Polymer Program

INSTITUTE OF MATERIALS SCIENCE

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Field Assisted Roll-to-Roll Manufacturing of Flexible / Transparent Piezoelectric Films

Abtract: The recent advances in flexible piezoelectric technologies have sparked a great interest in developing multifunctional next-generation transducers and actuators that are increasingly becoming high demand for a range of challenging applications, including self-powered structural and personal health monitoring systems to flexible loudspeaker devices.

In this research, novel quasi 1–3 piezoelectric nanocomposites are introduced with record-high piezoelectric voltage coefficients. These materials are produced via dielectrophoretic process where both piezoelectric lead zirconate titanate (PZT) nanoparticles and graphene nanoplatelets (GNPs) are simultaneously aligned in a polydimethylsiloxane—PDMS matrix to form densely structured cone-shaped “nanocolumn forests” in the thickness direction. The electric field induced alignment of particles not only improves the overall piezoelectric properties of the composite at relatively low filler concentrations, but also increases the transparency of the system by enabling the light to travel with little scattering or absorption in the “Z” direction through the particle depleted zones created between micro- and nano-sized columns. The details of these unique column morphologies are investigated by various off-line and on-line characterization techniques such as microcomputed tomography—microCT and real-time light transmission measurements to better understand the effect of both material (i.e., concentration) and process-based parameters (e.g., electric field, frequency) on pearl-chain formation.

To show its versatility and high-performance, the applications comprising both direct (e.g., force sensing, energy harvesting, structural and personal health monitoring) and inverse (e.g., loudspeaker) piezoelectric effect are also demonstrated and extensively characterized.

We also demonstrated the scalability of the process, large-area samples are also produced via the continuous dielectrophoretic process utilizing a novel 44 ft long custom designed multifunctional roll-to-roll (R2R) manufacturing line.