Increasing the Dielectric Constant of Poly(vinylidenefluoride)

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Introduction

High permittivity and high breakdown strength are both critical for high energy storage. Currently, at the High-Performance Materials Institute, our goal is to find an optimal composite of PVDF and Perovskite ceramic material in order to increase the dielectric constant of the material, while also maintaining the high breakdown strength originally found in PVDF. This research includes testing different materials and PVDF, along with differing concentrations in order to find the optimal composite.

Background

Capacitors allow for the storage of energy and the release of that energy instantly, which makes them ideal for power on demand. The amount of energy a capacitor can store is dependent on the material’s relative permittivity, also known as the dielectric constant. Dielectric materials play an important role due to their ability to increase charge and energy storage. Polymers have wide use as dielectric materials due to their light weight, processability, and high breakdown strength. Poly(vinylidenefluoride) (PVDF) is a polymer often used in capacitor applications because of its high breakdown strength. Perovskites have a high dielectric constant, and are also used due to their ferroelectric properties, meaning that the ions can split within the material, so there is more distance in between the charges. By combining it with PVDF, it is hypothesized to increase the dielectric constant of the entire composite. Currently, we have been working on a mixture of PVDF and Cesium Lead Bromide Perovskite in order to make a composite with superior energy storage capabilities compared to pure PVDF.

Methods

In this project, glass films were cut and then washed with Isopropyl and Acetone, in order to provide a clean surface for the PVDF and Perovskite mixture. The glass slides were then placed in the oxygen plasma machine, to provide a better surface for the solution to adhere to, while drying in the vacuum furnace. The slides were handled using tweezers, so the slides would not be contaminated. Upon receiving oxygen plasma, the glass slides were then placed on a leveled surface within the vacuum furnace. The PVDF control solutions, along with the PVDF and Perovskite solutions were then placed onto the slides using a pipet. After all the slides were filled, the samples remained in the vacuum furnace at 60 degrees Celsius for approximately 3 hours. After completely drying in the furnace, the slides were taken out and using a razor, peeled from the glass slide. Electrode tape and copper wire were then placed on the film to measure the capacitance, impedance, and loss tangent.

Results

The addition of Cesium Lead Bromide Perovskite to pure PVDF is hypothesized to cause an increase in the relative permittivity of the overall sample. The capacitance, along with the sample thickness and electrode area, determine the relative permittivity. The control samples, when measured, did not show a constant relative permittivity, but instead depicted a range from 0.022 – 0.089, therefore a conclusion cannot be made about the relative permittivity of pure PVDF. The relative permittivity of the composite samples also did not show a direct trend. The overall relative permittivity ranged from 0.027 – 0.053. In addition, with the increase in concentration of the Perovskite there was no trend found within the samples’ relative permittivity. This research is still on going and requires the testing and measurement of additional sample films.

Future Work

In order to see a change in the capacitance between the control and composite sample, the frequency range must be adjusted. The currently measured frequencies were above the cut off for the Perovskite polarization mechanism. The samples should be measured at approximately 0.1 Hz. With this future work, more varied data can be collected to form a definite conclusion about increasing the relative permittivity.