National Aeronautics and Space Administration

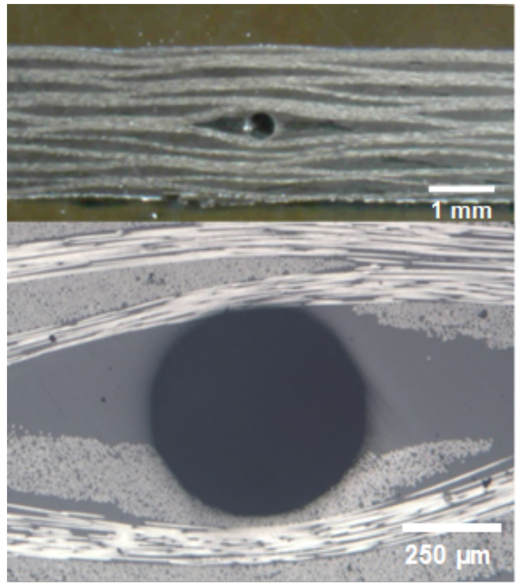
NASA facts

Small Spacecraft Active Thermal Control

Micro-vascular Composites Enable Small Satellite Cooling

The Small Spacecraft Integrated Power System with Active Thermal Control project endeavors to achieve active thermal control for small spacecraft in a practical and lightweight structure by circulating a coolant through embedded micro-vascular channels in deployable composite panels. Typically, small spacecraft rely on small body mounted passive radiators to discard heat. This limits cooling capacity and leads to the necessity to design for limited mission operations. These restrictions severely limit the ability of the system to dissipate large amounts of heat from radios, propulsion systems, etc. An actively pumped cooling system combined with a large deployable radiator brings two key advantages over the state of the art for small spacecraft: capacity and flexibility. The use of a large deployable radiator increases the surface area of the spacecraft and allows the radiation surface to be pointed in a direction allowing the most cooling, drastically increasing cooling capacity. With active coolant circulation, throttling of the coolant flow can enable high heat transfer rates during periods of increased heat load, or isolate the radiator during periods of low heat dissipation.

The Vaporization of Sacrificial Components (VaSC) technique used in this project allows miniature channels to be formed in structures made from composite materials through the use of a proprietary polymer which is embedded in the composite structure. After curing the composite, the polymer is removed through a vaporization process and a void is left where the polymer used to be. Using this technique, complex networks of micro-vasculature can be embedded in composite radiator panels through which gases or liquids may be circulated. The VaSC technique enables the manufacture of vascular channels with sizes and proportions impossible with any other technique. Furthermore, the ability to embed channels in composite materials enables the manufacture of vascular radiator panels much lighter than those made of metals such as copper, stainless steel, or even aluminum.



Twelve-layer carbon fiber panel with embedded 0.5 mm channel formed using

This technology is a key enabling factor to allow small spacecraft to explore the solar system beyond low Earth orbit. Existing NASA small spacecraft launching to the moon are experiencing technical issues related to overheating radios, under-clocking processors and duty-cycling limiting thruster systems. With the application of active thermal cooling, these problems are addressable and the range of technologies available to existing and future NASA missions opens significantly. The technology developed by this project will significantly reduce risk, unlike a passive system, as it can prevent over-cooling by reducing the fluid circulation rate. The technology will also allow for easy handling of short duration excessive heat loads, allowing advanced processors to ramp up their computations on an as-needed basis without concern for overheating. This system is also highly adaptable, and can be integrated directly into other deployable systems, such as solar panels. This can offer the further advantage of not only providing a cooling radiator in an orientation guaranteed to be positioned away from the sun, but also of providing a direct cooling path for the solar panels themselves.

Beyond satellites, this technology has multiple secondary Earth-based applications. It can be applied to electric vehicle battery blocks, which need constant cooling. The battery casings themselves can be built out of the same composite material as the spacecraft radiator, enabling the coolant to be in direct contact with the battery cells. It also has applications for aviation: as modern aircraft are now constructing their wing skins out of composite materials, these could have heated fluids pumped through micro-vascular embedded channels to prevent icing.

The Small Spacecraft Integrated Power System with Active Thermal Control project is led by the University of Illinois at Urbana-Champaign in the Center for Advanced Research for the Exploration of Space (ARES) in partnership with the NASA Ames Research Center in Moffett Field, California.

The project is funded through the SmallSat Technology Partnerships, a program within the Small Spacecraft Technology Program (SSTP). The SSTP is chartered to develop and mature technologies to enhance and expand the capabilities of small spacecraft with a particular focus on communications, propulsion, pointing, power, and autonomous operations. The SSTP is one of nine programs within NASA's Space Technology Mission Directorate.

For more information about the SSTP, please visit: http://www.nasa.gov/smallsats

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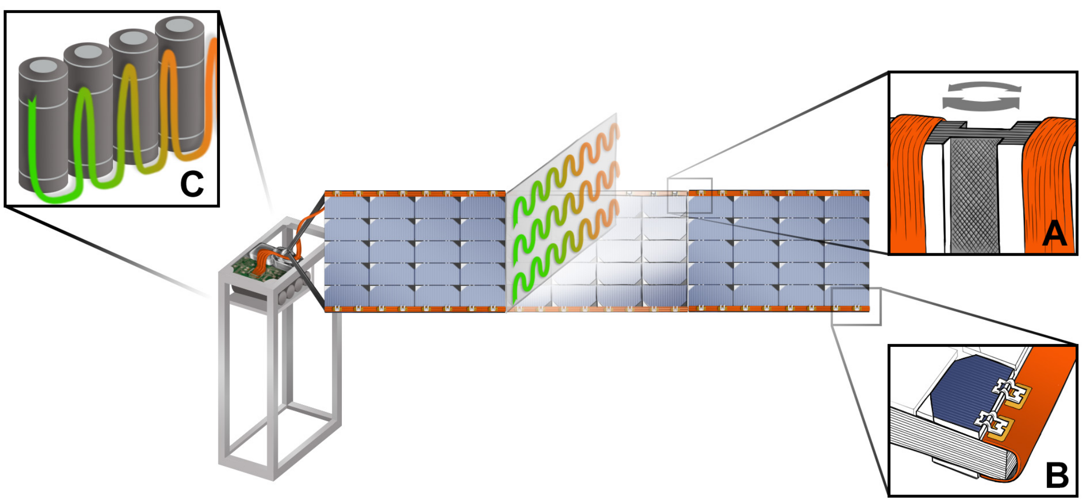

Example of a deployable integrated power generation and thermal control system on a gimbal in the context of a 6U bus – the microvascular composite radiator deploys normal to the back of the solar array. A – an integrated composite hinge allows the deployable to be stowed. B – solar cells mount to a FPC interconnect. C – the battery pack is housed in a microvascular composite casing allowing thermal regulation of the cells.

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