Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure
Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid
Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1

PAPER REF: 7228

MECHANICAL PROPERTIES AND MICROSTRUCTURE OF CARBON-FIBRE/ALUMINIUM-MATRIX AND CARBON-FIBRE/ TITANIUM-MATRIX COMPOSITES

Alexander Rudnev[1], Rida Gallyamova[2], Andrew Gomzin[2], Andrew Kolchin[1], Sergei Galyshev[1(*)], Fanil Musin[2], Sergei Mileiko[1]

[1]Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka Moscow distr., 142432 Russia
[2]Ufa State Aviation Technical University, Ufa, Bashkortostan resp., 450000 Russia
[(*)]*Email:* galyshew@gmail.com

ABSTRACT

This work introduced new results of the study mechanical properties and microstructure of carbon fibers reinforced Al-matrix and Ti-matrix composites. It is shown that carbon fibers coating based on silica can be produced by sol-gel procedure. It is shown that carbon-fiber/titanium-matrix composites can be produced by a liquid-phase route with the Ti-Ti_5Si_3 eutectic as an intermediate phase.

Keywords: composites, aluminium, titanium, carbon fibres, mechanical properties.

INTRODUCTION

Reinforcing aluminium and titanium with carbon fibres (CF) allows, first, enhancing the use temperature of the materials as compared with that characteristic for CFRP, and secondly, replacing metal alloys in many structural elements of aircrafts and aviation engines. This will yield an essential reduction in the total weight of the machines. In the case of the aluminum-matrix composites, the key issue is to prevent chemical interactions between the matrix and fiber with the formation of undesired aluminium carbide. A possible solution of this problem is coating the fibre by an appropriate material.

The development of carbon-fibre/titanium-matrix composites technology meets similar problem: chemical interactions between the matrix and fibre with a subsequent fibre degradation. A possible way to reduce chemical reactions at the fibre/matrix interface is to decrease infiltration temperature by using a Ti-based eutectic as an intermediate matrix.

RESULTS AND CONCLUSIONS

CF without coating and with a sol-gel coating of SiO_2 was annealed at a temperature of 600°C for 1.5 hours. SEM of CF with coating before (a) and after (b) heat treatment are shown in Figure 1. The fibrous form of annealed CF with coating (b) is also observed. It is most likely that in the annealing process in the air atmosphere, carbon burns out, while the silicon oxide is unchanged. For comparison, SEM of CF with coating before heat treatment is also shown (a). Microstructure of coated fiber reinforced Al-matrix composite are shown in Figure 2.

Table 1 shows the elastic properties of carbon fibre reinforced composite with Ti/Ti-Ti_5Si_3 matrix. Note that the Young's modulus of the composites reinforced with the fibres of low Young’s modulus is very high and is close to the Young's modulus of steels. This means that in the material, in addition to the matrix, eutectic and fiber, there is one more phase with a high Young's modulus. This is titanium carbide at the matrix-fiber interface (the Young's modulus of TiC is about 495 GPa. Specific value of the Young’s modulus of the composites can reach 65 $(m/s)^2$ that is twice as high as this property of structural metal alloys.

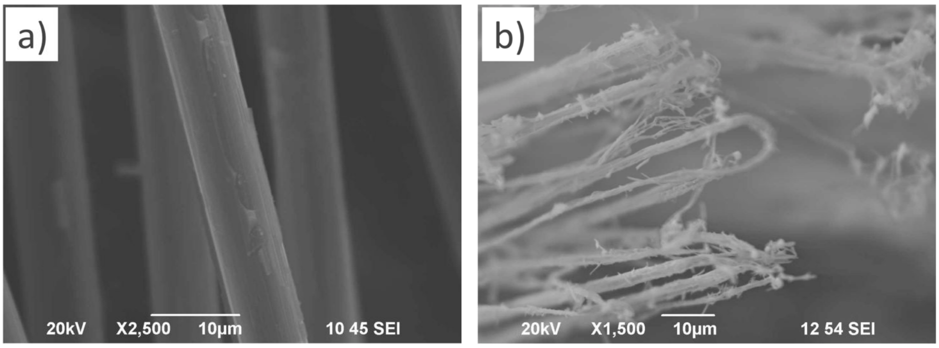

Fig. 1 - SEM of CF with coating before (a) and after (b) heat treatment

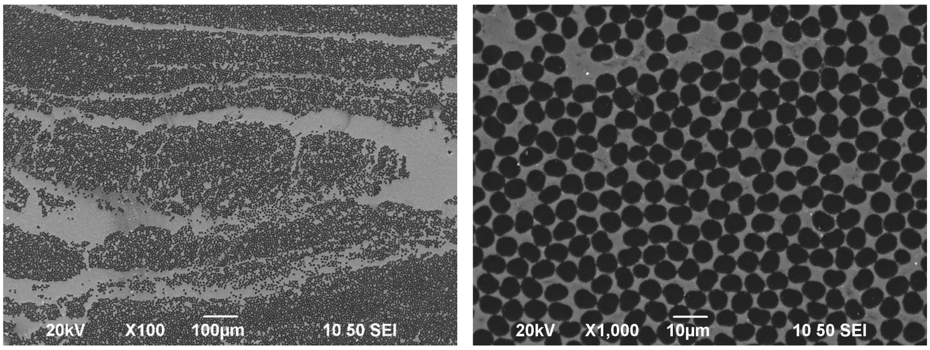

Fig. 2 - Microstructure of Al-matrix composite

Table 1 - Uniaxial tension test results

Volume fraction			Density, g/cm^3	Young’s modulus, GPa
C+TiC	Ti-Ti_5Si_3	Ti		
0.25	0.10	0.65	3.72	190
0.30	0.10	0.60	3.55	200
0.50	0.12	0.48	3.22	210

ACKNOWLEDGMENTS

The authors gratefully acknowledge the funding by The Russian Foundation for Basic Research, project 17-48-500843 and The Ministry of Education and Science of the Russian Federation within the framework of the base part of the state task №11.6454.2017/BP.

REFERENCES

[1] Gadiou R, Serverin S, Gibot P, Vix-Guterl C, The synthesis of SiC and TiC protective coatings for carbon fibers by the reactive replica process. Journal of the European Ceramic Society, 2008, 28, pp. 2265-2274.

[2] Mileiko ST, Rudnev AM, Gelachov MV, Carbon-fibre/titanium silicide interphase/titanium-matrix composites: Fabrication, structure and mechanical properties, Composites Science and Technology, 1995, 55, pp. 255-260.