Damage mechanisms and mechanical properties of directly bonded CFRTP and aluminium with nano-structured surface

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In recent years, the aerospace and automobile industries are increasingly focusing on decreasing the weight of the structures to improve the fuel efficiency and thereby reduce the global CO_2 emissions. As a result, lightweight, stiff and strong carbon fibre reinforced plastics are increasingly replacing metals in the design. Particularly, carbon reinforced thermoplastics (CFRTPs) are of recent interest due to their high impact performance along with their great formability and possibility for recycling. In addition, initiatives for moving away from heavy mechanical joints such as “a fully bonded aircraft” are arising. However, it is rarely feasible to replace an entire structure with CFRTPs, and thus dissimilar material bonding, will be necessary to achieve such goals. However, adhesively joining CFRTP to commonly used metals such as aluminium generally results in low bonding strength, and thus alternative bonding methods are of interest. Thus, the current study investigates the mechanical properties and damage mechanisms of a recently proposed method to directly bond CFRTP and aluminium by altering the aluminium surface. This is achieved by a combination of anodizing and etching treatments followed by a silane coupling treatment, resulting in a nano-structure on the aluminium surface (e.g. Fig. 1). After the treatment, the CFRTP and aluminium are bonded by hot-pressing. High static bonding strength is confirmed by single-lap tensile tests. In addition, double cantilever beam (DCB) and end notched flexure (ENF) tests monitored by a digital image correlation (DIC) camera both under static and fatigue loading are carried out to investigate the mechanical properties and damage mechanisms in more detail. DIC is used to track the local deformation of the specimen edge by applying a random pattern paint, making it possible to measure the local crack opening and shear displacements. Fig. 2 shows an example of the crack and points tracked by DIC. This allows for the determination of the cohesive law, which can be directly used in finite element simulations.

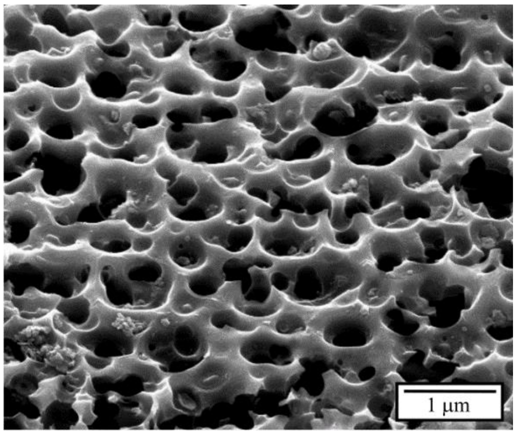

Figure 1. Example of one type of nano-structure manufactured on the aluminium surface.

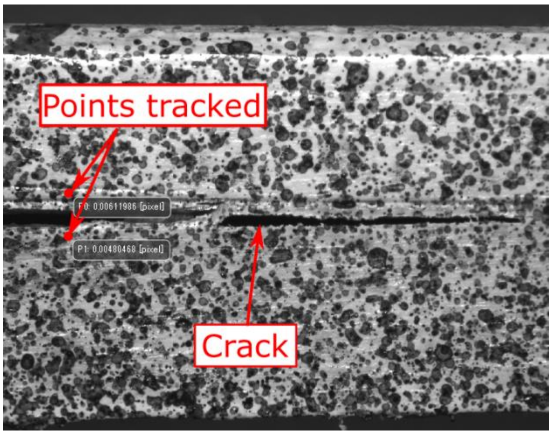

Figure 2. Example of the DCB specimen during crack growth with random pattern paint

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