Effects on bond strength and quality of embedding optical glass fibre sensors in adhesively bonded joints formed by structural film adhesives

N. Grundmann*, H. Brüning†, K. Brune† and B. Mayer†

* Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM)
Wienerstraße 12, 28359 Bremen, Germany
e-mail: neele.grundmann@ifam.fraunhofer.de, web page: https://www.ifam.fraunhofer.de

† Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM)
Wienerstraße 12, 28359 Bremen, Germany
web page: https://www.ifam.fraunhofer.de

ABSTRACT

The development of an SHM system for monitoring adhesively bonded CFRP joints is of growing importance due to the increasing application of CFRP parts in aircraft construction over the past decades. Integrating a sensor system for SHM purposes directly in an adhesively bonded joint presents the advantage of direct stress/strain monitoring in the adhesive without interfering CFRP layers [1]. But embedding a sensor in the adhesive bears the risk of significantly reducing the bond strength [2, 3]. Therefore, special attention should be paid to the intrusive effects on the bond strength that the sensor embedding might have. Optical glass fibres carrying Fibre Bragg Grating sensor (FBGs) are particularly suitable for embedding in adhesively bonded joints due to their small dimensions.

In this work, the influences of embedding optical glass fibres with different cladding diameters and coating types on bond strength and quality of structural film adhesives are investigated. Fibres with cladding diameters of 50 µm, 80 µm and 125 µm and either Acrylate or Polyimide coatings are included in the research. Since the research focusses on bonding of CFRP structures in the aeronautic industry, the fibre-coating combinations are tested with the film adhesives FM 300K® and FM 300-2® by Cytec Industries Inc. The use of FM 300K® and FM 300-2® poses challenges for embedding optical glass fibre sensors and their coatings such as high temperatures during the curing process, the thin film layer thickness and the fabric carrier in the film adhesive. Visual inspections and single lap tensile shear tests are performed. In addition, the effects of ageing on samples with different embedded optical glass fibres are investigated.

Finally, S-N-curves (single lap shear fatigue) are generated with samples carrying the polyimide coated 80 µm glass fibres to investigate the long term effect that sensor embedding has on the fatigue strength of the adhesively bonded join.

REFERENCES

[1] [1] Webb, S., Shin, P., Peters, K., Zikry, M. A., Stan, N., Chadderdon, S., Selfridge, R., Schultz, S. (2014): Characterization of fatigue damage in adhesively bonded lap joints through dynamic, full-spectral interrogation of fiber Bragg grating sensors: 1. Experiments; Smart Materials and Structures, Volume 23(2), Article ID 025016

[2] [2] Canal, L. P., Sarfaraz, R., Violakis, G., Botsis, J., Michaud, V., Limberger, H. G. (2014): Monitoring strain gradients in adhesive composite joints by embedded fiber Bragg grating sensors; Composite Structures, Volume 112: 241–247

[3] [3] Da Silva, L. F. M., Moreira, P.M.G.P., Loureiro, A.L.D. (2014): Determination of the strain distribution in adhesive joints using Fiber Bragg Grating (FBG), Journal of Adhesion Science and Technology, Volume 2