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Investigation in situ des mécanismes d'endommagement dans un composite polyamide renforcé par des fibres courtes

In situ SEM damage mechanisms investigation of short glass fiber reinforced polyamide composite

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Injection molded polyamide composite reinforced with short glass fibers has been widely used in automotive industry due to its high strength to weight ratio and the ability of injection process to produce complex parts. A reliable design of components made of this composite should consider the development of progressive properties degradation due to the damage. A better understanding of the damage mechanisms shall contribute to a better formulation of local damage criteria and thus to include with a higher accuracy the physical modeling of their effects to predict the overall mechanical behavior of the composite.

For this purpose, in situ SEM tests were performed to observe the damage mechanisms of injection molded polyamide-66 reinforced with 30%wt of short glass fibers (PA66GF30). The observation was focused on dry as mold state (0% water content) of PA66GF30, which correspond to a relative humidity RH=0%. The specimens were subjected to a flexural load using a three-point bending micro-device and were assembled inside an environmental SEM to allow the in situ observations. Specimens were cut following two specific orientations with respect to the mold flow direction (MFD): longitudinal and transverse. Prior to observation, the surface samples were polished and metalized with gold. As the polyamide absorbs water during polishing, the samples were put after polishing inside a vacuum oven at 80°C for 15h to ensure that the RH content goes back to zero in the whole sample.

Results show that the damage mechanisms for both longitudinal and transverse orientations were similar. The damage was initiated from fiber ends and from the locations where the fibers are close one another (Fig. 1).

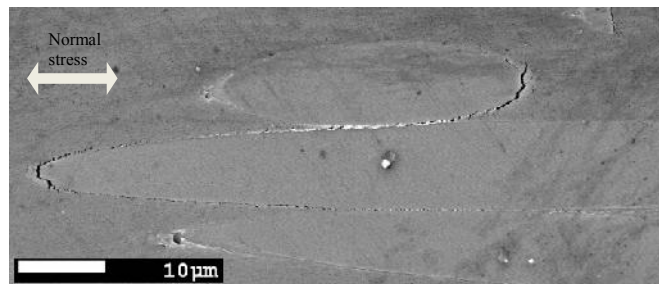


Fig. 1. Damage initiation at fiber end and interface decohesion at the location where fibers are close one another for a load $P=56\%$ of S_{UTS}

The damage then propagated to the entire interface of the fiber. Afterwards, crack propagation in the form of transverse crack were formed at the locations where fibers are close each other (Fig. 2). These transverse cracks then lead to a damage accumulation and then the final failure of the sample. It was also found that the damage has a diffuse nature at the tensile zone of the flexural loading while damage was localized in few fiber/matrix interfaces at the compression zone of the flexural loading.

These experimental findings are of importance for identifying local damage criteria that are currently implemented into a predictive micromechanical model [1]. To this end, the multi-scale model would be extended to integrate fiber-matrix interface damage kinetic coupled with the viscous rheology of the thermoplastic matrix in relation with the PA66GF30 composite material microstructure.

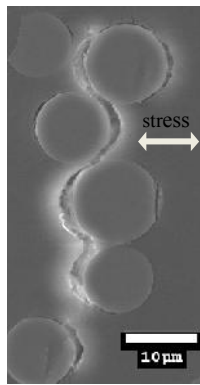


Fig. 2. Crack propagation in the form of interface debonding and transverse crack for a load $P=81\%$ of S_{UTS}

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References

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