New optical sensors to detect moisture diffusion in glass fibres reinforced polymer composites

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INTRODUCTION

Glass Fibre Reinforced Polymers (GFRP) composites are of growing interest due to their low cost and convenient fabrication. However, it is necessary to undertake accurate structural monitoring of composites, to prevent failures.

In this research, novel Optical Fibre Sensors (OFSs) have been designed and fabricated to detect moisture diffusion through the epoxy matrix of GFRP [1].

MATERIALS AND METHODS

Optical glass (GIF 625 silica multimode fibre, Thorlabs) were chemically etched to reach the core, where the light is confined, exposed to the surrounding environment [2]. Moreover, they were cut and a silver coating was deposited on each tip to make them work as single termination probes. The sensors were later embedded in GFRP plaques. The GFRP samples were fabricated using an epoxy resin (Ampreg 26, Gurit) and E-CR glass fibres (Advantex) with simple infusion technique where two plies of glass fibre where disposed with orientations of 0° and 90° and the optical sensors placed between the plies. The uncured plate was left at room temperature for 24 hours and then thermally cured at 80 ℃ for 5 hours.

RESULTS AND DISCUSSION

The smart GFRPs were immersed in simulated sea water at 80 ℃ at 50 Bar of Nitrogen for 1 day. The novel optical sensors were able to detect the early stage water diffusion through the composite as an attenuation of the optical signal provided by the reflective tips. A notable signal drop occurred after approximately 3.5 hours, Fig. 1. This reduction corresponded to the time at which the moisture reached the exposed core of the optical glass fibre sensor. The diffusion experiments showed satisfactory levels of reproducibility and accuracy.

The GFRP samples were mechanically tested (ASTM D3039) to evaluate the influence of the OFSs on mechanical properties. The results reported in Tab. 1 shows that the sensor presence does not significantly affect composite strength.

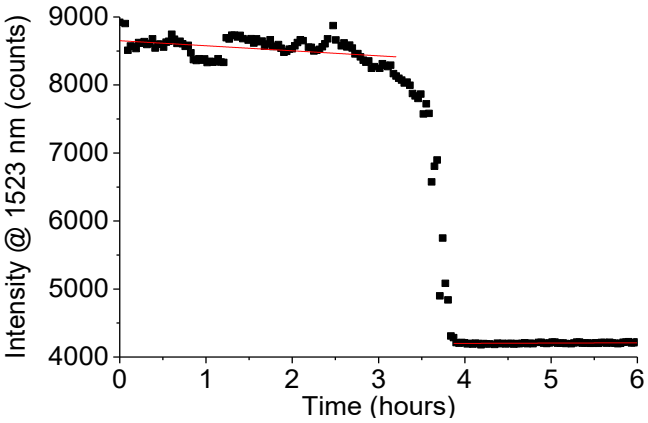

Figure 1: Optical intensity of a signal at 1523 nm provided by an embedded OFS, during a water diffusion test.

Table 1. Tensile test results.

	Tensile strength (MPa)	Elastic Modulus (GPa)
GFRP	367.3 ± 14.9	21.8 ± 5.2
GFRP + OFS	355.8 ± 23.4	20.4 ± 2.9

CONCLUSIONS

Novel optical glass fibre sensors were successfully fabricated and tested in GFRPs. The results demonstrated the potential for monitoring water diffusion in composites. Tensile testing showed that sensor inclusion had little effect and corroborated that OFSs do not affect the material mechanical performance.

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Acknowledgements

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642557.