“Neoker Single Crystal Alumina Fibers as reinforcement in Al-based MMC’s: first steps”

C. Cerecedo¹, V. Valcárcel², A. Solís¹, J.Y. Pastor³, M. Molina¹, R. Prieto¹, E. Louis¹ and J. Narciso¹

¹Neoker, S.L. Pol. Industrial Novo Milladoiro-C/Xesta, 78 A1, Coruña, Spain
²Departamento de Ciencia de Materiales. CISDEM. Universidad Politécnica de Madrid. Spain
³(IUMA instituto de materiales de Alicante) Universidad de Alicante. Spain

INTRODUCTION

α-Al₂O₃ whiskers are good candidates for use as strengtheners in advanced composites, specifically, single crystal α-Al₂O₃ whiskers grown with c-axis orientation, because of their favorable fracture strength, stiffness, and creep resistance, even at high temperatures are optimum reinforcements. Very few methods are currently available to obtain single-crystal α-Al₂O₃ whiskers, and these methods were too complex and expensive for use on an industrial scale. A novel method for obtaining c-axis alumina single-crystal whiskers (developed at the Institute of Ceramic Materials of Galicia) has been scaled-up to industrial production by Neoker, a Spin-Off of the University of Santiago de Compostela, Spain. The technology for the production of the whiskers involves the reaction between aluminum and powdered silica in Ar atmospheres containing metal vapors.

Alumina whiskers preforms were obtained as cylinders with a diameter of 16 mm and high temperature.

MECHANICAL BEHAVIOUR

As can be seen from the below images, the matrix is ductile, while fibers fracture in a fragile modus.

As previously stated, the mechanical performance of the material starts to degrade from 300 ºC due to the apparition of plastic phenomena that reduce the overall mechanical performance of the matrix. At higher temperatures, K IC is steadily diminishing, and at 500 ºC it can be considered negligible. The effect of the fiber reinforcement is very interesting form 300 ºC to 400 ºC, causing the composite to maintain higher mechanical performance even at temperatures when the aluminum becomes softened due to plastic behavior. The activation of such plastic deformation is hindered by the introduction of the alumina fibers.

MATERIALS AND METHODS

The short alumina whiskers were processed and pressed into cylindrical fiber preforms. They consist of 20%vol α-Al₂O₃, fabricated by Neoker,S.L., with a diameter of 0.5-5 µm and a length of hundreds of micrometers. The main fact about sizes is that the "aspect ratio" is very high and that is proportional to their reinforcing capacity.

Neoker fibers are composed only by pure alumina and there are no secondary phases. C-axis pure single crystal alumina whiskers, with a white "cotton-like" appearance are deposited by vapor-liquid-solid deposition process. C-Axis growth it’s a quite technical but extremely important characteristic that allow avoiding a lot of problems related to creep and fatigue at high temperature.

The alumina whiskers preforms were obtained as cylinders with a diameter of 16 mm and length of 45 mm using a manual press. They were afterwards heated at 1650 ºC for 2 h.

The final Al composite were obtained by infiltrating the fiber preforms with molten aluminum at the University of Alicante. The infiltration was developed with gas at 675ºC and at 40 Bar.

CONCLUSIONS

- Fibers are randomly oriented, although they are mostly normal to the test direction.
- The mechanical performance is almost constant between -196 to 200 ºC, with the composite showing a linear elastic behavior until fracture. From 300 ºC the apparent fracture toughness of the composite starts to degrade due to the apparition of plastic phenomena that reduce the overall mechanical performance of the matrix. At 400 ºC, K IC is steadily diminishing, and at 500 ºC it can be considered negligible. The effect of the fiber reinforcement is very interesting form 300 ºC to 400 ºC, causing the composite to maintain higher mechanical performance even at temperatures when the aluminum becomes softened due to plastic behavior. The activation of such plastic deformation is hindered by the introduction of the alumina fibers.
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Fibers are a very promising material for high added-value applications, specially where creep and fatigue at high temperatures represent an issue to solve.