Composite joint toughening by multiscale architecturing through integrated manufacturing

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The intensive use of Carbon Fibre Reinforced Polymer (CFRP) Composites in aerospace is motivated by their high strength to weight ratio. However, the manufacturing of complex aeronautic structures combining metallic and composite parts requires an efficient bonding process [1]. Joints obtained through bonding with adhesives suffer from low to moderate toughness [2] and the process requires multiple steps separating the manufacturing of the composite parts and the bonding. Several strategies have been proposed to enhance the joint toughness, such as introducing a mesh or cavities in the bondline [3]. One strategy to improve the efficiency of the process is to bond the metal part to the composite panels during the curing process, without using any adhesive. On the road to the integrated bonding of hybrid metallic composite structures, the present works investigates potential toughening strategies by bonding composites via co-curing of two composites parts while relying on joint architecturing principles.

The co-curing of the composite parts is performed through resin transfer moulding. Architectured films made of tough patterned thermoplastics such as polyamide and polyetherimide are inserted at midplane (Fig.1). The bondline made of the composite resin and tough thermoplastic structures replaces conventional adhesives. Double cantilever beam samples are extracted to determine the mode I fracture toughness.

A stick-slip behaviour is systematically found associated to the heterogenous joint pattern. For all joints, the lower bound arrest toughness is ~800 J/m² while energy release rate during crack propagation is at least equal to 2000 J/m², as rationalized by fracture mechanics concepts. This is higher than most reported values for classical composite bonding, closer to 1000 J/m² [2]. The micromechanical origin of the high toughening potential is unravelled through fracture surface analysis and finite element models including the details of the joint architecture.

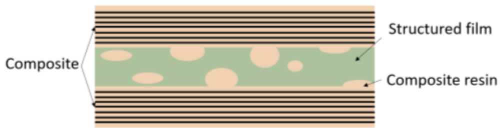

Fig. 1: Schema of joints with architectured bondline

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