

Development of flexible energy storage device for wearable electronics using all-organic composites

Jindong Wei, Zhen-Yu Ko and Z.-Y. Cheng

Materials Research and Education Center, Auburn University, Auburn, AL 36849-5341

Curtis Hill and Jennifer M. Jones

Marshall Space Flight Center, Huntsville, AL 35812, USA

As the demands and applications of wearable electronics increase, the need of power supply for wearable electronics becomes the critical issue. Both batteries and capacitors can be used as power supplier. In terms of energy storage device, capacitors have many advantages over the batteries, but have a lower energy storage density. To improve the energy density, composites, in which inorganic particles are embedded in a polymer matrix, have been identified as a promising approach to create the dielectrics with a higher energy storage density. The physics behind the composite approach is that the inorganics have a higher dielectric constant and polymers can stand with a higher electric field so that the composites can exhibit a relative dielectric constant and stand with a relative electric field. Therefore, the composites can exhibit a higher energy storage density. However, the embedment of inorganic particles into polymer severely reduces the flexibility of the polymer. To develop flexible energy storage ultracapacitors as an energy storage device for wearable electronics, an all-organic composite approach, in which a dielectric polymer is mixed with polar organic molecules, is introduced. It is experimentally found that by adding a small amount of polar organic molecules into dielectric polymers, the polymers exhibits a high dielectric constant and can stand with a higher electric field. More importantly, the flexibility of the all-organic composites is better than the polymer matrix. Therefore, the all-organic composites can be a strong and promising candidate for the development of flexible energy storage devices for the wearable electronics. In this study, three different dielectric polymers and three different polar molecules were studied. All the all-organic composite systems exhibit a significant improvement on the energy storage density.

These new flexible energy storage devices are being developed to be fabricated with on-demand additive electronics manufacturing processes, so that they can be fabricated when needed in space on the International Space Station and planned lunar habitat and other future missions. These flexible energy storage devices will provide the storage in concert with other printed power generation devices to allow crew health and structural health monitoring sensor devices and systems to be self-powered, not requiring any external power or batteries.