

Nano- and Micro- Fabrication based research at RMC

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RMC: Research Fields

- Mechanical and Aerospace Engineering
- Chemistry and Chemical Engineering
- Electrical and Computer Engineering
- Physics

- CFI/PAMM (RMC)

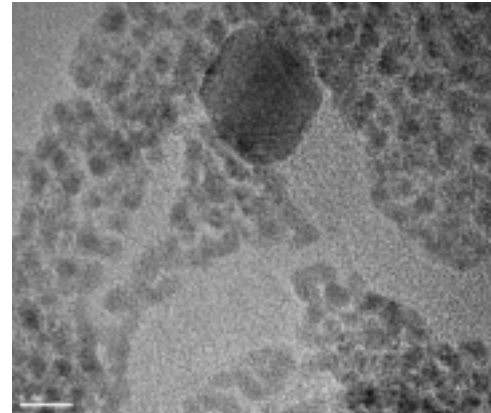
PAMM Contribution

- **RMC**
 - Mechanical and Aerospace Engineering
 - Chemistry and Chemical Engineering
- **Methodology:**
 - High-fidelity simulations will guide nanofabrication
 - Characterization of prototypes in the later stages
- **Applications:**
 - Nanoreactors applied to energy and materials
 - Nano-catalysis
 - Advanced nanomaterials (*e.g.* Graphene/Nanotubes)
 - Space-related nanotechnology-based application for spacecraft
 - Electric propulsion for micro-satellites and nano-satellites

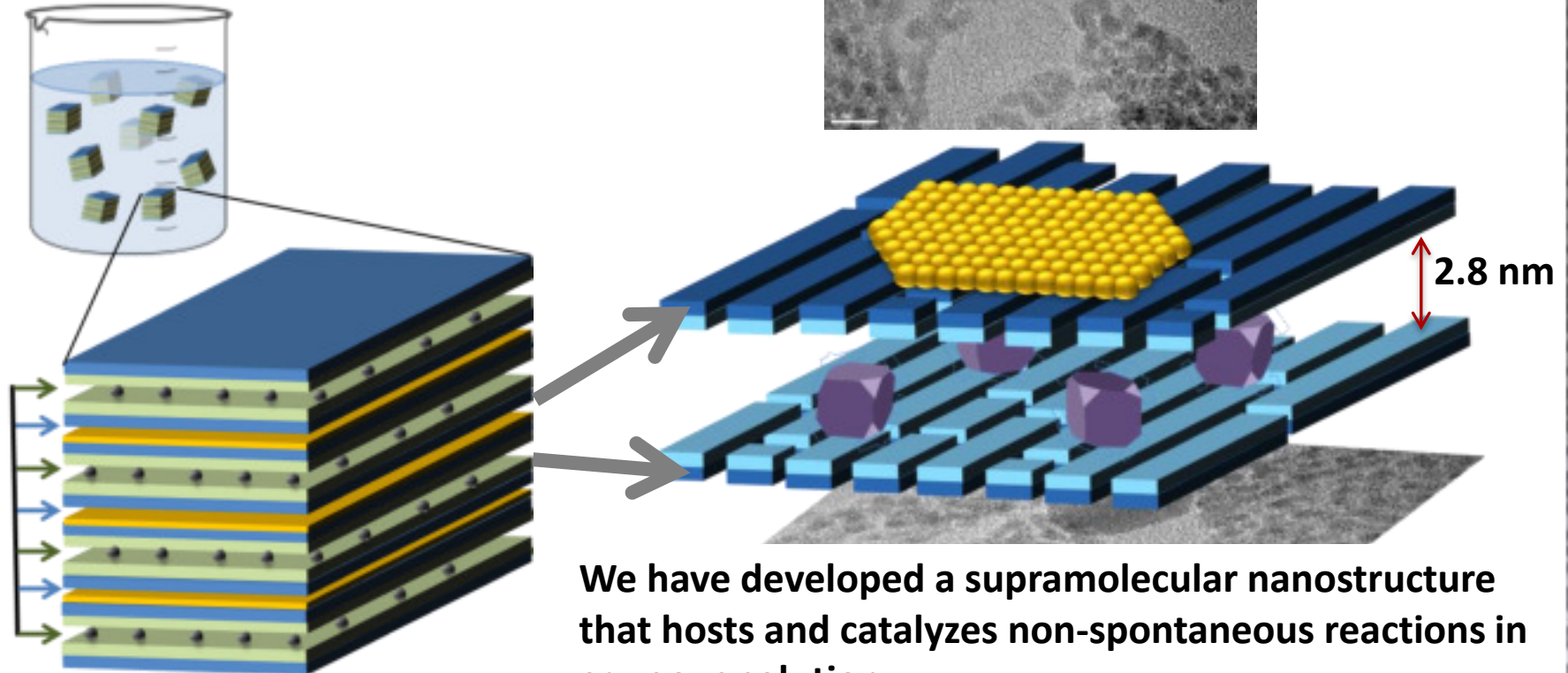
Nanoreactors: Mimicking natural processes

