

Novel high energy density, high reliability capacitors

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Overview

Future civil airframes will make much greater use of electrical systems for actuation of ailerons, flaps, rudder, landing gear, together with applications in de-icing, in-flight entertainment and air conditioning. These electrical systems will form part of a fully integrated power optimised aircraft design that is forecast to deliver substantial increases in the overall energy efficiency of the airframe. Consequently, as well as providing propulsion, aeroengines are forecast to generate up to 1MW of electrical power during flight. However, if this power is to be generated efficiently and without large weight penalties, a number of radical step-change technologies are required. One of these is a new reliable, lightweight power capacitor technology for elevated temperature applications. The current generated on-board requires various types of conditioning and manipulation before and during distribution and use. In many of these power systems, electrolytic capacitors are employed currently for various types of power conditioning. While electrolytic capacitors provide unmatched absolute capacitances, they suffer from catastrophic and unpredictable failure, and as power requirements increase, forecast electrolytic capacitor weight and volume becomes problematical. Further, because electrolytic capacitors rely on a liquid electrolyte, they are restricted in their temperature operation, reducing design flexibility for capacitor bank location within the airframe.

The broad thrust of the research is to combine the lightweight, high dielectric breakdown and manufacturing technology of polymers with the high dielectric performance (energy storage) capability of ceramics in a nanocomposite film capacitor configuration, studying both experimental and theoretical aspects.

The consortium

The project consortium brings together a university research group with expertise in capacitor technology and their manufacture (Oxford University, Department of Materials) with the leaders of the leMRC flagship project on Power Electronics (Nottingham University, Department of Electronic and Electrical Engineering), a major end user (Rolls-Royce plc), a capacitor manufacturer (Norfolk Capacitors Ltd), a materials supplier (Scott Bader) and an industrial test-house (Nanion) in an integrated supply chain approach to move the current state of the art from technology readiness level (TRL) 3 (laboratory demonstration) to TRL6/7 (system/subsystem model or prototype demonstration in a relevant environment).

Objectives

1. To investigate the manufacturability of polymer based nanocomposite films for power capacitor applications at the near industrial scale.
2. To investigate the manufacturability of novel polymer matrix/nanoparticles combinations at the laboratory scale, with migration to large scale manufacture at the project mid-point.
3. To undertake comprehensive performance and reliability testing and to understand performance in terms of manufacturing approaches and microstructural features.
4. To move the current state of the art from technology readiness level 3 (laboratory demonstration) to TRL6/7 (system/subsystem model or prototype demonstration in a relevant environment).

Industrial relevance

The UK knowledge and manufacturing base for power capacitors is small but strong, and requires continuous investment to provide products that compete on performance achieved through innovation and a high intellectual content. Applications of more electric technologies are certain to grow, and it is essential that the UK remains competitive in the underpinning enabling, high value added manufacturing technology. This proposal seeks to make an important contribution to the field in the UK and to provide a foundation for further activities linked with UK industry.