Shape Memory Polymer Composites for deployable antennas

SMART SMALL SATELLITE SYSTEMS THALES IN NTU

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Abstract:

The space industry is planning more satellite communication missions based on smaller satellites (micro, nano, pico CubeSats). Smaller satellite platforms are often power limited, therefore deployable high gain antennas could compensate for the lack of power. The objective of this activity is to develop a prototype model of a deployable high-gain antenna that exploits the advantages of a Shape Memory Polymer Composites.

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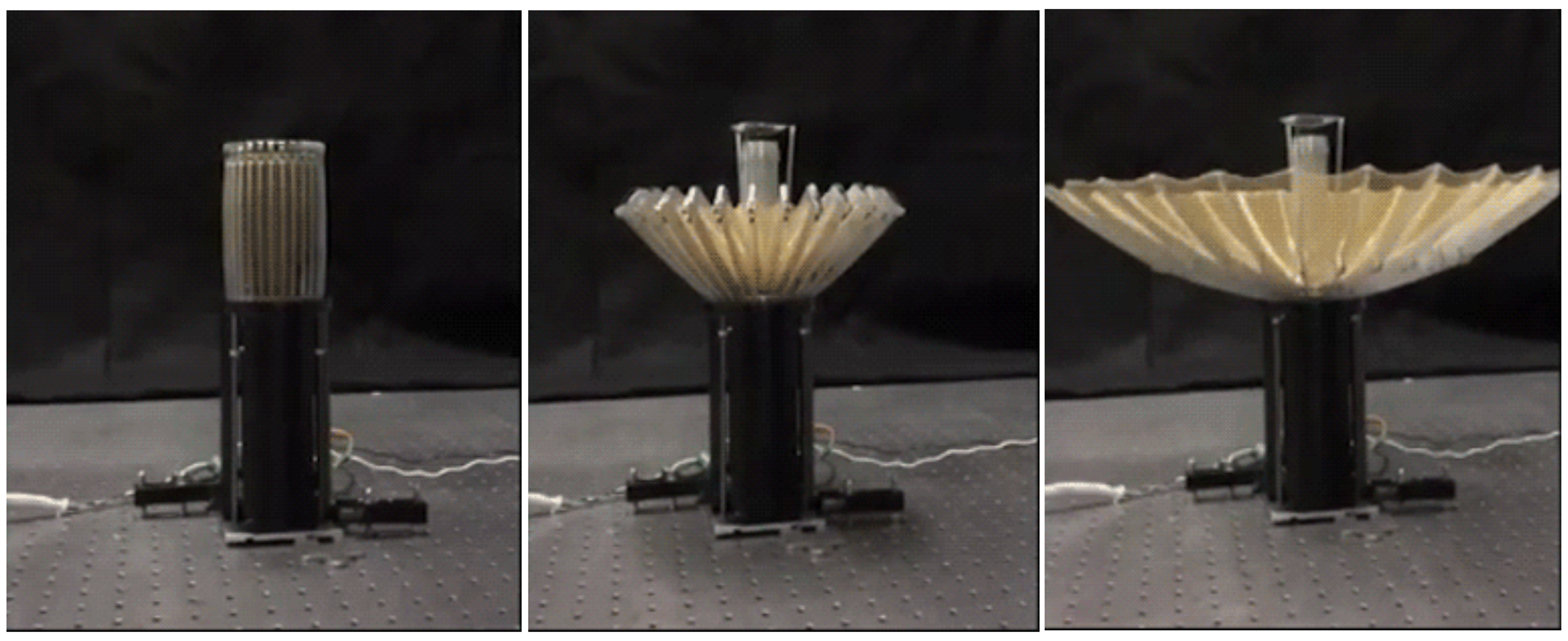

Stowed Deployed

Fig 1. State of the art – Caltech/ NASA-JPL's 0.5 m diameter deployable Ka-band (35.75 GHz) reflector antenna. Gain of 42.6 dBi.

N. Chahat, R. E. Hodges, J. Sauder, M. omson, E. Peral, and Y. Rahmat-Samii, "CubeSat deployable Ka-band mesh re ector antenna development for earth science missions," *IEEE Transactions on Antennas and Propagation*, vol. 64, no. 6, pp. 2083–2093, 2016.

