The Curious Case of the Interface in Nanodielectrics

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Nanodielectrics are a novel class of materials, where nanometric fillers are added to polymer dielectrics to modify their properties. While nanocomposites with similar compositions sometimes behave erratically leading to conflicting results from across experiments and research groups (for good reasons), some of the effects of dielectric and conductive fillers on dielectric properties are fairly well-established. I will therefore start with a discussion on what we do know about nanodielectrics after two decades of research worldwide, and what remains open to speculation.

We know that the introduction of even small amounts of fillers may affect composite properties significantly, precisely because in nanodielectrics, interfaces abound. We are beginning to understand that much of the curious behaviour of the nanocomposites might be accounted for by the interface/ interphasial polymer around the nanometric fillers, but we know very little about their nature and extent. Nonetheless, there is a mounting body of evidence from experimental characterization as well as theoretical and computational studies.

Several models of the interface around a nanoparticle have been proposed in the literature. Direct methods to validate such hypotheses typically involve microscopic techniques like Atomic Force, Electrostatic Force and Raman spectroscopy, or Molecular Dynamics or Density Functional based simulations. Indirect methods involve computational exercises to correlate experimentally measured data on composite properties like dielectric permittivity, space charge accumulation, etc. to probable interphase properties.

In this tutorial, I shall discuss the manner in which the interphase does or may affect the nanocomposite properties, and the relevance of this knowledge to tailoring nanodielectrics for specific applications.