Multifunctional adhesives through nano-enabling for use in space

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ADAMANT COMPOSITES

Adhesives & How Nano-enabling Can Unlock Innovation

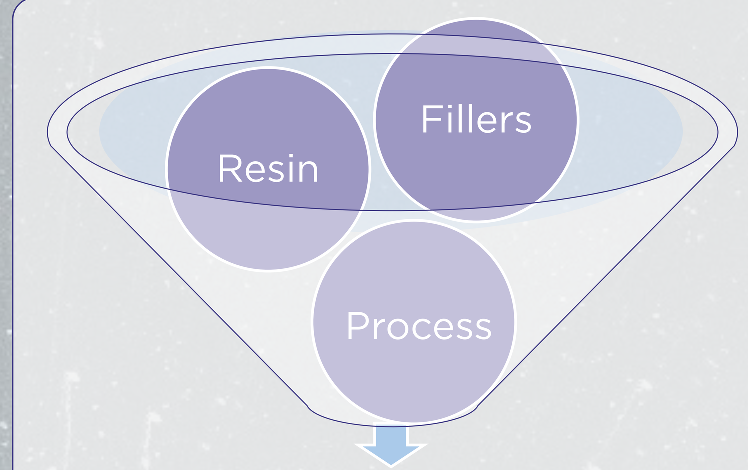
Adhesives' strengths:

- ✓ Lightweight
- ✓ Low costs
- ✓ Uniform joint
- ✓ Operator friendly
- ✓ Simple design
- ✓ Versatile
  - High variety of formulations
  - High variety of applications
- ✓ Easy to scale-up

Adhesives' limitations:

- o Inert materials
  - Thermally insulating
  - Electrically insulating
- o Lower mechanical strengths than other joining techniques
- o Organic materials
  - Degradation
  - Contamination

Nano-enabling:



Study cases:

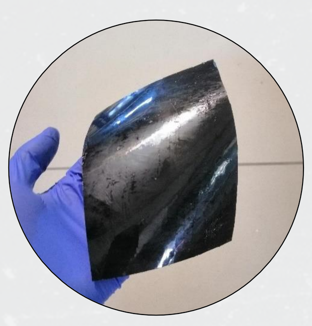
Two building blocks...

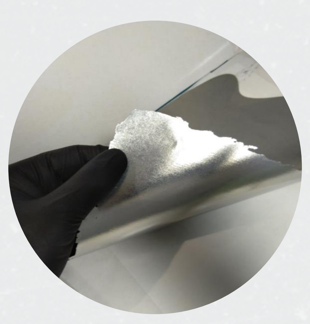
...to relieve thermal (and electrical) constraints...

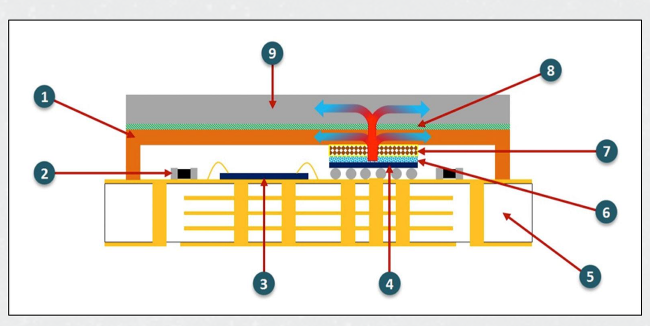
...in spacecrafts.

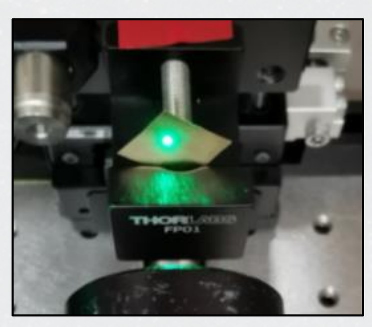
Film Adhesive for Space Electronics

Through HEATPACK, technological building blocks were developed in order to improve heat propagation in electronic packaging for spacecrafts and unlock innovative applications. The nano-enabled B-stage film shall offer thermal and electrical, on top of structural bond strength, while being space-qualified & REACH-compliant. Although the thermal conductivity is the driving development property, the film adhesive must be able to survive in the space environment!









