

# Thermo-electro-mechanical couplings in organic matrix composites for aircraft applications

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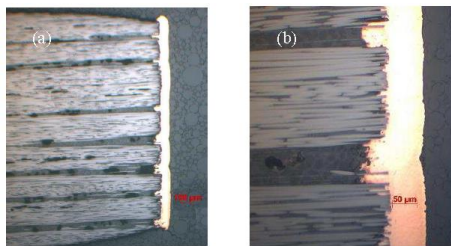
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Partners: AIRBUS GROUP INNOVATIONS Suresnes, AIRBUS SAS Toulouse, ONERA, MMSMAT-EC Paris, PIMM-ENSAM Paris, ICA Toulouse, LMOPS University of Chambéry

Research programs: FNRAE VICOMTHE (2008-2010)

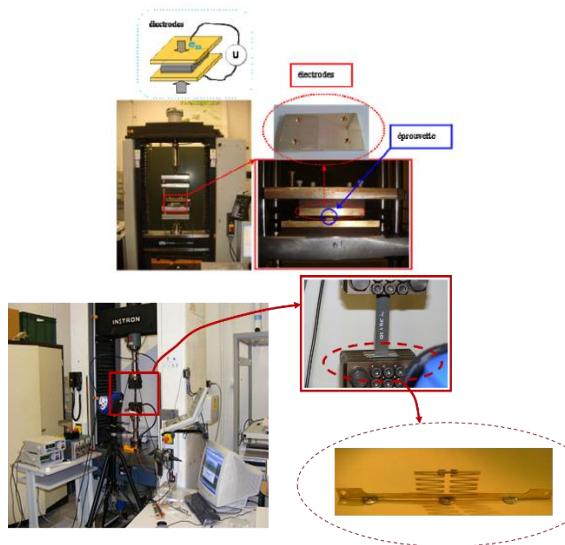
Experimental tools: Voltage measurement, Infrared thermography, Electro-mechanical fatigue, dedicated compression test for through-the-thickness electrical resistivity

Context: The aim of this operation is to characterise the thermoelectric behaviour of CFRP laminates and the effect of electric currents of several intensities and duration on the mechanical/physical behaviour of functional composites. This aim is carried out by building and developing specific experimental test (coupled, uncoupled, multi-scale ...) and by interpreting them by the aid of dedicated multi-physical/multi-scale models based on the Thermodynamics of Irreversible Processes. The models are implemented into commercial finite element software (such as, for instance, ABAQUS).

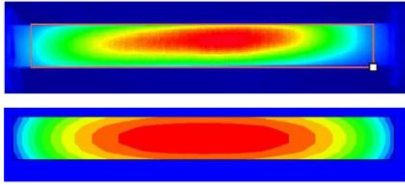


## Characterisation of the thermoelectric behaviour of CFRP laminates and of the effects of electric currents on the mechanical behaviour of functional OMC

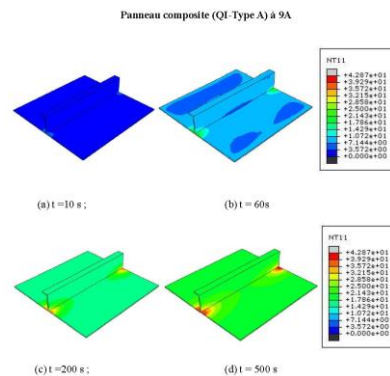
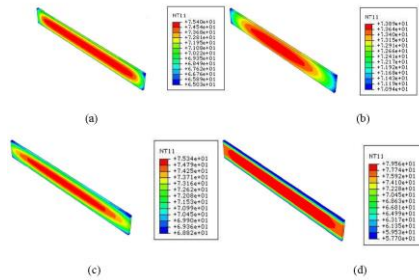
- ✓ Carbon fibers, epoxy matrix, carbon nanotubes
- ✓ Voltage/resistance/conductivity measurements
- ✓ Dedicated compression setup for the accurate measure of the through-the-thickness conductivity of OMC
- ✓ Electrical aging
- ✓ Electro-mechanical fatigue



## Modelling of thermo-electro-mechanical couplings



- ✓ Employment of Thermodynamics of Irreversible Processes for the development of coupled multi-physics models
- ✓ Development of dedicated subroutines (UMAT/UEL) in the commercial finite element software ABAQUS for the simulation of thermo-electro-mechanical coupling in composite materials



### Publications:

- Lin, Y., Gigliotti, M., Lafarie-Frenot, M.C., Bai, J., Marchand, M., Mellier, D. (2015) "Experimental Study to Assess the Effect of Carbon Nanotube Addition on the Through-Thickness Electrical Conductivity of CFRP Laminates for Aircraft Applications", *Composites Part B: Engineering*, 76: 31-37
- Lin, Y., Gigliotti, M., Lafarie-Frenot, M.C., Bai, J. (2015) "Effect of Carbon Nanotubes on the Thermoelectric Properties of CFRP Laminate for Aircraft Applications", *Journal of Reinforced Plastics and Composites*, 34: 173-184
- Gigliotti, M., Lafarie-Frenot, M.C., Lin, Y., Pugliese, A. (2015) "Electro-Mechanical Fatigue of CFRP Laminates for Aircraft Applications", *Composite Structures*, 127: 436-449
- Lin, Y., Gigliotti, M., Lafarie-Frenot, M.C., Bai, J. (2014) "Thermo-electrical Coupling Effect on Tensile and Fatigue Strength of Composite Materials for Aeronautical Application", *Acta Aeronautica et Astronautica Sinica*, 2014 issue 12: 3315-3323
- Gigliotti, M., Grandidier, J.C., Lafarie-Frenot, M.C. (2011) "Development of Experimental and Modelling Tools for the Characterisation of the Thermo-electro-mechanical Behaviour of Composite Materials for Aircraft Applications", *Mechanics & Industries*, 12: 87-101