Graphene Used Successfully in Space

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CHANTILLY, Va. ─ A successful collaboration between the Graphene Flagship and the European Space Agency (ESA), experiments testing graphene for two different space-related applications showed extremely promising results.

Graphene is a sheet of carbon atoms that all lie in a single plane next to one another. Graphene is extremely flexible, and the way the carbon atoms bond together makes them extremely strong and very conductive of electricity and heat. Compared to copper for example, thermal straps composed of bonded graphene sheets have 10 percent of the mass with up to twice the thermal conductivity. The challenge is producing it in large quantities.

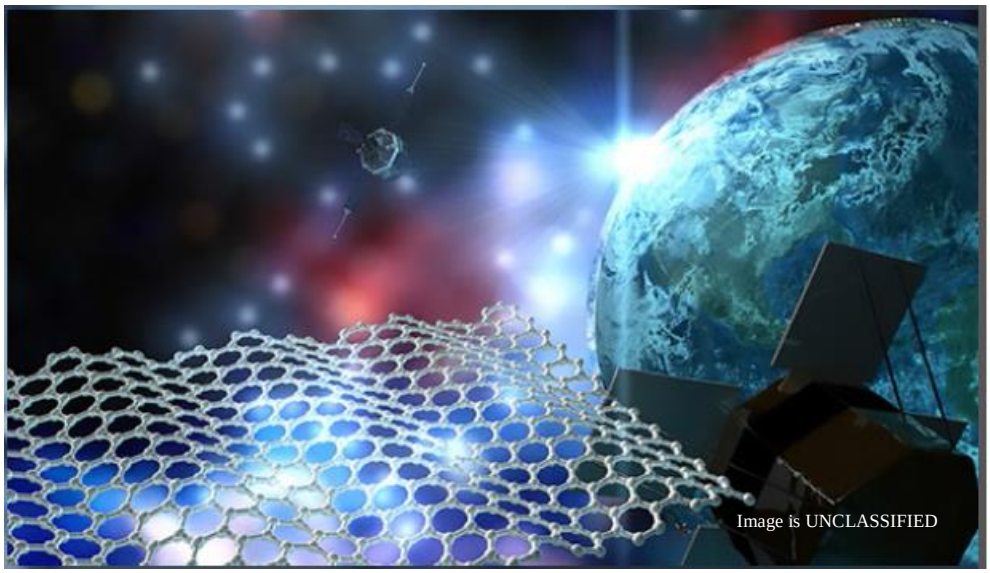
Graphene's tremendous thermal properties are promising for improving the performance of loop heat pipes and thermal management systems used in aerospace and satellite applications. Graphene could also be used in space propulsion due to its lightweight and strong interaction with light. The Graphene Flagship tested both these applications in November 2017 and February 2018 experiments.

The first experiment investigated how graphene improves heat transfer in loop heat pipes in a low-gravity environment. The main component of the loop heat pipe is a metallic wick, typically made of a porous metal. The wick transfers heat from hot objects into a coolant fluid. Cooling systems are used extensively in satellites and aerospace instruments. The wicks were coated with two different types of graphene-related materials to improve the efficiency of the heat pipe. The ESA tested coated wicks for the loop heat pipes in two low-gravity parabolic flights. The results of the parabolic flight revealed that graphene improved the wick, which means that future applications using graphene could result in improved reliability and energy management. The Graphene Flagship plans to build a full graphene-containing heat pipe that can go in a satellite.

Concurrently, a team of graduate students from Delft Technical University in the Netherlands participated in the ESA's Drop Your Thesis! Campaign. The team, named GrapheneX, designed and built an experiment to test graphene for use in solar sails using free-floating graphene membranes. The idea was to test how the graphene membranes would behave under radiation pressure from lasers. Solar sails are a form of spacecraft propulsion using radiation pressure exerted by sunlight on large mirrors. High-energy laser beams can be used as an alternative light source to exert much greater force than would be possible using sunlight. Solar sail craft offer the possibility of low-cost operations combined with long-operating lifetimes. Since they have few moving parts and use no propellant, they can potentially be used numerous times to deliver payloads.

After five tests, the scientists found that graphene responded well. They observed laser-induced motion of a graphene light sail. Due to the success of the GrapheneX experiment, the team plans to further their research by exploring how radiation pressure impacts graphene light sails.

The NRO Advanced Systems and Technology Directorate's (AS&T) Advanced Materials Division is exploring the use of graphene-bonded sheets for use as thermal straps in spacecraft. These carbon-based thermal straps might supplant their metal counterparts and find applications in such critical components as cryocoolers, antennas, electronics, and optical systems.



Artist's conception of graphene being used in space.

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