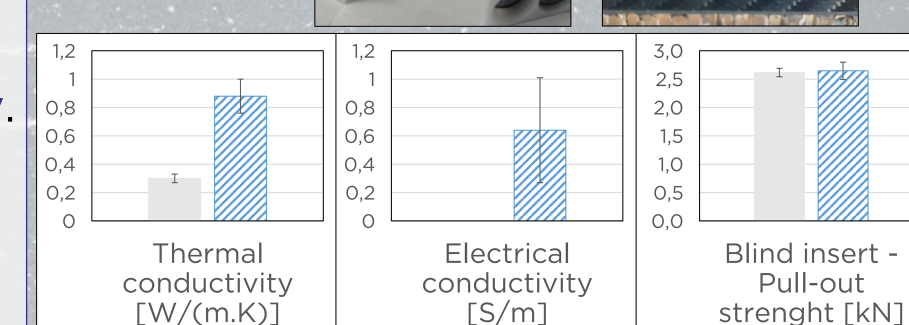
Property	Functionality & compliance to the space environment	Film value
Thermal & Electrical Conductivity	• Intrinsic conductivity depends on the fillers (chemistry/surface/microstructure/fraction) • Interface resistance can be significant. • Thinner films have a lower resistance. • Investigation at different temperatures & after thermal shocks.	Thermal cond. Up to 6,4 W/(m.K) Electrical cond. Up to 5,5x10^{-3} S/m Thickness 100-140um
Shear strength	The joint strength should be evaluated as it is and after thermal shocks.	Under evaluation.
Outgassing	Outgassing is mainly a property of the epoxy and is not affected by inert fillers.	Compliant with ECSS TML = 0,770% / CVCM = 0,001% / RML = 0,273%
Ionic impurity	Ionic impurity is important due to the proximity with electronics.	Low ionic impurity (e.g., Cl- 179ppm, K+ 5.2ppm)
Glass transition Temperature	Tg can be tuned through the fillers (hindering polymeric chain freedom of movement)	Tg=80°C-100°C
CTE	Lower CTE enables thermomechanical stability.	[-90°C;+85°C]: 27ppm/K
To be extensively qualified at the system level (incl. vibration, constant acceleration, thermal shocks, thermal cycling, etc.) in order to reach TRL6.		

Paste Adhesive for Spacecrafts' Structure

Adhesives are extensively used in spacecrafts through insert potting. A typical satellite has more than 2500 inserts. Nano-enabling the potting adhesive brings an additional thermal path into the spacecraft's structure, but also facilitate grounding by making the potting material a conduction path.

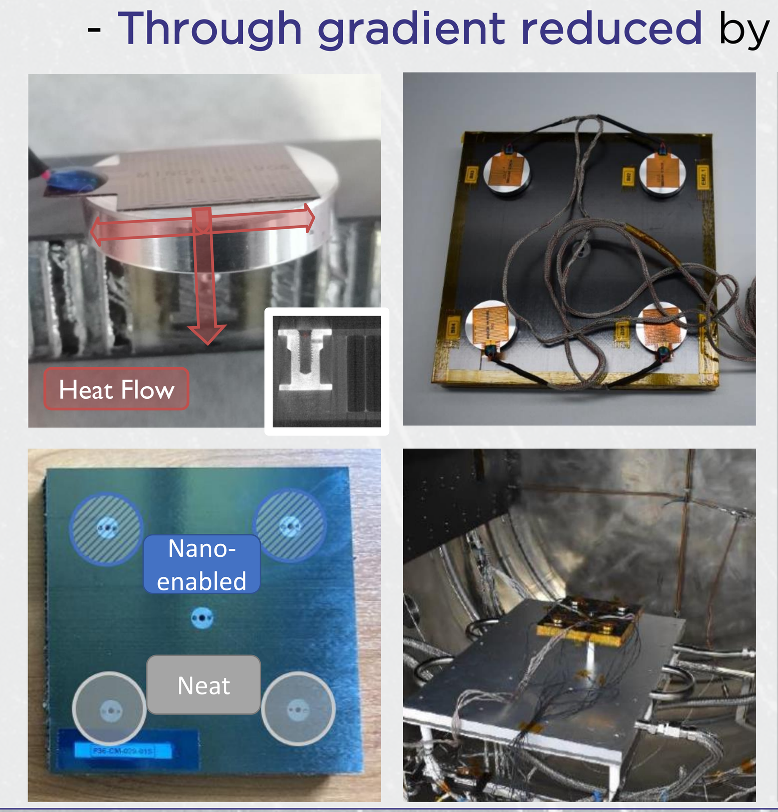
At the material level, the nano-enabled adhesives exhibited:

