SEMS: RESEARCH PROJECT DESCRIPTION

1. Project Background and Description

Towards High Energy Density and Low Loss Polymers Capacitors

The aim of this project is to break the compromise between high energy density storage and high efficiency in polymer film dielectrics.

With the rapid development of science and technology and the rising environmental and sustainability demands, high-performance energy-storage devices used for power systems, electronics, electric appliances are dramatically desired. Many applications, such as hybrid vehicles, power factor correction, and pulsed power application (e.g. DC link converters and medical defibrillators) require capacitors with high energy density, to reduce the size and/or weight of the related systems, combined with mechanical toughness, easy processability and low cost.

For these applications, dielectric polymeric film capacitors are desirable because of their fast discharge speed, high power density and good processing performance. However, the energy density of commercially available dielectric films, such as BOPP, are relatively low and cannot meet technological demands.

In the past decade, different polymer-based dielectric materials have been intensively investigated to improve the energy density values. Polyvinylidene fluoride (PVDF) is a promising polymer for energy storage applications, thanks to its relatively high dielectric properties. PVDF is a ferroelectric polymer. It possesses relatively high dielectric constant (>10) and very high breakdown strength (about 300-800 kV/mm depending on the processing routes and testing methods). Our group has recently developed significant expertise in PVDF film capacitors and, in particular, on how bespoke polymer processes can induce ultra-high energy densities [1-2].

However, typical ferroelectrics still exhibit quite low efficiencies (high loss). Achieving simultaneously high efficiencies, high energy-storage densities as well as high temperature stability, is as challenging as important for any future industrial and commercial break-through.

References:

1. X. Ren, …, E. Bilotti, M.J. Reece*. *Nano Energy*, 2020, 104662.

2. N. Meng, …, M.J. Reece, E. Bilotti*. *Nature Communications*. 2019, v 10, 4535.

2. Project Scope

The aim of the project will be achieved by:

1. developing bespoke polymer processing techniques to develop unique crystalline structures
2. Studying the effect of nano-structuring and nanoscale confinement on energy storage
3. Study multilayer polymer films, combining properties of different polymer and nanofillers
4. Evaluating the addition of a small amount of nanoparticles with high electrical resistance and high thermal conductivity (e.g. boron nitride nanoplatelets).

3. Desired Skills from the Student

The ideal PhD candidate will have a University degree in Material Science and Engineering or equivalent subjects and knowledge of aspects of: i) Polymer processing, ii) Electrical and dielectric characterisation, iii) thermal and structural characterization and iv) nanomaterials and nanoparticles.

4. Supervisors

Primary Supervisor: Dr. Emiliano Bilotti, SEMS, QMUL. e.bilotti@qmul.ac.uk

Secondary Supervisor: Prof. Mike Reece, SEMS, QMUL. m.j.reece@qmul.ac.uk

Additional Supervisor: Dr. Haixue Yan, SEMS, QMUL. h.x.yan@qmul.ac.uk