

# New thermal coatings for spacecraft and satellites developed using metamaterials

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The SpaceX Dragon spacecraft arrives at the International Space Station. Copyright: NASA. The SpaceX Dragon spacecraft arrives at the International Space Station. Credit: NASA

A team of researchers, which includes the University of Southampton, have developed new technology which could prompt a significant change for a spacecraft or satellite.

Metamaterial optical solar reflectors (meta-OSRs) are the first-surface coatings on the outside of a spacecraft, designed to effectively radiate infrared heat away from it while reflecting most of the optical solar spectrum.

For a satellite or spacecraft, the OSRs play a crucial role in the system's thermal control. Glued to the external skin of the radiator panels, OSRs are designed to reject solar radiation and dissipate the heat that is generated on board.

OSRs are commonly made of quartz tiles that combine thermo-optical properties with an ability to withstand the environment in space.

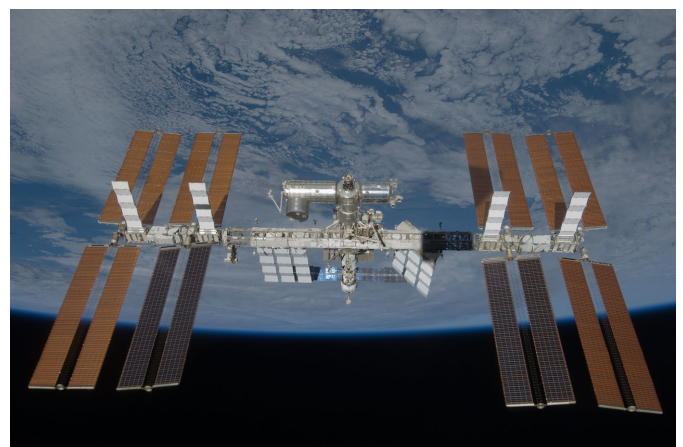
However, quartz tiles are heavy and fragile, add

significantly to assembly and launch costs, and cannot be applied to curved surfaces. Other commercial solutions based on polymer foils suffer from fast performance degradation and are therefore unfit for missions lasting more than three to five years.

The team demonstrated that a new meta-OSR coating is enabled by the use of metal oxide, a material commonly used for transparent electrical contacts, which, in this instance, is patterned into a metamaterial with very strong infrared emissivity while retaining a low absorption of the solar spectrum.

The team also demonstrated a 'smart' radiator based on their metamaterial design, which allows tuning of the radiative cooling of the spacecraft using another type of [metal oxide](#).

Prof Otto Muskens, from the University of Southampton and principal investigator of the study, said: "The meta-OSR [technology](#) is entirely based on durable and space-approved inorganic coatings, which can be applied onto flexible thin-film substances with the potential to be developed as a [new technology](#) solution.



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The International Space Station seen from Space Shuttle Discovery. Credit: NASA

"Since the assembly and launch costs of OSRs is several tens of thousands of US dollars per square metre, even small improvements in weight reduction can make a significant change to the space industry."

Supported by a two-year Horizon 2020 space technology project, the University of Southampton is a member of the META-REFLECTOR consortium, which also includes the Italian research centre Centro Ricerche Elettro-Ottiche (CREO), Danish nanoimprint developer NIL Technology and Thales Alenia Space.

The work of the consortium is featured in *ACS Photonics* in two reports: 'VO2 Thermo-chromic Metamaterial-Based Smart Optical Solar Reflector' and 'Metasurface optical solar reflectors using AZO transparent conducting oxides for [radiative cooling](#) of spacecraft'.

Dr. Kai Sun from the University of Southampton added: "All of the partners have actively worked together to ensure the design and fabrication are suitable for its transfer to mass-production. It is an exceptional research experience to transfer the cutting-edge research idea to a commercial product."

The team are currently working on upscaling the prototypes to larger areas through processes developed by NIL Technology, while first tests of the metamaterials in space are being prepared.

Dr. Sandro Mengali, from CREO who have supported the study, said: "Passive control of the thermal emissivity is important to preserve precious heat during start-up and eclipses and to maintain the temperature stability of the spacecraft.

"Currently, thermal emissivity control requires bulky mechanical components such as louvers, which are extremely expensive and prone to failure, posing significant risk to missions.

"The smart meta-OSR technology will offer a valuable new tool for thermal engineers of [spacecraft](#), of particular importance for the lightweight segment of the satellite market."

**More information:** More information regarding the META-REFLECTOR consortium is available online: [www.meta-reflector.eu/index.htm](http://www.meta-reflector.eu/index.htm)

Kai Sun et al. VO2 Thermo-chromic Metamaterial-Based Smart Optical Solar Reflector, *ACS Photonics* (2018). DOI: [10.1021/acsphotonics.8b00119](https://doi.org/10.1021/acsphotonics.8b00119)

Kai Sun et al. Metasurface Optical Solar Reflectors Using AZO Transparent Conducting Oxides for Radiative Cooling of Spacecraft, *ACS Photonics* (2017). DOI: [10.1021/acsphotonics.7b00991](https://doi.org/10.1021/acsphotonics.7b00991)

Provided by University of Southampton

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