MATERIALS ENGINEERING SEMINAR

"Effect of Blend Composition and Uniaxial Orientation on the Structure Evolution of Structural Hierarchy and Resulting Dielectric Properties of PET/PEI, Nylon 12, and PEI Films"

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Purdue MSE PhD Dissertation
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ABSTRACT

Demand for energy storage devices such as fuel cells, batteries, and solid-state capacitors is rising due to the rapid increase in economic growth. To meet the needs of the high-end electronics and energy industry, it is important to operate these devices in elevated temperatures and under high voltage. The dielectric materials for advanced capacitors must have high temperature tolerance (Tg>80C) high dielectric constant, low loss and high breakdown strength to meet the demands of the future. In order to understand fundamental relationships between the processing, structural hierarchy and electrical properties, in this research, we focus on crystallizable Nylon 12 and noncrystallizable Polyether imide and its chemical variants.

Nylon 12 films were melt cast with a range of take up speeds to prepare films of varying preferential chain orientation. Increase of take-up speed increased the orientation of the chains in the amorphous and crystalline domains in the machine direction. Interplanar spacing of the (001) plane (d001), whose pole is transverse to the chain axis and in the direction of hydrogen bonding, increased with take-up speed indicating weakening in the hydrogen bonding. This facilitates dipole rotation, which gave rise to an increase in dielectric constant. Moreover, crystallite size found to be correlated linearly with breakdown strength. In addition, we examined the solid-state deformation of these films at various temperatures with their mechano-optical behavior and concluded that the structural evolution and resulting electrical behavior of Nylon 12 were heavily influenced by the strong hydrogen bonding between their molecules.

Thermoplastic poly ether imide films and its chemical variants were produced using solution casting method. PEI samples that have t-butylaniline endcap showed the lowest breakdown value. By adding 2 % p-phenylenediamine defect to the main chain, dielectric breakdown increased 67 %. Changing the end cap of the sample to adamantylamine, increased the breakdown value 26 % more. Further improvement on dielectric breakdown was achieved by high band-gap silica coating of the film surfaces using plasma assisted CVD method.

Date: Thursday May 26, 2022
Time: 1:00pm
Place: via WebEx:
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