Investigation of Novel Coatings for Aluminum Particles for Composite Dielectric Materials

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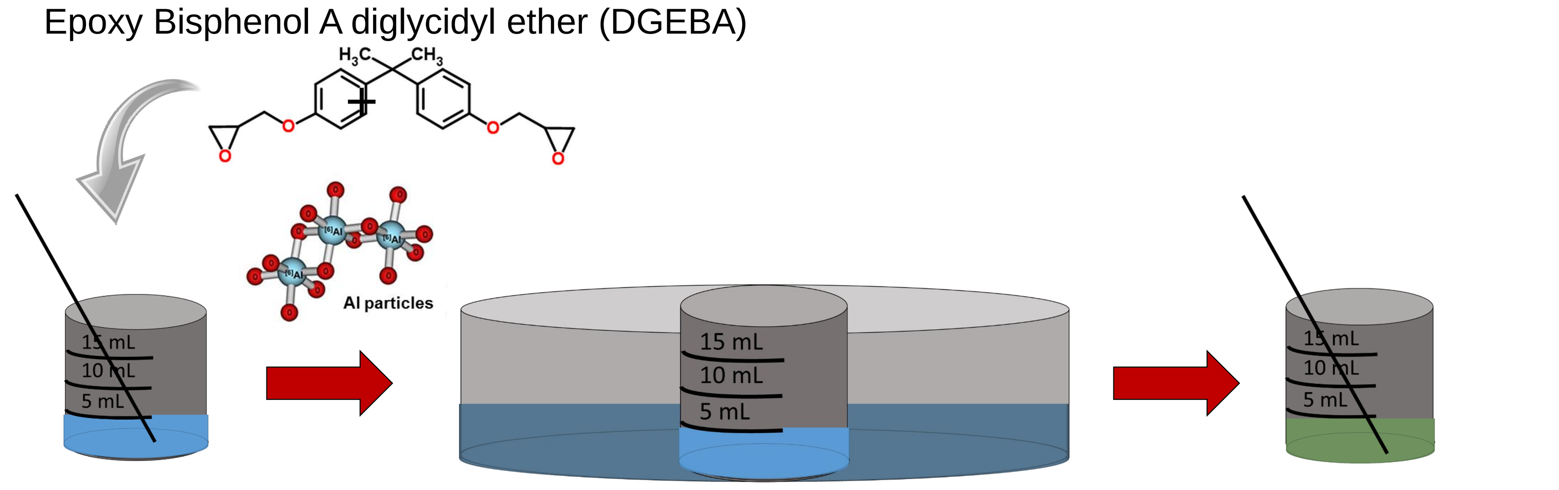
Introduction or Abstract

- Piezoelectric ceramics and dielectric polymers have been extensively studied for energy storage (capacitor) and data storage applications.
- Polymer dielectrics are used because of their high dielectric breakdown strength but they have low relative permittivity values.
- On the other hand, ceramic dielectric materials have higher dielectric values but suffer from lower breakdown field strength and tend to overheat, which results high energy loss and lower energy conversion efficiency.
- Dielectric composites that incorporate a high permittivity material (usually a ceramic) in a matrix with high breakdown field strength (typically a polymer) are of interest where opportunities of leveraging both characteristics is ideal.
- However, the high dielectric materials are typically inorganic compounds that do not exhibit good adhesion with the organic matrix, resulting in inconsistent dielectric properties over large frequency ranges and leaching over the cycle life of the device or as a function of high concentration of active filler.
- Recently, researchers have turned towards core-shell processing techniques that result in an organic chain coating that enhances the interaction between the inorganic and organic phases of the composite.
- In this work, the materials of interest were surface treated aluminum – epoxy composites.
- The dielectric composite solution was spin coated onto stainless steel sheets and were corona polarized at 45 kV/mm under a constant temperature of 75ºC.
- Hysteresis loops were observed to determine the dielectric breakdown of the material and to characterize the appropriateness for application as capacitor materials.

