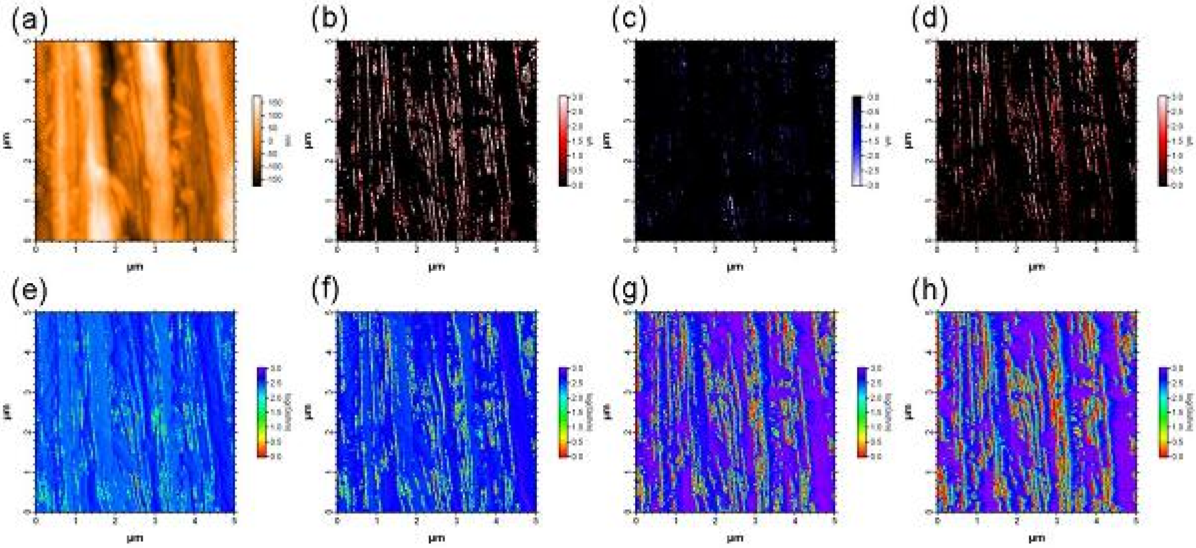

Fig. 1: Topography, surface current distribution, surface resistance distribution images obtained at the same location on Bekinox® fiber (a) topography, (b) (c) (d) electrical current distribution at 2 V, -2 V and 2 V again, (e) (f) (g) electrical resistance distribution at 1 V, 3 V, 4 V and 5 V, respectively. Image size is 5x5 μm².

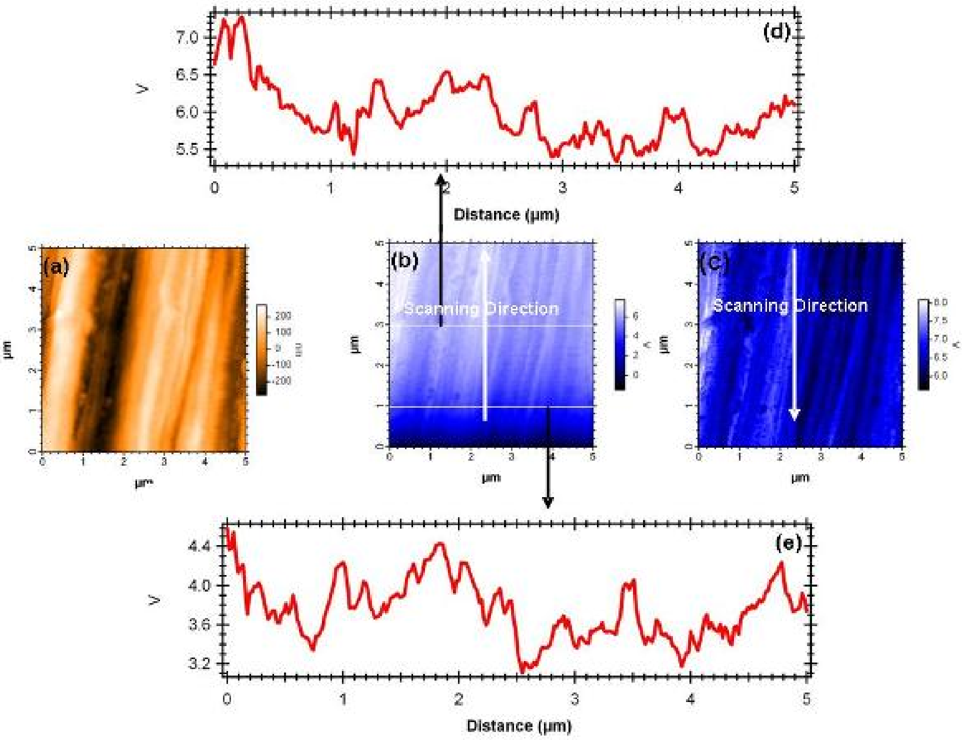

Fig. 2: Topography and successive KPFM images on Bekinox® fibers in non-galvanic while changing the applied voltage from 0 to 8 V (a) topography, (b) (c) successive KPFM images, the white arrows present the scanning direction (d) (e) two profiles from KPFM images, the average value of profile (d) is higher than profile (e).