High Energy Density of Polymer Nanocomposites Induced by Modulation of Their Topological-Structure

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The capacitor is a ubiquitous device used in the modern electronics devices, or high-density energy storage applications, for example to recuperate the braking energy in hybrid cars. Polymers with high dielectric strength and favorable flexibility have been considered promising materials for dielectrics and energy storage applications, while the achievable energy density (U_e) of polymer is rather limited by the intrinsic low dielectric constant and ferroelectric hysteresis. Concomitant enhancement of E_b and D (ε_r) is thus essential to raise U_e of the dielectric material. For polymer nanocomposites, ceramic nanofillers with different specific surface area are preferred to their spherical counterparts or 2D nanosheets for the improvement of E_b of nanocomposites. In this contribution, we attempt to describe the important significance of different specific surface area and topological-structure research in relevant fields, poly(vinylidene fluoride-hexafluoropropylene) (PVDF-HFP)-
based nanocomposite films filled with different specific surface area Al_2O_3 (0Dor 2D) by electrospinning techniques. Topological-structure modulated polymer nanocomposites are assembled layer-by-layer with the electrospun fibers via a hot-pressing process. Modulation of the topological-structure induces substantial redistribution of the local electric field among the constituent layers, giving rise to enhanced electric polarization at different electric field and increased breakdown strength. These synergistic effects lead to a high energy density of 20 J/cm^3 and a high discharge efficiency of 75% at 550 kV/mm. High energy density at high electric field is thus achieved by modulating the topological structure of polymer dielectric nanocomposites, which is of critical significance to make dielectric nanocomposites viable energy storage devices.