Enzyme structure provides nanoscale reaction spaces which increase substrate concentration and reactivity combining:

- **Confinement**
- **Metal catalysts**



Unsupported nanoreactors in aqueous environment at neutral pH

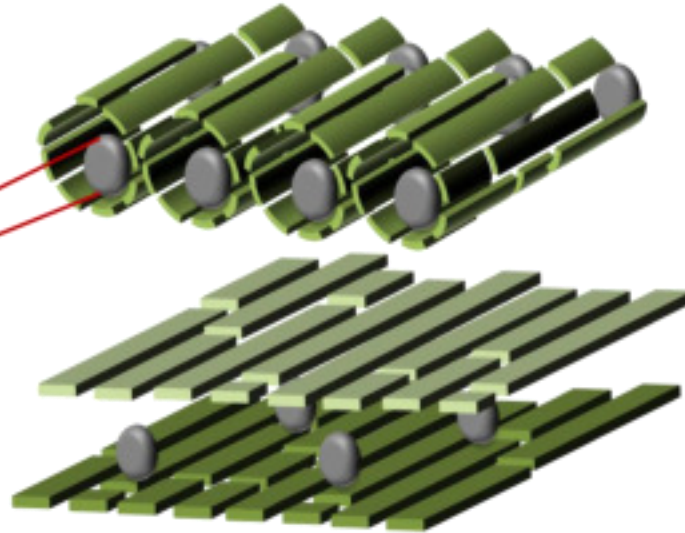
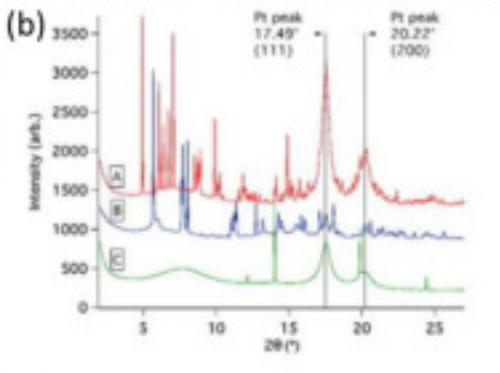
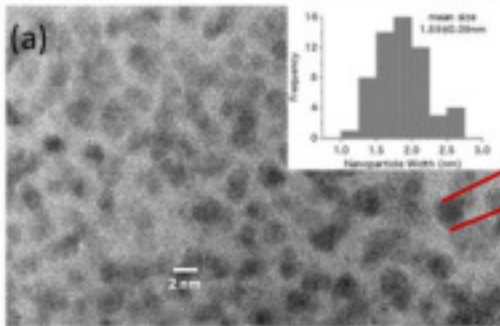


Confined hydrophilic and hydrophobic active centers

We have developed a supramolecular nanostructure that hosts and catalyzes non-spontaneous reactions in aqueous solution.