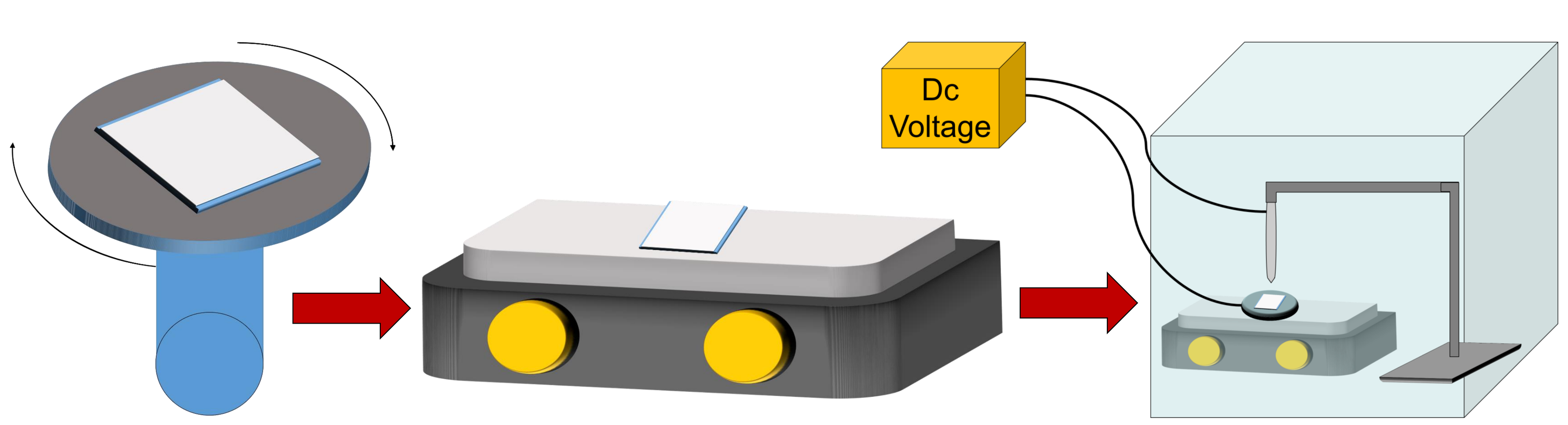
Applications

Methods (Datum)

Epoxy Bisphenol A diglycidyl ether (DGEBA)

