The main goal of Skeleton Technologies’ ESA PECS-1 project was to develop electric double layer capacitors (EDLC, from hereafter ultracapacitors), for a variety of space applications with 30-50% better performance (capacitance and power) than existing commercially available ultracapacitors. For this purpose, 3 different electrochemical systems were designed: 1) high-energy ultracapacitor, fine-tuned to maximum energy density; 2) high-power ultracapacitor, fine-tuned to the lowest inner resistance; 3) ultracapacitor with optimized energy and power characteristics to combine both, the good energy density and high specific power (Pmax).

Actions

The project lasted 12 months (01.04.11-01.04.12). To reach the maximum result from this project, it was decided that reasonable dimensions of the carbide-derived carbon (CDC) based electrical double-layer capacitors (ultracapacitor) regarding capacity should approximately be in the range of 10 to 100 Farads, where the advantage of ultracapacitors is highest compared to existing other energy storage technologies such as electrochemical batteries and power delivery systems such as conventional electrolytic capacitors.

Decision making regarding design of the electrochemical system for ultracapacitors was based on the aim to be flexible and not to stay limited by one or two specific applications. It is known that a double-layer capacitance and inner resistance of ultracapacitor devices follow the opposite trends. The smaller are pores, the higher capacitance (i.e. energy-density). However, it also has to be considered that small pores increase the steric restrictions inside pores and consequently slow down the response of electrolyte ions to the changes of external potential field, which therefore increases inner resistance and worsens the power characteristics of ultracapacitor.

Two possibilities were considered for improving the performance of ultracapacitor: 1) Increasing the energy density of ultracapacitor by improving the packing density, i.e. the steric restrictions inside pores and consequently slow down the response of electrolyte ions to the changes of external potential field, which therefore increases inner resistance and worsens the power characteristics of ultracapacitor.

Further steps

Further R&D in EDLC design and electrochemical characteristics has to be carried out in order to produce ultracapacitors mature for space applications. The main requirement is to move from a single cell prototype level towards a reliable product level and assemble working modules from the prototype. Also in parallel with the latter further research has to be done in order to achieve beyond state-of-the-art electrochemical characteristics and critical environment performance. Critical environment performance testing has to be carried out with relevant industry players such as Thales Alenia Space, EADS Astrium, Surrey Satellite Technology Ltd, etc in order to validate ultracapacitor applicability for space.

Contact

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