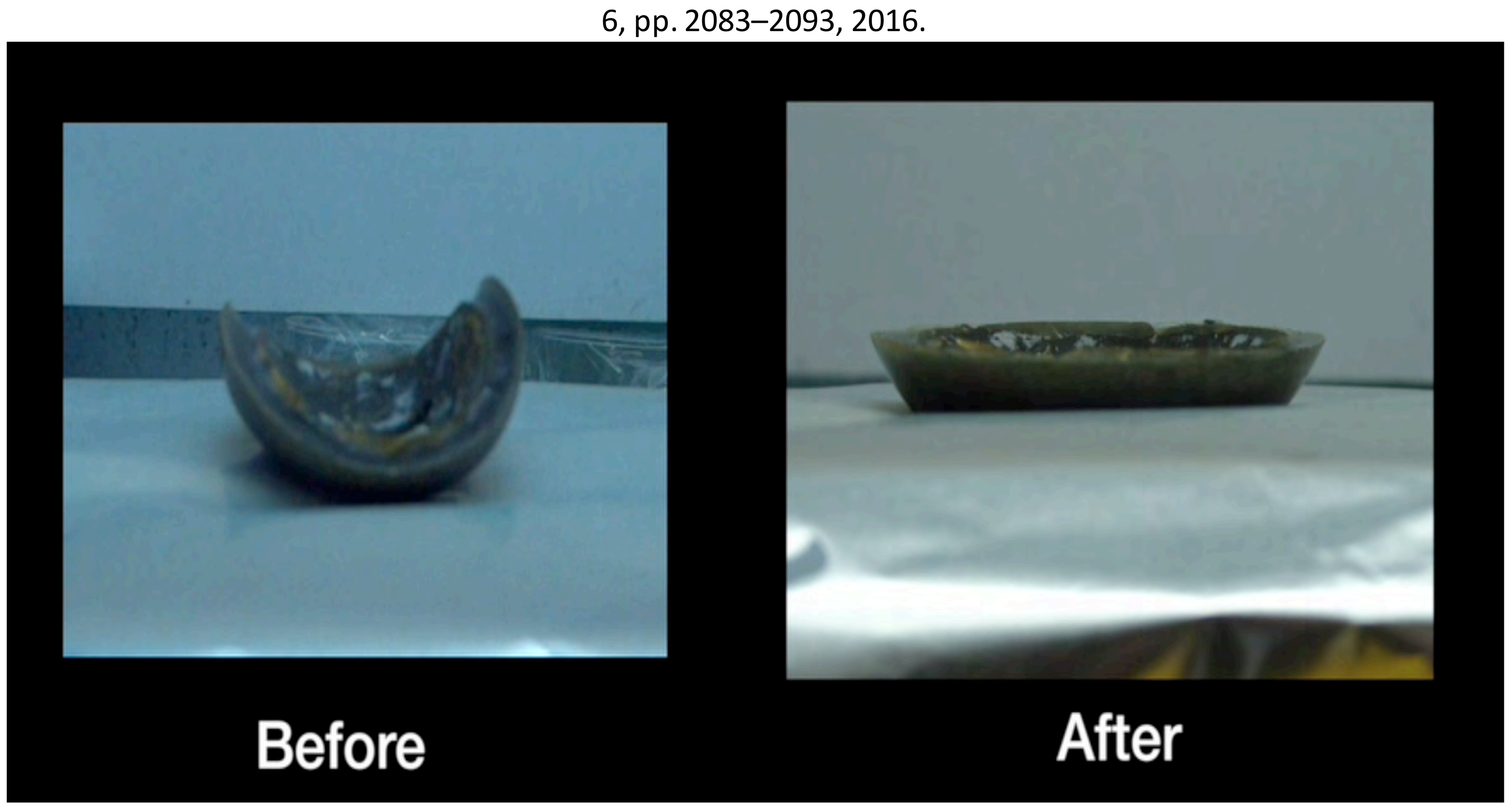

Fig 2. 3D-Graphene SMP composite device in shape of paraboloid. Thermal actuation in oven (130℃) takes 2 mins for full recovery.

Introduction:

Shape memory polymer composites are made of 1) electrically/ thermally conductive scaffold and 2) shape memory polymer matrix. By compositing SMP with a novel nanoscale carbon-based foam with high specific surface area & high porosity, a polymeric composite with good mechanical properties and thermoelectric conductivity is obtained.

Deployment of SMP reflector is done via current-induced Joule heating and with fast recovery times. Above the response temperature, the polymer matrix will soften and release stored strain energy to deploy into the pre-programmed parabolic shape. Upon cooling below the response temperature, the structure rigidizes.

Project Objectives:

Development of new Shape Memory Polymer (SMP) Composite material

to enable Reflector Antennas for CubeSats which are:

(1) Lightweight
(2) high data-throughput
(K-band and up)
(3) packaging efficient

Key Differentiators:

By incorporating a novel carbon-based nanoscale foam into the SMP polymer matrix, the antenna structure will be

(1) mechanically strong without heavy supporting structures,
(2) larger diameter, surface accurate
(3) More flexible and stronger (per unit mass) for packaging strains

Developmental Work:

Characterization of

- RF properties at different frequencies
- Reflector deployment concepts with targets requirements of low surface RMS and PIMS disturbance with Thales Alenia Space, Italy, L'Aquila, Antenna Dept

Potential Benefits:

Advantages over competing technologies		
Astromesh reflectors (SoTA)	Shape memory ALLOY	Other carbon-filled SM POLYMERS
Mesh reflector have frequency limitation of up to 60 GHz (Freeland et al, Marks et al)	Difficult to shape into curved surfaces, required for parabolic reflector profile	Requires much higher fill rates (1-5%), to achieve only moderate electrical & thermal conductivity
Non-RF reflective components accounts for more than 50% subassembly weight	Much denser than SMP	Higher fill rate also causes brittleness and limits poor bending radius/ packaging efficiency

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