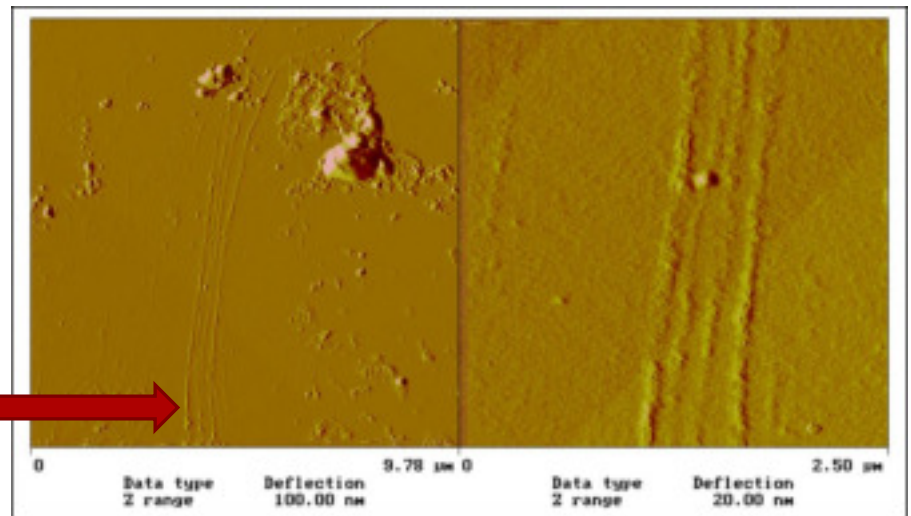
McTaggart et al. Chem. Phys. Lett. 2015

Synthesis of Nanowires



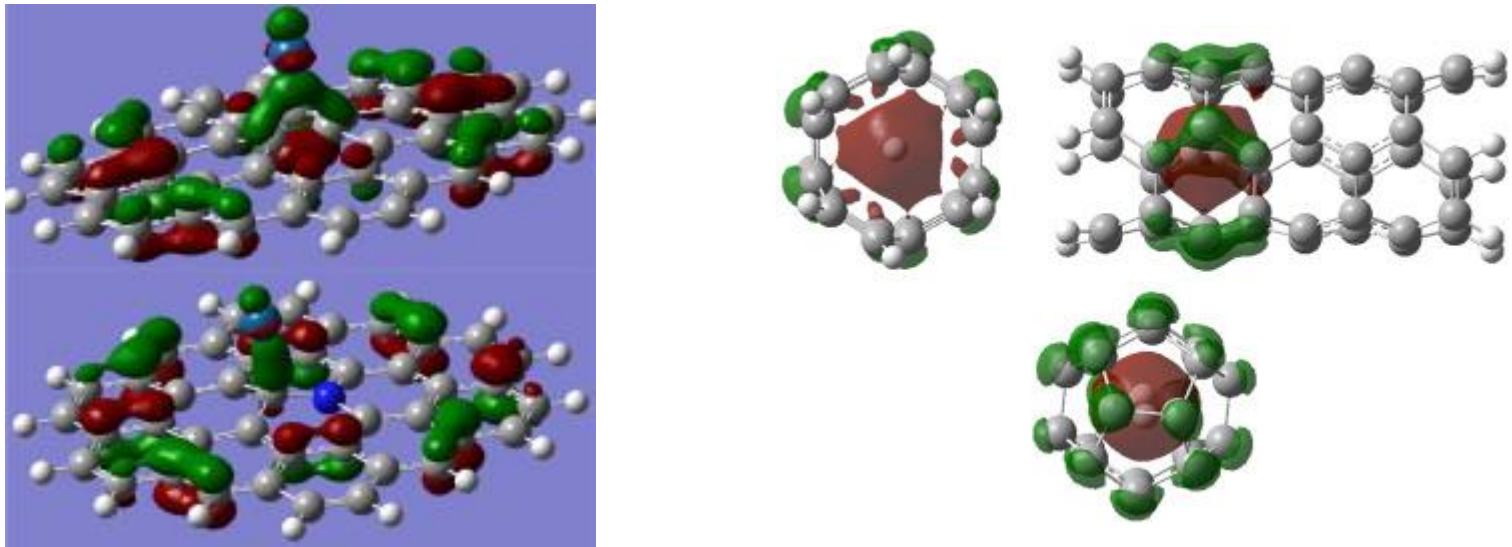
Polypyrrole growth inside the nanotubes

Polypyrrole Nanowires ~ 2.5 nm in diameter



Nanotube/Graphene related Research

- Doping of graphene and carbon nanotubes: improved stability and catalytic efficiency



