MEASUREMENT METHOD OF IN-SITU TENSILE STRENGTH OF SIC FIBER IN SIC/SIC COMPOSITE

Yoshihisa Tanaka, The Center for Ceramic Matrix Composites, Katayanagi Advanced Research Laboratory, Tokyo University of Technology, Japan
tanakayh@stf.teu.ac.jp
Takumi Kiyohara, Faculty of Engineering, Department of Mechanical Engineering, Tokyo University of Technology, Japan
Mitsuhiko Sato, The Center for Ceramic Matrix Composites, Katayanagi Advanced Research Laboratory, Tokyo University of Technology, Japan
Yutaka Kagawa, The Center for Ceramic Matrix Composites, Katayanagi Advanced Research Laboratory, Tokyo University of Technology, Japan
Mitsuaki Furui, Faculty of Engineering, Tokyo University of Technology, Japan

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Measurement of in situ tensile strength of SiC fiber in SiC matrix is important to understand mechanical behavior of SiC/SiC. Fractographic approach is one possible way to measure in-situ tensile strength of the fiber. According to the approach, tensile strength of SiC fiber, σ_F, is given by $\sigma_F = \phi\omega/\sqrt{a_i}$, where ϕ is a constant depend on fracture toughness of SiC fiber, ω is a numerical constant, and a_i is the characteristic crack length, usually used “mirror-mist-hackle” zone approach. It seems reasonable that both intrinsic (heat exposure, chemical degradation etc.) and extrinsic (stress states, effective volume etc.) factors affect to the fracture toughness of SiC fiber when the fiber is incorporated in SiC matrix. Definition and determination procedure of a_i also affects to the constant ω. However, effects of such the factors on the constant ϕ and ω are not known.

The major attention of this study is to develop measurement method of in-situ SiC fiber strength in SiC matrix, using fractographic approach. Here, only degradation during fabrication process (heat-exposure history) is considered because chemical degradation is inhibited by BN interphase layer. Under this condition, in-situ tensile strength of the fiber is roughly given by $\sigma_F = C(\Delta T, \Delta t)/\sqrt{a_c} + \sigma^{res}$, where σ^{res} is the residual stress in SiC fiber, ΔT and Δt are temperature and time, respectively. Stress states is assumed to be unidirectional and residual stress of SiC fiber in SiC matrix is neglected ($\sigma^{res} \sim 0$). It should be noted that within this study, both ϕ and ω are included in a constant $C(\Delta T, \Delta t)$.

Tensile strength of as received Hi-Nicalon™ SiC fiber and heat exposed Hi-Nicalon™ SiC fiber (1450℃ and 1500℃ for $0.5h$ in Ar) are carried out. Fracture surfaces of tensile tested fiber are observed by SEM. Fracture surface observations reveal well identifiable lengths, a_1 and a_2 ($a_1 < a_2$) are available. This characteristic fracture lengths are observed both before and after heat-exposure. Relationship between the length, a_2, and tensile strength of the as-received SiC fiber, σ_F, follows $\sigma_F \propto 1/\sqrt{a_2}$. Therefore, the length a_2 is assumed to be equal to the critical crack size a_c (= a_2) and the length is used for prediction of the fiber strength.

Tensile strengths of as received and after heat-exposed SiC fibers follow the Weibull probability distribution function: $lnP_F(\sigma) = -\left(\frac{L}{L_0}\right)\cdot\left(\frac{1}{\sigma_0}\frac{C(\Delta T,\Delta t)}{\sqrt{a_c}}\right)^m$, $P_F(\sigma)$ is the probability of failure under applied tensile stress σ, L is the fiber length, σ is the stress, and m is a constant. Subscripts “0” indicates characteristic values. Assuming that the strength follows the Weibull statistical distribution, and numerical curve fitting of a set of experiments, the parameters $C(\Delta T, t)$ are obtained. The constants $C(\Delta T, \Delta t)$ for the original SiC fiber ($\Delta T = \Delta t = 0$) is ~5.4 and heat exposed at 1450°C ($\Delta T = 1450℃, \Delta t = 0.5h$) is ~5.2, heat exposed at 1500°C ($\Delta T = 1500℃, \Delta t = 0.5h$) is ~5.1. This change means that application of $\sigma_F = C(\Delta T, \Delta t)/\sqrt{a_c}$ needs selection of $C(\Delta T, \Delta t)$ according to heat exposure history of the SiC fiber. This evidence suggests that care should be taken for application of $\sigma_F = \phi/\sqrt{a_i}$ for measurement of in-situ fiber strength: modification of ϕ is necessary and physical meaning of a_i should be considered. Further study is needed to examine physical meaning of a_2 and $C(\Delta T, \Delta t)$, and the effect of extrinsic factors, *e.g.* residual stress of SiC fiber in SiC matrix.

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