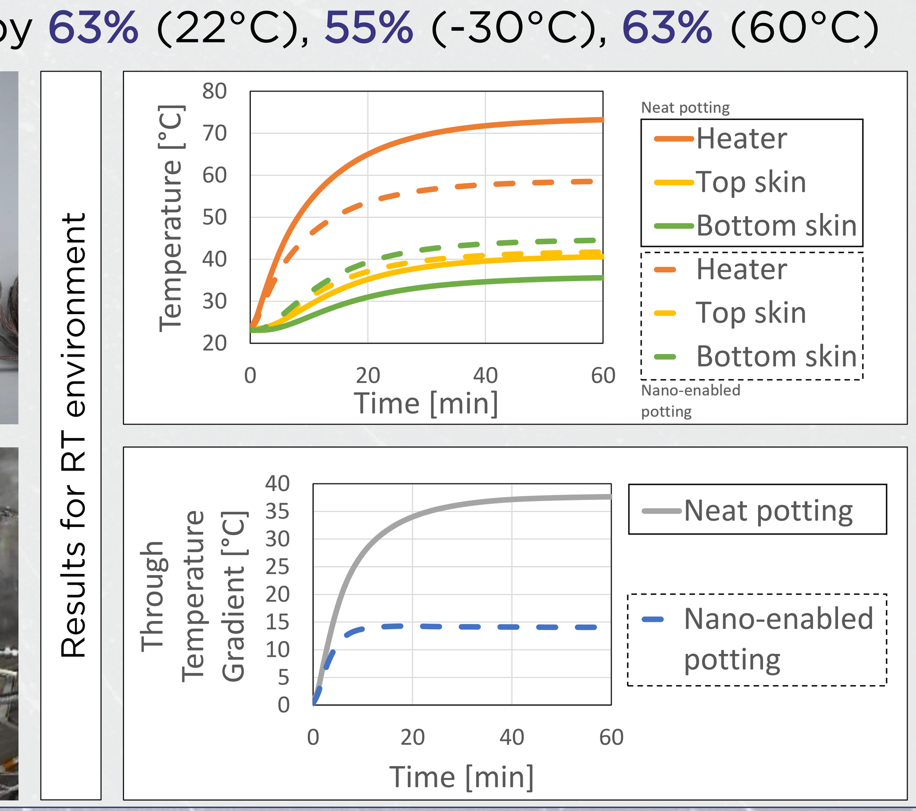
- A two-fold thermal conductivity.
- A measurable electrical conductivity.
- No effects on the pull-out strengths.



(full grey: neat; stripped blue: nano-enabled)

- ➢ Design of demonstrators to prove the thermal benefice in operation.
- ➢ Heaters to simulate the heat commonly created by an equipment and thermal sensors to monitor the heat spread in time.
- ➢ Environment: TVAC (10^{-5}mbar), 3 different chamber temperatures (22°C, -30°C, 60°C)
- ➢ Outcomes:
  - Reduction in reached temperatures and faster equilibrium
  - Through gradient reduced by 63% (22°C), 55% (-30°C), 63% (60°C)





Nano-enabling as a versatile and promising tool for space (and above)

Wide range of functionalities

- **Thermal conductivity**
- **Electrical conductivity**
- Mechanical strength (ex: fracture toughness)
- Flame retardant
- Radiation shielding, etc.

...not limited to adhesives

- Carbon-fiber reinforced polymers
- Foams
- Etc. (any polymer-based materials)

Wide range of applications in space

- **Structure**
- **Electronics assembly**
- Electronics enclosure
- Optical bench
- Shielding

... and above

- Energy (ex: battery package)
- Automotive
- Sport goods (ex: diving fins)
- Marine applications, etc.

The B-stage film adhesive has been developed with funding under the **European Commission H2020** grant agreement No 821963 (Project: HEATPACK "new generation of High thErmAl efficiency componenTs PACKages for space").
The testing and qualification of the film adhesive was made in collaboration with **Thales Alenia Space** (France), the **University of Bristol** (UK) and **Warsaw University of Technology** (Poland).

The paste adhesive has been developed under the contract 4000126884/19/NL/AR/zk from the **European Space Agency** (Project: HITEC "High Thermal and Electrical Conductive Bonding Materials for Space").
The testing and qualification of the paste adhesive was made in collaboration with the **University of Patras** (Greece) and **Beyond Gravity Germany** (Germany).

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