Micro-textured electrolyte-electrode interfaces in solid-state supercapacitors

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There has been considerable interest in thin film solid-state supercapacitors for energy storage applications. Such supercapacitors typically consist of two electrodes sandwiching a solid electrolyte layer. Efforts have focused on improving the energy density of such devices by exploring different nano-scale materials and conductive polymers as electrode materials. The use of nano-scale materials allows for increase in electrode surface area, thereby improving the capacitance and energy storage capability. Here, we present a novel approach to improve supercapacitor capacitance and energy by the micro-scale texturing of the electrolyte-electrode interface. The texturing increases the surface area available for the nano-scale electrode material, thereby increasing the capacitance of the device. Devices with textured interfaces show 2-4 times higher capacitance than devices with non-textured interfaces. To the best of our knowledge, this is the first such report of a physical texturing approach applied to improve supercapacitor performance.

The texturing involves the molding of a hydrogel electrolyte on a sandpaper of known grade (Figure 1). This is done by pouring electrolyte solution (aqueous solution of polyvinyl alcohol and phosphoric acid) on a sandpaper (600B grade, average particle size ~ 25 μm). This is followed by curing the electrolyte at room temperature, and de-molding the solid electrolyte textured on one side (Figure 1A-C). Electrolyte solution is poured on another sandpaper, and the single-side textured solid electrolyte is placed on the wet electrolyte, such that the textured side faces outwards (Figure 1D-E). Subsequent curing and de-molding yields a free-standing, double-side textured electrolyte (Figure 1F). Surface characterization by white light interferometry shows a micro-scale texture with average surface roughness of 1.7 μm, compared to 25 nm for an untextured electrolyte with the same chemical composition (Figure 2). The texturing is highly reproducible and depends on the grade of sandpaper used.

Applying the micro-textured solid electrolytes in carbon nanotube-based thin film supercapacitor devices (Figure 3) shows the benefit of the texturing. Devices with textured electrolyte show between 2-4 times higher capacitance than those made with untextured electrolyte layers.

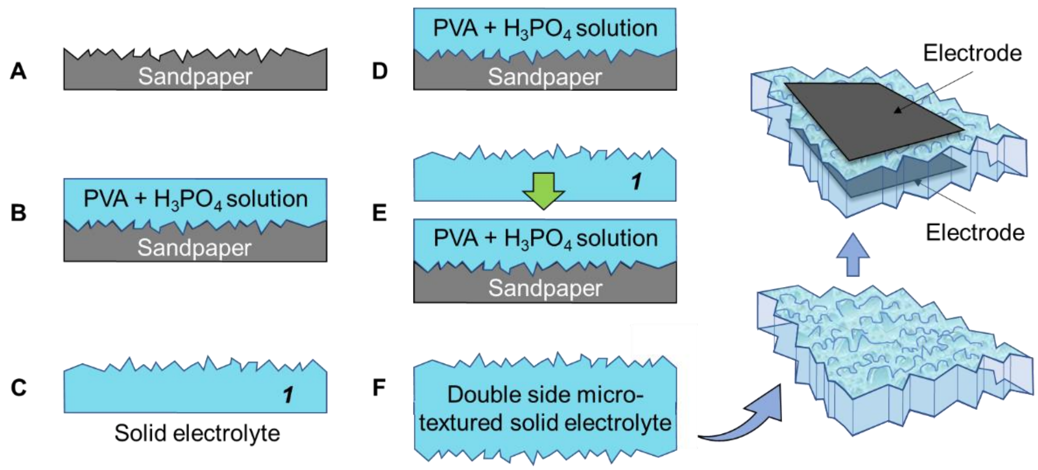

Figure 1: Schematic diagram of micro-texturing of a solid electrolyte.

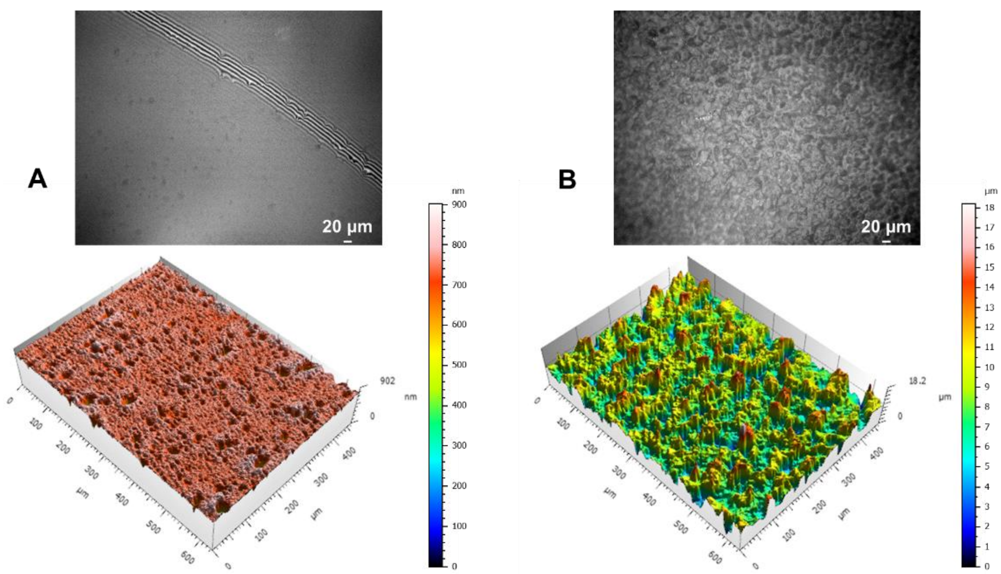

Figure 2: Microscope and optical profilometer images of (A) non-textured, (B) micro-textured solid electrolyte.

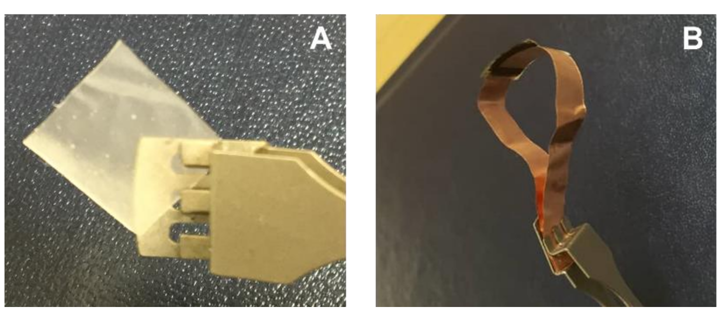

Figure 3: Photographic images of (A) free-standing micro-textured electrolyte, (B) a thin film supercapacitor device consisting of the micro-textured electrolyte.