MATERIALS ENGINEERING

SEMINAR

"Understanding Processing Induced Changes in The Structural Hierarchy of Nylon 11 and Its Clay Blends, and PVDF/PMMA Blends and Their Effects on Dielectric Properties"

By

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ABSTRACT

Polymer based dielectrics are typically known for their low cost to manufacture, and longer lifetimes compared with inorganic dielectrics. Within this class, biaxially oriented polypropylene (BOPP) is considered state of the art and takes a big portion of the market share. It is a semi-crystalline material known for its superior breakdown strength and low loss. However, having a low dielectric constant as well as low operating temperatures leaves much to be desired. Due to this, current work has been focused on understanding processing effect on polymers to develop an in-depth understanding of structure-process-property relationships.

Commercially available polymers were melt-cast into capacitor grade films with thicknesses ≤ 20µm and having a thickness uniformity of 10% along its width. The materials studied in this work include Nylon 11, Nylon 11/clay nanocomposite blends and PVDF/PMMA blends. Uniaxial stretching has been performed on cast Nylon 11 films, while a continuous processing approach was adopted for the two blends for easy translation to a commercial process. Offline structural (WAXS, SAXS, birefringence, TEM), thermal (DSC, TGA) and dielectric (dielectric constant, dissipation factor, breakdown strength) analysis was conducted to relate processing induced morphological changes to overall properties, while also advancing an understanding on structural features necessary for improved dielectric performance.

Breakdown strength in uniaxially stretched Nylon 11 was found to be strongly influenced by the crystallinity while the dielectric constant and loss was attributed to the presence of the triclinic α' polymorph which has highly ordered hydrogen bonds that pack tightly and restrict dipole movement.

In the second study, the effect of clay concentration on the dielectric properties was studied and for the first time, shear amplification effect was observed in an isothermal film casting process, that helped improve orientation in the cast films in a continuous manner. Clays achieved near parallel orientation with the film surface and helped increase tortuosity through the film thickness, delaying breakdown.

In the final study, the effect of PMMA composition on the crystallizability of PVDF was studied. Incorporation of over 30wt% PMMA opened a new processing window for PVDF, while aiding quenching to amorphous state at higher concentrations. Crystallinity in cast films was strongly correlated with the breakdown strength. Systemic thermal annealing experiments were performed on these films to enhance crystallinity in a step-wise manner. Relaxation of PMMA as well as crystallization of PVDF caused macro phase separation that led to density differences in the bulk of the polymer, proving detrimental to breakdown. However, at longer times, lamellar thickening as well as crystallization caused densification of the crystalline regions, improving breakdown strength.

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