C. Malardier-Jugroot *et al.* Graphene Science Handbook: Nanostructure and Atomic Arrangement, 305-318, 2016, CRC Press

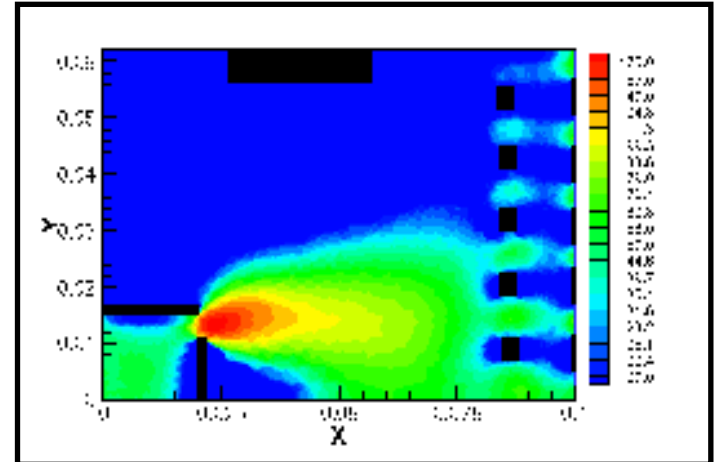
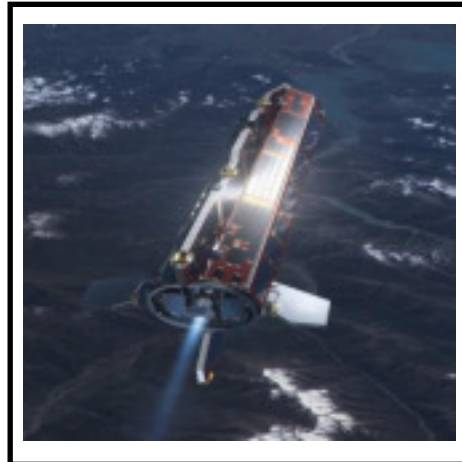
C. Malardier-Jugroot, *et al.*, “Development of environmentally friendly nanoreactors”, International Patent, WO2015/024093A1, 2016

Development of plasma-based microsystems

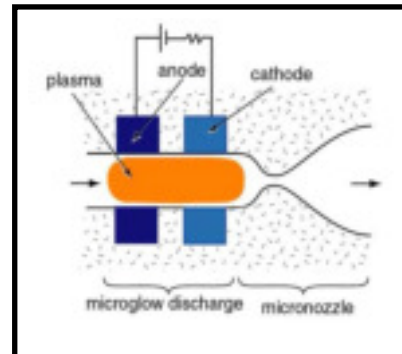
- **Mechanical and Aerospace Engineering**
- Research Theme: Ionised Gases and Plasmas
- Objectives: Investigate Complex Phenomena in Gases/Plasmas
- Methods: High-fidelity simulation as design aid
- Applications: Advanced Electric Propulsion for Spacecraft
Microsystems, Micro-propulsion
Active Flow control for Aerospace applications

Electric propulsion for Spacecraft

- High exhaust velocity (10 x compared to classical)
- Fuel efficiency
- Micro-satellites



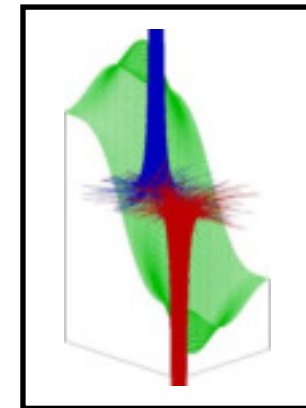
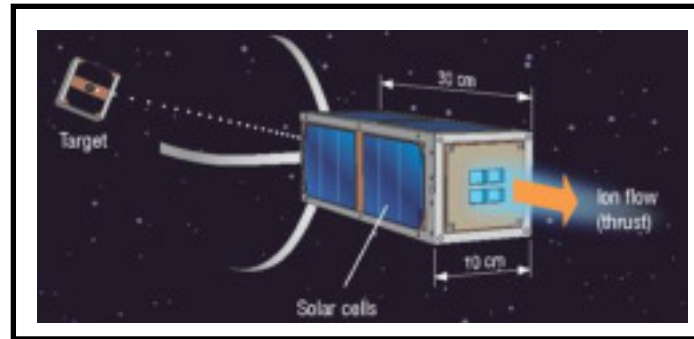
Electric Spacecraft Propulsion: Ion thruster