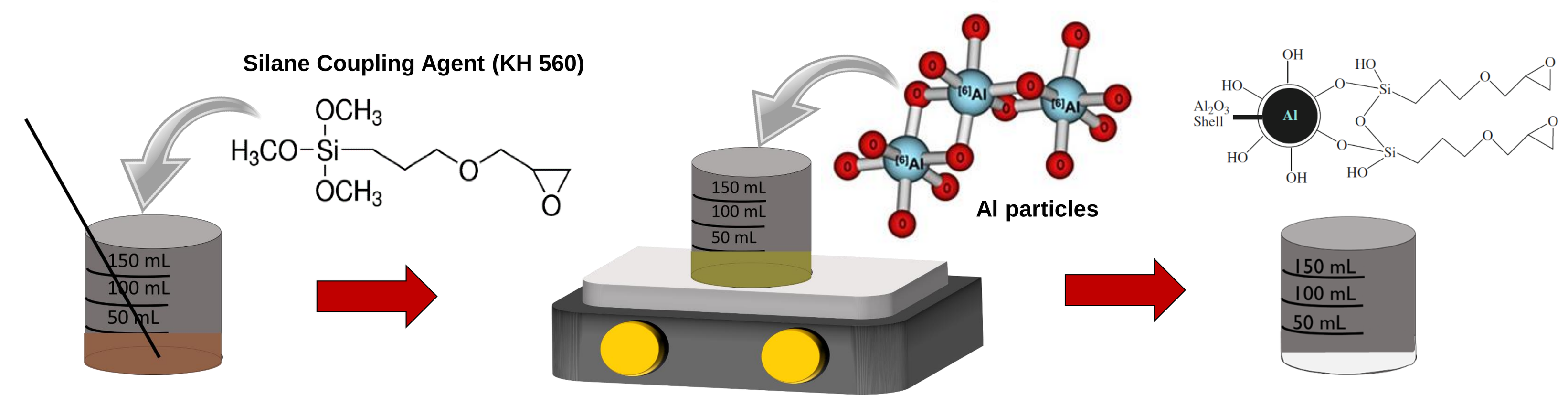


Mix Al particles with Epoxy matrix — Sonicate for 1 hour — Add hardener



Spin coating — Cure samples for 8 hours at 75ºC — Corona poling for 30 minutes

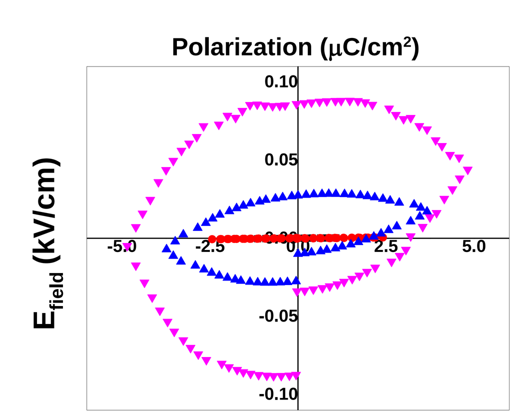
Aluminum Surface Treatment [1]



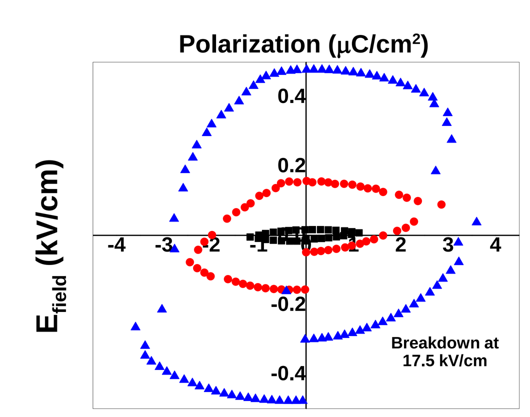
Mix coupling agent with ethanol — Add Al particles and stir for 8 hours at 80ºC in reflux system — Filter by gravity and air dry for 8 hours at room temperature

