Testing and Analysis of Functional Resistivity Composites for High Voltage Power Modules

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How does Zinc Oxide affect the magnitude and frequency of partial discharge in high voltage wide band gap power module insulators?

Abstract

This project seeks to determine how zinc oxide nanofiller size and filler ratio can affect partial discharge mitigation in functional resistivity composites for high-voltage wide band gap power modules. Composites using polydimethylsiloxane (PDMS) and zinc oxide particles (ZnO) of varying sizes and concentrations will be fabricated and tested for partial discharge magnitude. Through this research, the mixture combinations that reduce partial discharge magnitude and frequency will be identified, supporting the development of more reliable insulating materials for advanced power electronics.

Research Setup

- Measures the partial discharge through the sample by placing it between 2 electrodes with a high voltage applied.
- A waveform generator connected to a voltage amplifier induces a square wave at 60hz.
- The ground plane has a current transducer that measures the current that is applied is leaked through the sample to ground from the high voltage electrode
- The current transducer measures PD and the switching noise, the switching noise is then filtered using the average of all measurements at each step.
- A comparative study is done to understand the differences in PD between samples.

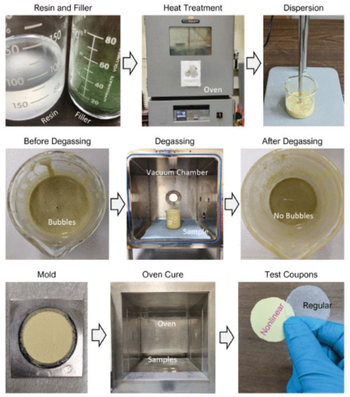

Figure 1: Fabrication Process [1]

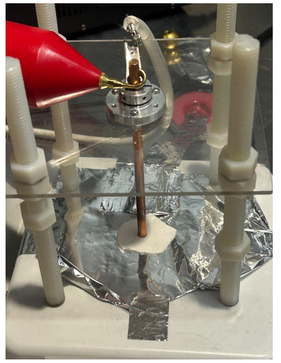

Figure 2: Testing Setup Photo

Results

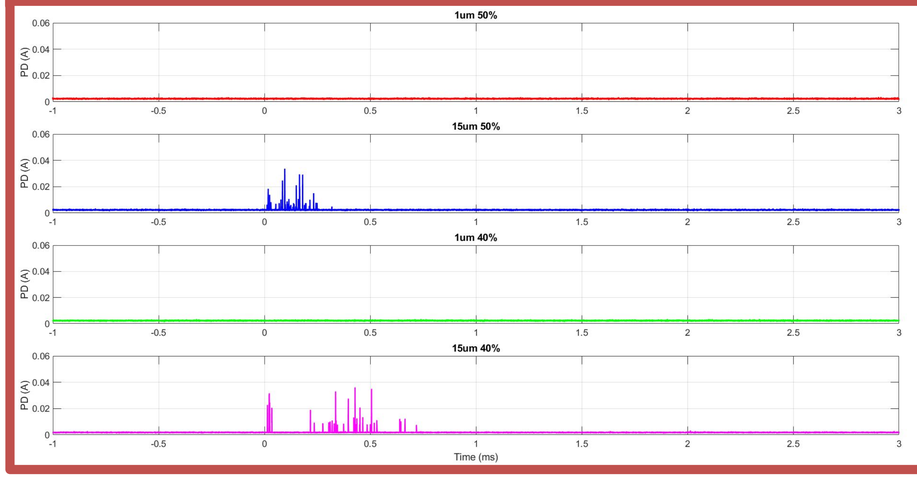

Figure 3: Filler Size Comparison at 50% and 40% for 1um and 15um at 6kv using square waves

Conclusions

- 15um filler size have less PD than 1um filler size at the same voltage magnitude.
- As the concentration of ZnO filler increases, the magnitude of PD decreases.
- Samples of larger particle size can have higher filler % due to a lower viscosity when curing.

Future Work

- Use a larger variety of filler sizes to ensure the trend is consistent and determine the functional relationship to particle size .
- Use different frequencies of the square waves to determine how the PD varies.
- Temperature and humidity can vary in the experiment to measure how it affects PD in the samples
- Use different matrices such as epoxy, glass, and other formulations of silicone .

References

1. O. Faruqe, F. Haque, P. C. Saha, I. Jovanovic, N. Uzelac and C. Park, "Partial Incorporation of Nonlinear Resistive Field Grading Materials: A Strategy for Enhanced Field Reduction and Safety," in IEEE Transactions on Dielectrics and Electrical Insulation, vol. 30, no. 1, pp. 474-483, Feb. 2023, doi: 10.1109/TDEI.2022.3207424.

2. O. Faruqe, F. Haque, P. Saha, A. J. Morgan, W. Sung and C. Park, "Development of Nonlinear Resistive Field Grading Materials for Electric Field Mitigation in Power Electronic Modules," 2022 IEEE Energy Conversion Congress and Exposition (ECCE), Detroit, MI, USA, 2022, pp. 1-5, doi: 10.1109/ECCE50734.2022.9947481.

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