DOI: 10.1017/S1431927603442700
Microsc Microanal 9(Suppl 2), 2003

Transverse Coefficient of Thermal Expansion Determination of Carbon Fibers Using ESEM and TEM at High Temperature

J. Jiang*, R.L. Littleton**, Z.P. Luo**, E.A. Ellis** and O. Ochoa*

* Department of Mechanical Engineering, Texas A&M University, College Station, TX 77843
** Microscopy and Imaging Center, Texas A&M University, College Station, TX 77843

Carbon fibers are attractive light structural materials for the aerospace industry because of their low density, high specific tensile modulus and strength [1, 2]. An accurate determination of the coefficient of thermal expansion (CTE) is essential for predicting the properties of carbon fiber-reinforced composites in order to improve their performance. Here we present the transverse CTEs for IM7 and P55 carbon fibers at high temperature as determined by environmental scanning electron microscopy (ESEM) and transmission electron microscopy (TEM).

The transverse CTEs of carbon fibers were in principle determined from the change in the cross-sectional diameter. In order to measure the change in diameter of carbon fibers, we used two experimental methods: fiber end-on measurements using the ESEM and fiber side-on measurements (i.e. perpendicular to the long fiber axis) using the TEM. Two types of carbon fibers, IM7 and P55, were examined. Specimens for ESEM were prepared by drilling a 0.7mm diameter hole into a 5 by 3 mm graphite rod (Fig. 1). Subsequently, approximately fifty IM7 or P55 carbon fibers were lowered into the graphite rod hole, immobilized in order to prevent the carbon fibers from moving during heating, and trimmed so that they are flush with the end of the graphite rod. Specimens for TEM were prepared by positioning several fibers parallel to each other over a slotted grid and secured by placing another slotted grid on top. Specimens were observed in an ElectroScan ESEM E-3 and JEOL 2010, both equipped with heating stages ($\leq$ 1000 ^{o}C) and operated at 30 kV and 200 kV, respectively.

Fig. 2 shows the ESEM images of a P55 carbon fiber at 27 and 403 ^{o}C. Specimens were held for 20-30 minutes at 403 ^{o}C prior to recording images. A total of 20 data points were taken. For the fibers tested, the CTEs obtained were 22.5×10^{-6} and $15.0\times10^{-6}/^{o}$C. The CTE values for the IM7 fibers were 60.3×10^{-6}, 50.5×10^{-6}, 51.0×10^{-6} and $32.5\times10^{-6}/^{o}$C, respectively.

In Fig. 3, TEM micrographs are shown depicting a IM7 carbon fiber at 20 and 855 ^{o}C. The change in diameter (Δd) is indicated and used for the calculation of CTE values with CTE = $(\Delta d/d)/\Delta T$. The CTE values obtained for IM7 carbon fibers were 4.2×10^{-6} and $5.1\times10^{-6}/^{o}$C, and for P55, 3.3×10^{-6} and $3.7\times10^{-6}/^{o}$C. Smaller range of data variation was obtained by the TEM method [3].

References

[1] L.H. Peebles, Carbon Fibers: Formation, Structure, and Properties, CRC Press, Boca Raton, 1994.
[2] Z.P. Luo et al., Microsc. Microanal. 8 (suppl. 2) (2002) 1254.
[3] The support provided by Mr. Michael Effinger of NASA Marshall Research Center is gratefully acknowledged.

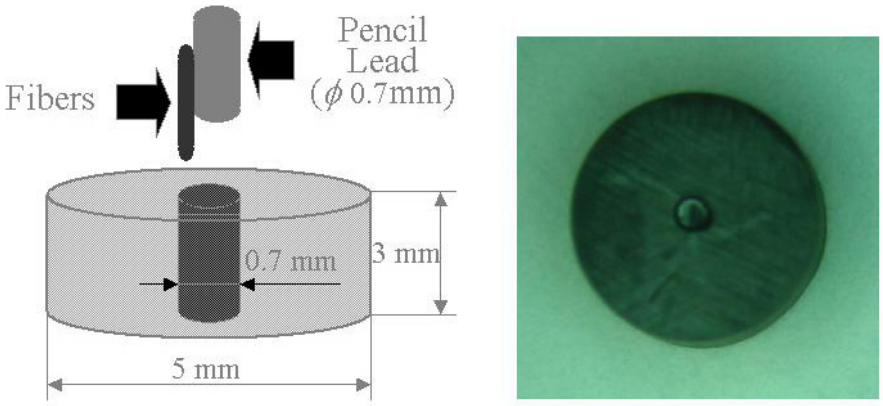

FIG. 1. Specimen for ESEM testing.