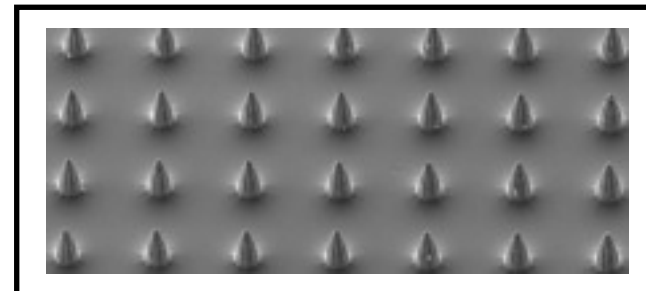
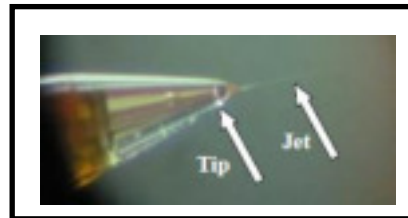
Nanofabrication of elements or entire miniaturized engine

Electric propulsion for Spacecraft

- Nanofabricated electrospray
- Self-neutralizing
- Nanosatellites



Electric Spacecraft Propulsion: Colloid thruster



Single emitter – or nanofabricated array (NASA)

PAMM: Space Simulation Conditions

- Enhance capabilities for Space Simulation testing
- Advanced materials and spacecraft sub-systems/propulsion
- Low pressure space conditions
- Low temperature



PAMM: Deposition and Nanoimprint



a) Low Pressure CVD Reactor

a-1) Gas Cabinet – H₂ & CH₄

a-2) Exhaust Gas Scrubber (H₂ & CH₄)

b) Semi-automated Top Side Nano Imprint Lithography System



Hard Stamp: 1" x 1" active imprint area, ≤ 50 nm pattern resolution

Soft stamp: Up to 150 mm active imprint area, ≤ 50 nm pattern resolution

PAMM: Elemental and Structural Analysis

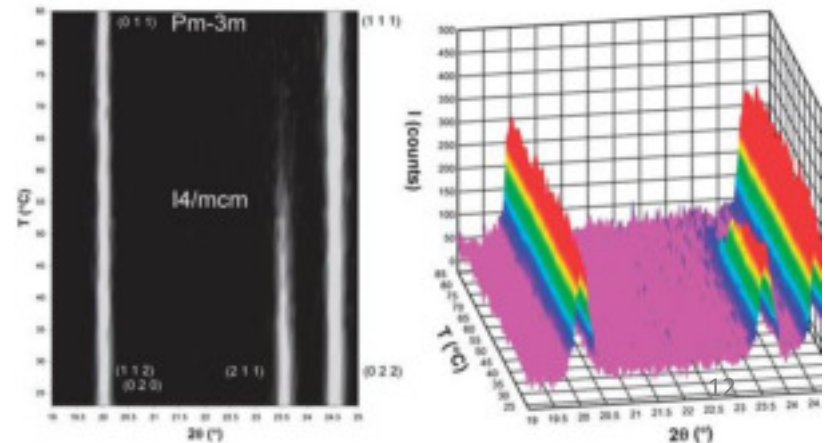


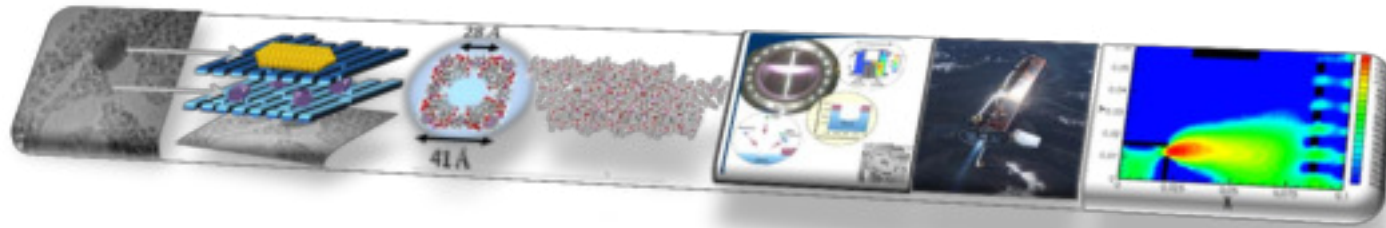
WDXRF for detailed elemental analysis of thin films and liquid samples:

- bulk elemental analysis with mapping
- small spot analysis
- evaluates up to 90 elements
- solid or liquid samples



X-Ray diffractometer for analysis of powder and thin films including polycrystalline materials





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