6 months Internship Offer 2025: Development of polymeric alveolar structures for aerospace impact applications

Location: Institut Clément Ader – IMT Mines Albi, France

Context: Sandwich structures are widely used in lightweight applications due to their exceptional strength-to-weight ratio, achieved by placing a low-density core between two rigid skins (such as composites or metals). Various core configurations have been explored in the literature, including Nomex® and aluminum honeycombs, lattice structures and similar designs [1]. Among these, alveolar structures, and more particularly polymeric foams, offer a promising and customizable solution. This class of materials provides a versatile approach to integrate multiple functions within the sandwich structure without significantly increase its mass [2]. A particularly interesting application is the use of foam-cored sandwich panels in impact-resistant design. Impact loads primarily produce out-of-plane strains, which are largely dependent on the core material rather than the skins. This has led to an extensive body of research focusing on the properties of core materials for impact applications [3]. One of the primary challenges in this field is developing foams with exceptionally low density while retaining mechanical performances, as density and mechanical properties are typically inversely related. A promising approach involves using in-situ expandable reactive foams, which allow the alveolar structure to form directly during the manufacturing process, rather than assembling pre-formed cores with the skins. However, these materials are particularly challenging to manage because the foaming and solidification steps are highly dependent on processing conditions. This method offers advantages such as tunable manufacturing processes and the ability to incorporate specific fillers and short fibers, enhancing the mechanical properties of the foam. Additionally, it enables the integration of out-of-plane stiffening elements directly during processing, which can further improve the structural response of the sandwich panel. However, the integration of expandable cores within composite structures remains particularly complex, highlighting the need for further innovation in both manufacturing techniques and material design.

Internship objectives: In this context, the intern will focus on developing foaming techniques using reactive thermoplastic and thermoset polymers to create polymer foams suitable for integration into sandwich structures. Techniques such as emulsification, the use of expandable additives and monomer evaporation will be investigated. After identifying the most promising techniques, the integration of fillers and short fibers to enhance the mechanical properties of the foams will be explored. The most relevant formulations will be initially characterized through optical microscopy to assess cell size and structure (open or closed cells), triple weighting method to determine density and open porosity, and quasi-static mechanical compression tests to evaluate mechanical performances. Finally, the most promising foams will be further tested using a drop tower test to measure energy absorption capacity.

Profile: Final-year engineering student or Master's student specializing in polymer and composite materials engineering, with a strong background in physico-chemical properties, polymer rheology. Experience with reactive thermoplastic or thermoset processing techniques would be an asset.

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Duration: 6 months **Level:** Engineering school, last year **Start:** February 2025

References:

[1] Castanie, B., Bouvet, C., Ginot, M. Review of composite sandwich structure in aeronautic applications, *Composites Part C: Open Access*, 1 (2020) 100004
[2] Wu, G. et al. A review of thermoplastic polymer foams for functional applications, *Journal of Material Science*, (2021), 56:11579-11604
[3] Dorival, O., Navarro, P. et al., Experimental results of medium velocity impact tests for reinforced foam core braided composite structures, *Journal of sandwich structures & materials*, 20(1), 106-129, 2018