Self- Sensing behaviour in glass fiber based epoxy laminates using MWCNTs

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SHM is the process of implementing damage detection and characterization strategy for engineering structures. It can provide cost savings by reducing the number of scheduled non-destructive evaluation (NDE) services, thus reducing the number of hours the structure is out of service. In addition it can provide real time monitoring, evaluating the strain levels observed, and providing real-time data for health and monitoring systems.

The addition of nanoreinforcements to the matrix of composite materials entails a fundamental advantage: they can be used as internal sensor of the state of the material. Over the past decade, carbon nanotube composites have been extensively studied for their mechanical, thermal, electronic, and optical properties. However, the area where nanotube additives could have their most dramatic impact is in in situ health monitoring and damage prognosis. This area of research has largely been overlooked so far.

Thostenson and Chou [1] conclude that carbon nanotube network is sensitive to matrix-dominated damage mechanisms such as microcracking and transverse cracking in fiber composite while acoustic emission is more sensitive to energy release as delamination and fiber breaking. So, real-time monitoring of electrical resistance data may provide information on the transition of damage from matrix cracking to delamination and fiber breakage. Marioli-Riga et al. [2] have reported the use of carbon nanotubes as sensors of the strain state of glass fiber composite materials, proving the existence of an immediate change of electric resistance of multiscale/multifunctional composite material due to the application of a mechanical strain, both tensile and compression. There is also a direct correlation between the applied mechanical stress and the change in the electric resistance.

In this work the electrical conductivity change effect during an electromechanical tensile test of glass fiber reinforced epoxy/CNT laminates is studied in order to assess the use of these nanomaterials as self-sensing structures for health monitoring applications.

Different glass fiber reinforced epoxy/CNT laminates are manufactured by hand lay up, where the macro-reinforcement consisted of 800gsm glass fiber. The CNT loading level used is 0,5%wt. The applied curing cycle is 8h@80ºC, and 0,5bar of vacuum.

The 250x15x2mm samples are tested by means of tensile test (ISO 527-4) using an Universal Instron 5500 equipment (test speed: 2mm/min). On the other hand, electrical conductivity measurements are performed using a Keithley 2410 source/meter. The electrical conductivity is studied in four different configurations for each sample (in all the cases 0,1mA was applied) (Fig.1).

Electromechanical tests, where resistivity measurements are carried out at the same time as the mechanical load is applied, are also performed; The trend in all the samples shows an increase of the resistance while increasing the applied tensile load (Fig.2). The gauge factor is obtained for stress monitoring. It is defined as the ratio between the electrical resistance change and the elongation of the sample during the electromechanical test. $GF = (\Delta R/R)/\xi$ (Fig.3).

A lineal relation is preferred in order to be able to predict the material behaviour. The samples studied in oblique configuration present a higher curvature than the surface configuration samples, so, for sensing properties the surface configuration leads to having the better results.

References

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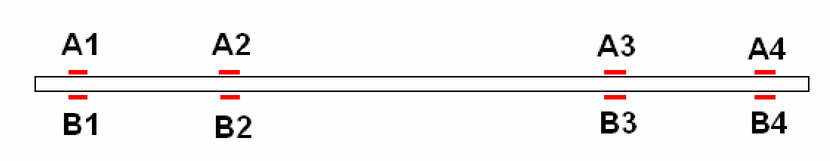
[2] N. D. Alexopoulos, C. Bartholome, P. Poulin, Z. Marioli-Riga. Composites Science and Technology 70, (2010) 260-271

Figures



CONFIGURATION	APPLIED CURRENT	MEAN VOLTAGE
A	A1-A4	A2-A3
B	B1-B4	B2-B3
C	A1-B4	A2-B3
D	A4-B1	A3-B2

Fig.1 Different configurations in electrical conductivity test

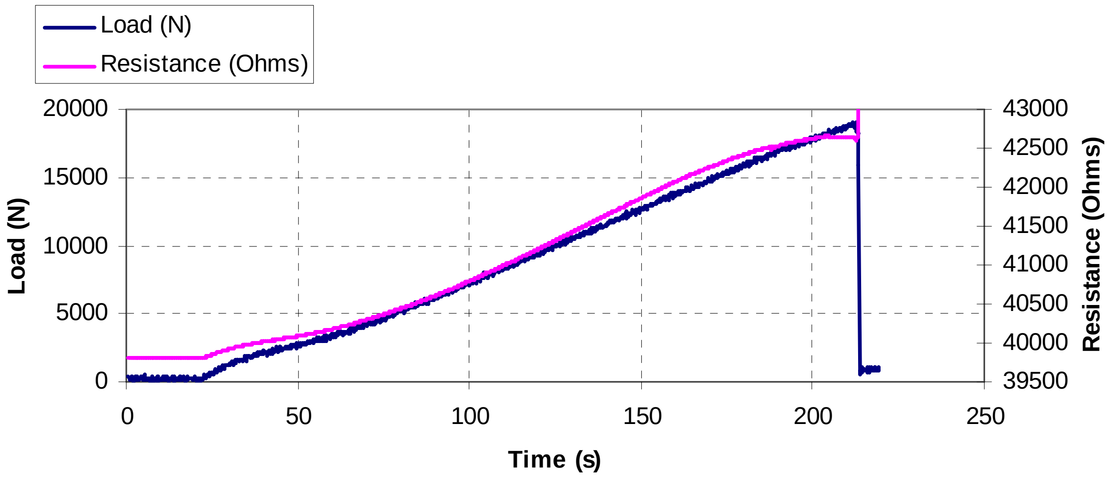


Fig.2 Load vs electrical resistance in one of the samples

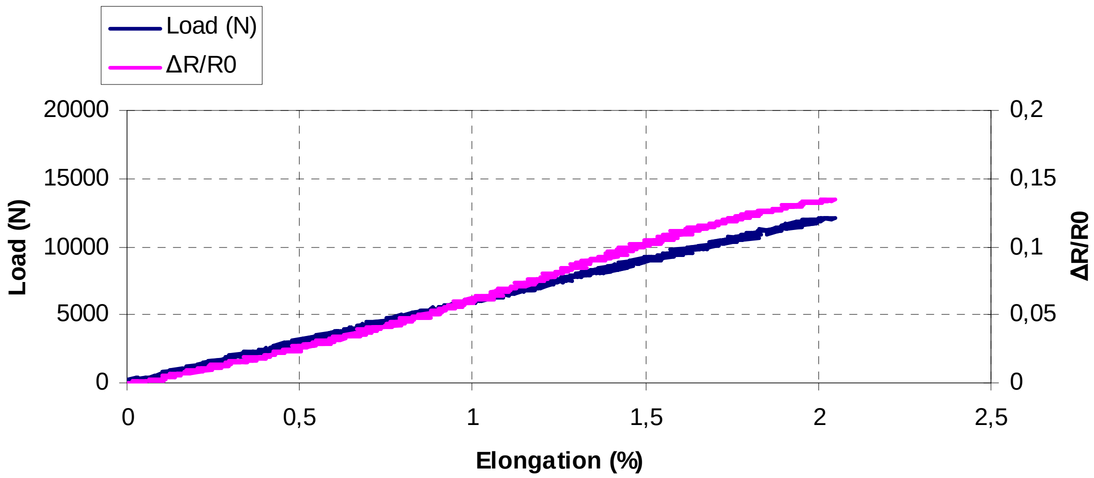


Fig. 3 Gauge factor graphic in one of the samples