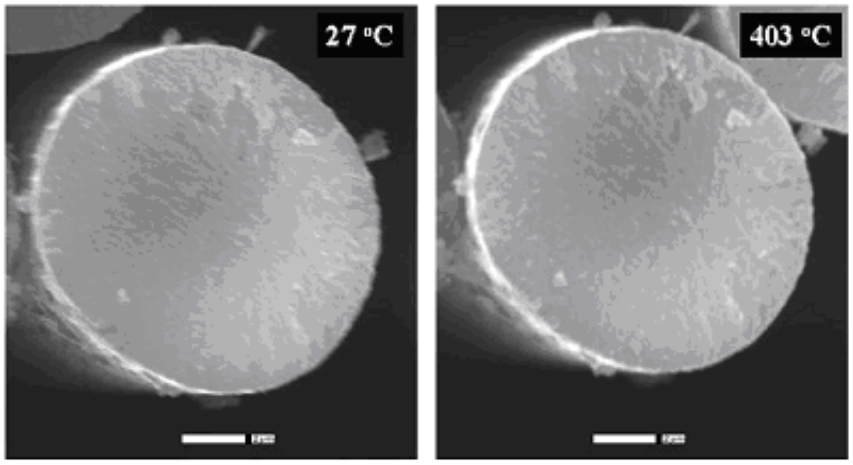

FIG. 2. ESEM images of a P55 carbon fiber.

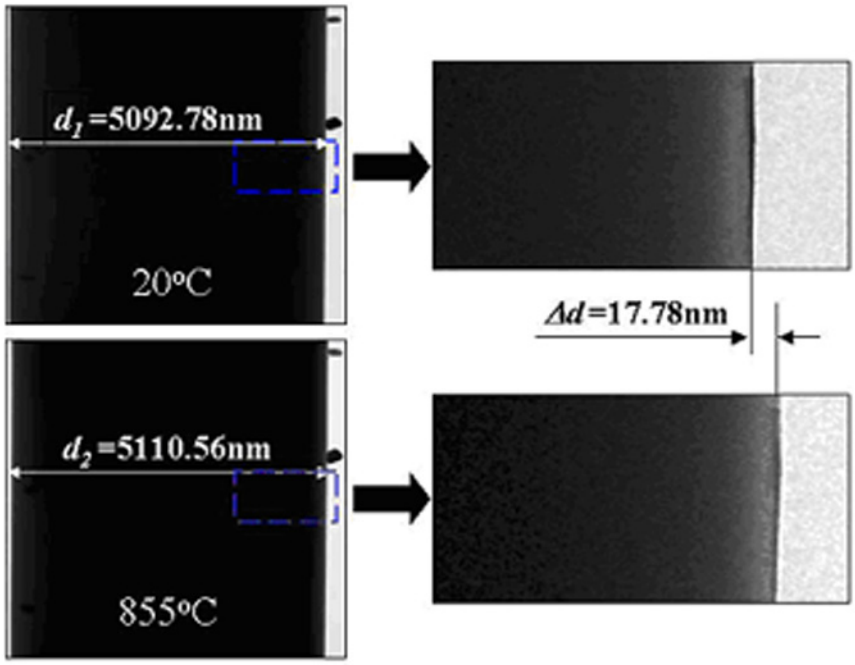

FIG. 3. TEM negatives of an IM7 carbon fiber.

https://doi.org/10.1017/S1431927603442700 Published online by Cambridge University Press