Micro-plasma based surface modification of flexible ZnO-Epoxy-Carbon Nanotube composites

Mechanical Engineering
Students: Adithya Katakam, Sandeep Mohan, Walker Tuff, Sanjeev Kumar, Emma Van Fossen
Advisors: Sankha Banerjee, PhD, Edbertho Leal-Quiros, PhD
Energy Devices and Plasma Applications Laboratory (Energy Engineering Research Group)

FRESNO STATE
Lyles College of Engineering

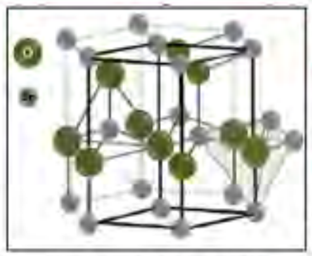
Abstract

Atmospheric pressure and ambient temperature micro-plasmas have been used for polarization of piezo-composites towards alignment of the electric dipoles. Dielectric polarization is caused when a dipole moment is formed in an insulating material because of an external electric field. When a dielectric interacts with electric field a shift in charge distribution takes place, aligning the positive and negative ions with the electric field. By this mechanism important circuit elements such as capacitors can be developed. The same phenomenon of plasma micro-discharge can also be used for surface modification of piezoelectric-composites towards activation and enhancement of electrical properties of the material surface. This can be achieved by chain polymerization of the surface in organic composite thin films that changes the surface bonding characteristics. The current work focuses on the development and use of a corona discharge setup for surface modification of piezoelectric flexible composites: ZnO-Epoxy and ZnO-Epoxy-Carbon Nanotubes..

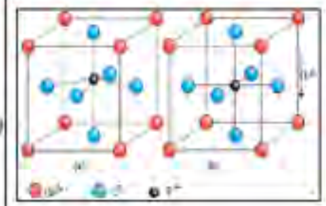
Introduction

Materials such as zinc oxide (ZnO), barium titanate (BaTiO3), lead titanate, and bismuth sodium titanate that become electrically polarized upon the application of mechanical energy. This effect is known as piezoelectric effect. There are two types of piezoelectric effects: the direct piezoelectric effect is the linear phenomenon of obtaining electrical output due to mechanical input on the piezoelectric materials, and the inverse piezoelectric effect which is a reverse phenomenon which converts electrical energy into mechanical energy. These effects are caused by a lack of symmetry in the molecular structure, and have potential applications in the harvesting of energy from applied stresses. This projects concerns zinc oxide and barium titanate, which are lead free piezoelectric materials, to investigate their polarization characteristics. Polarization is defined as the dipole moment obtained per unit volume of the dielectric. To measure the polarization characteristics parameters such as piezoelectric strain coefficient, dielectric constant and tangent losses were measured. Creation of these dipole moments were effected through corona polling applied to the piezoelectric sample. In corona polling, a corona discharge is created by applying a high energy potential to an electrode needle causing the surrounding air to ionize. The ionized charge causes an impact within piezoelectric composites orienting the dipoles in the direction of the applied charge [1]. The materials having Lead-based deposits possess serious environmental concerns and issues during material fabrication and disposal due to the presence of volatility and toxicity of lead. Thus, to reduce the usage of the Lead-based piezoelectric, a perfect replacement is made with the usage of lead free piezoelectric materials.

Introduction



Structure of Zinc Oxide [1]



Structure of Barium Titanate [2]

The samples are poled using corona discharge

Fabrication and Surface Modification

The fabrication process for these samples begins with the sonication of a suspension containing epoxy, ethanol, and either zinc oxide or barium titanate. This suspension is then applied to a conductive stainless-steel substrate through a spin coating process. Once the sample has been distributed onto the substrate, it is cured over an eight hour period using a hot plate set on 75 degrees Celsius.

Results/Analysis

A barium titanate sample

Relative sizing of the sample

The surface modification of these samples is accomplished through the application of a corona discharge to the sample. The discharge is generated by applying a high voltage, low current charge to a tungsten needle, which is positioned over an aluminum electrode. A mesh dispersion plate is placed between these two components, and the sample is positioned on the aluminum electrode beneath the mesh.

stable discharge regime

pulse dicharge regime

Conclusions

The results from the surface modification analysis demonstrates that corona discharge can be used to modify the surface bonding energy.

References

[1] Amin, Gul. "White LEDs Printed on Paper-A Doctoral Thesis-Part I." EDN Network. Linkoping University, 6 Aug. 2012. Web. 17 Dec. 2016.

[2] "Barium Titanate, BaTiO3." GITAM, Department of Engineering Physics. N.p., n.d. Web. 17 Dec. 2016.

Acknowledgments

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