Enhancement in energy density of electroactive polymer-based wearable devices using silicone rubber and carbon nanotube based composite dielectric film

LSSE Kyutech, Japan, *(D) Nitin Kumar Singh, Kazuto Takashima, Shyam S. Pandey

E-mail: nitinmjpruiitp@gmail.com

Electroactive polymers (EAP) can convert mechanical energy into electrical energy and vice versa making them suitable for wearable applications like generators, actuators and sensors. However, currently utilized EAPs exhibit low energy density, which limit its widespread applications. The net energy available throughout one electromechanical conversion cycle divided by the active mass of the electroactive polymer is known as the energy density. In generator and actuator mode total available energy density is being controlled by four instabilities such as mechanical failure of film, failure due to electrical breakdown, pull in instability (when rate of spread of electrical charge is not in equilibrium with mechanical strain) and loss of stress. For the safe operation of EAP based generators and actuators, available energy density is calculated by area enclosed by all these four instabilities. Perlin et. al. reported energy density of acrylic based electroactive polymers equivalent to 0.4 J/g, which was later enhanced up 0.6 to 0.7 J/g for silicone-based polymers.

In this work uniaxial tensile measurement was performed on carbon nano tube (CNT) and silicone mixed composite films for three consecutive cycles. Later first stretching cycle of stress strain curve was used for fitting the experimental data with available theoretical modeling for the rubbery materials. Stress strain data was well fit with Yeoh's second order term and further mechanical fitting parameters were calculated. All nonlinear equations involved in four instabilities were solved by putting the value of constraints (extension coefficient λ, mechanical fitting parameters, applied electrical field and dielectric constant). After putting the value of constraints and simulation, area enclosed by all four instabilities was calculated as shown in the Fig. 1.

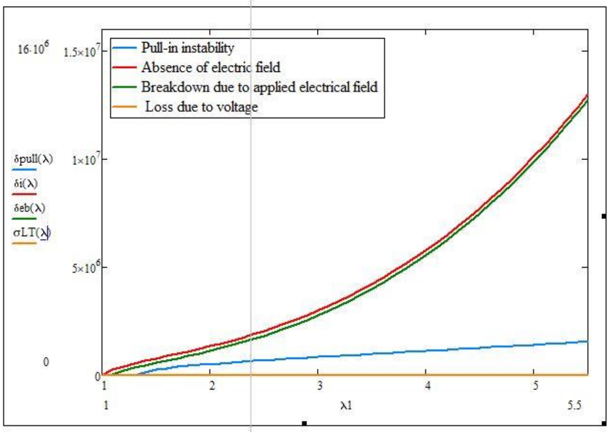

Fig. 1. Energy density estimation of CNT and silicone based composite film.

It was found that energy density is directly proportional to the dielectric constant and CNT based fillers improved the dielectric constant of film consequently enhancement in the energy density. Our results reveal that composite film used for present investigation exhibited comparatively higher value of energy density which was equivalent to 1 joule/gram suggesting that such films can improve the performance of generator and actuators. In case of sensor mode, energy density can be calculated by area under stress strain curve only because sensor does not involve high actuation electric field. Details about such investigation will be discussed during my presentation.

