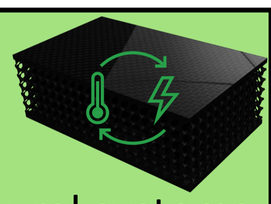
Smartwiches

Additively manufactured Smart nano-enabled thermoplastic Triply Periodic Minimal Surface cores for Energy-autonomous Sandwich composite panels

Project Overview



Smartwiches aims to develop next-generation multifunctional 3DP sandwich composite meta structures.
The project integrates **Additive Manufacturing** & **Nanotechnology** to create lightweight, **Energy-autonomous** structural systems.

Challenge Statement

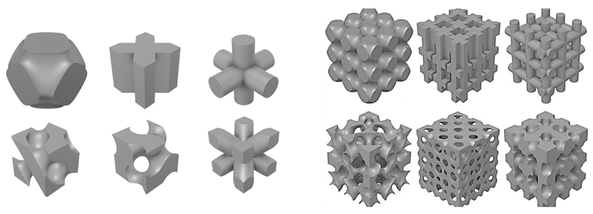
☑ Modern engineering structures demand lightweight, high-performance & multifunctional materials.

☐ Conventional sandwich composites, although efficient in strength-to-weight ratio ratio, suffer from:

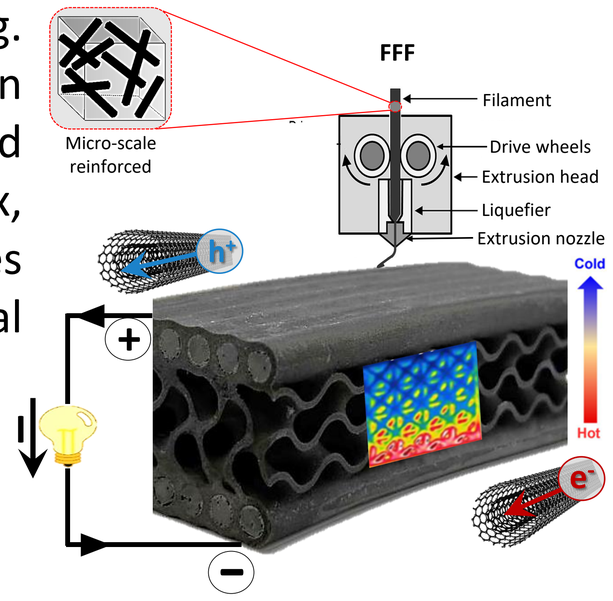
- Brittle failure mechanisms in core materials
- Lack of multifunctionality (e.g. structural components act simultaneously as load-bearing elements & energy harvesters)
- Inefficient utilization of thermal management
- Limited integration with Industry 4.0 smart systems (e.g. self-powered sensing & real-time monitoring)

Vision

◎ Additive Manufacturing e.g. Fused Filament Fabrication (**FFF**) unlocks micro-reinforced thermoplastic complex, topology optimized geometries such as Triply Periodic Minimal Surface (**TPMS**) lattices



*3D printed TPMS unit cells towards **nano-enabled** TPMS cores*



Energy-autonomous Sandwich panels with variable stiffness

Research Objectives

- Semiconductor physics investigation of new organic p- & n-type molecularly doped carbon nanomaterials
- Development & characterization of novel p- & n-type thermoelectric films on planar substrates & within 3DP microporous TPMS scaffolds
- Fabrication & testing of 3DP TPMS cores with variable stiffness & energy harvesting features
- Demonstration of 3DP sandwich panel with increased power density & real-time monitoring attributes

Key Innovations

- 3DP recyclable thermoplastic TPMS cores eliminate stress concentrations, enabling tailored mechanical performance for advanced engineered applications
- 3DP thermoplastic TPMS by design microporous scaffolds facilitate the controlled formation of conductive segregated networks with tunable electronic properties at low nanofiller loadings due to high surface area
- 3DP recyclable thermoplastic multifunctional sandwich panels with fully integrated self-powered sensing arrays

Expected Results

- Highly efficient p- & n-type thermoelectric TPMS segregated structures based on “carbon negative” active materials usage & environmental footprint
- High performance engineered thermoplastic TPMS core structures with enhanced mechanical properties
- Validation of multifunctional 3DP sandwich composite panel demonstrator as thermoelectric generator with ultra-responsive self-sensing capabilities

Expected Impact

- **Civil Infrastructure:** Smart panels with real-time monitoring for increased safety & durability
- **Aerospace & Automotive:** Lightweight, high-performance structures for reduced CO_2 emissions
- **Energy Systems:** Conversion of wasted heat into usable electric power through embedded thermoelectric generators
- **Defense Applications:** Enhanced reliability & multifunctionality in demanding environments

Host Institution

University of Ioannina

Physics Department

Research Project ID

- **Principal Investigator:** Dr George Karalis (g.karalis@uoi.gr)

- **Scientific Area:** Engineering Sciences & Technology
- **Scientific Field:** Chemical and Materials engineering
- **Scientific Subfield:** Materials engineering
- **Project Duration:** 24 months
- **Total Budget:** 99,550.00 €

Acknowledgements

This research was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “4th Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers” (**Project Number:** 28695).

H.F.R.I. Hellenic Foundation for Research & Innovation