Results

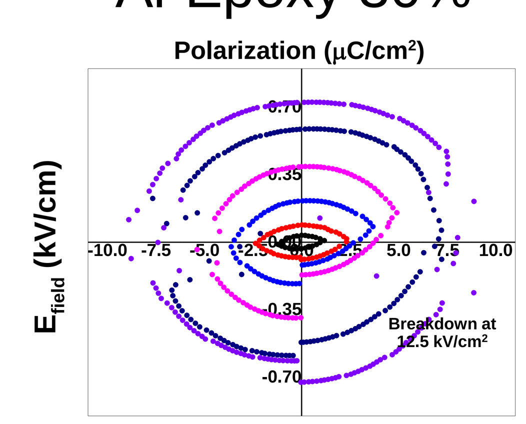
Al-Epoxy 10%



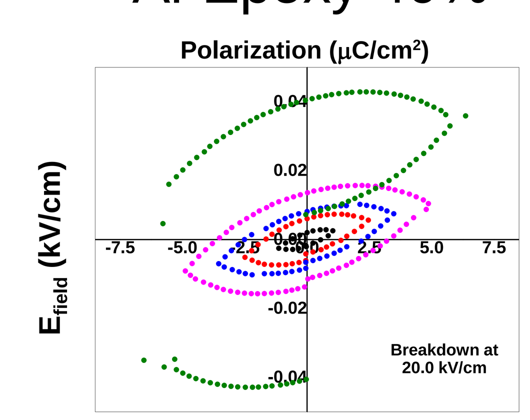
Al-Epoxy 20%



Al-Epoxy 30%

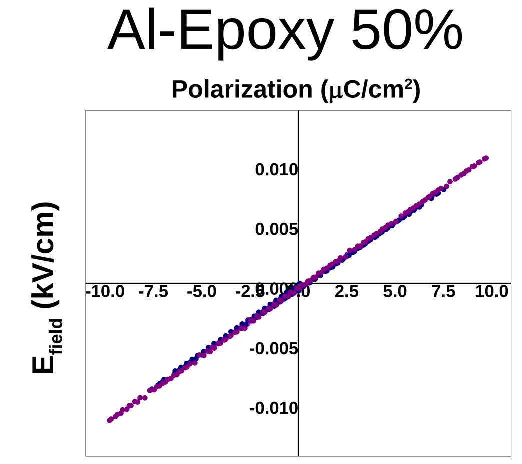


Al-Epoxy 40%

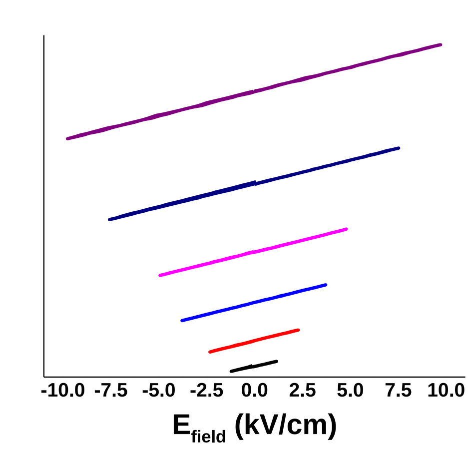


1.25 kV/cm
2.5 kV/cm
3.75 kV/cm
5.0 kV/cm
6.25 kV/cm
7.5 kV/cm
8.75 kV/cm
10.0 kV/cm

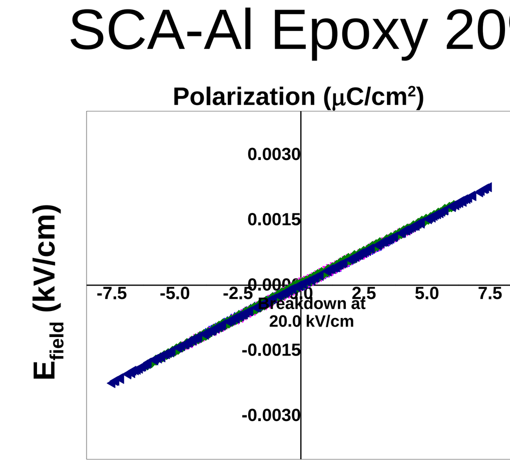
Al-Epoxy 50%



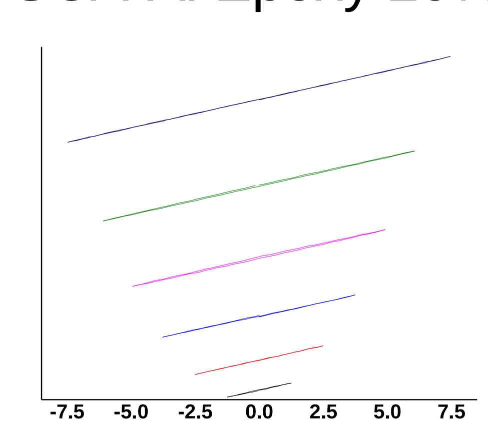
Al-Epoxy 50%



SCA-Al Epoxy 20%



SCA-Al Epoxy 20%



Conclusion

- Increasing concentration of Al particles in Epoxy helps to make the composite act as a capacitor
- Surface treatment of Al particles with KH-560 greatly improves the performance of the material
  - Higher Dielectric breakdown strength
  - Better capacitor properties

Future Work

- Measure the capacitance to determine the dielectric permittivity
- Measure conductivity
- Prepare samples with surface treated Al particles (10, 30,40 and 50 % v/v)
- Scanning Electron Microscope (SEM) images:
  - Crossection
  - Surface
- Characterize Al powder before and after treatment using vibrational analysis like FTIR and Raman spectroscopy.

References

1. Wenying Zhou, D. Y. (2011). Effect of coupling agents on the dielectric properties of aluminum particles reinforced epoxy resin composites. *Journal of Composite Materials, 45*(19), 9. doi: 10.1177/0021998310394694

Acknowledgements

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