§6. Effect of Al_2O_3 Long Fiber on Mechanical Properties of BPSCCO Superconductor

Matsunaga, K. (The Graduate Univ. for Advanced Studies)
Nishimura, A.

High Tc Superconductors such as BPSCCO and YBCO are candidate materials for current leads and superconducting joints between super fluid helium and normal liquid helium, because of the high current capacity and the low thermal conductivity. The high Tc superconductors are one kind of ceramics, so it is very brittle and it is hard to change the mechanical properties without combining with reinforcement materials. In this study, to investigate the effect of reinforcement fibers on the mechanical properties, a composite plate composing of long fibers of Al_2O_3 and BPSCCO matrix was made, and the mechanical properties were evaluated at room temperature. Regarding the short fiber addition, the data are presented in Reference 1.

BPSCCO powder, of which size is less than 10 μm, was used for a matrix, and long Al_2O_3 fiber of about 10 μm diameter was applied as a reinforcement material and arranged uni-directionally in the matrix. Three layers composed the composite plate as shown in Fig.1. The Al_2O_3 fiber layer was located near the both surfaces and the mid-part was BPSCCO. The plate size was 40 mm_W x 50 mm_L x 7 mm_T. The fibers were disposed in the direction of 40 mm. After compressing by a cold isostatic press, the plate was heat-treated at 1078 K for 90 ks. Then 3-point bend bars of 4 mm_W x 40 mm_L x 5 mm_T and tensile test specimens of 1.5 mm_T x 4 mm_W x 40 mm_L were machined out. To measure the strength, 3-point bending tests were carried out under the supporting span of 30 mm. Apparent stiffness of the composites was evaluated by the tensile tests using special extensometers of less than 1 μm precision. The extensometers were newly developed and used for measuring the elongation. The gage length is 6 mm, the capacity is +/- 0.5 mm and the output is about 2.5 mV/V. All mechanical tests were performed at room temperature.

The bending strength against the fiber ratio at Al_2O_3/BPSCCO layer is shown in Fig.2. The addition of the fiber to the matrix made the strength lower. SEM observation of the fracture surface showed that the fibers were pulled out. From these results, it is considered that the bonding strength on interface between the fiber and the matrix is weak, and unbalance of load carrying through fiber happens because of irregular arrangement of the fibers, and that the unbalance causes a fiber break and it results in a final failure.

The stress - strain curves and the apparent stiffness against volume ratio of the fiber is shown in Fig.3 and Fig.4.

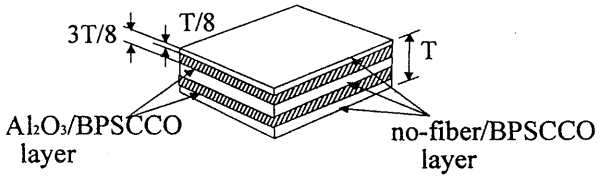

Fig. 1 Illustration of structure of composite HTS plate.

By using the double extensometers, bending component was cancelled and the stiffness was measured successfully. As the volume ratio of Al_2O_3 fiber is increased, the stiffness becomes large. A linear relation between the stiffness and the volume ratio is obtained empirically. The mixture law gives higher stiffness than measured value. This would come from the looseness and the irregularity of the fiber disposition, but it is clear that the stiffness of the high Tc superconductor can be improved applying a composite process and technique.

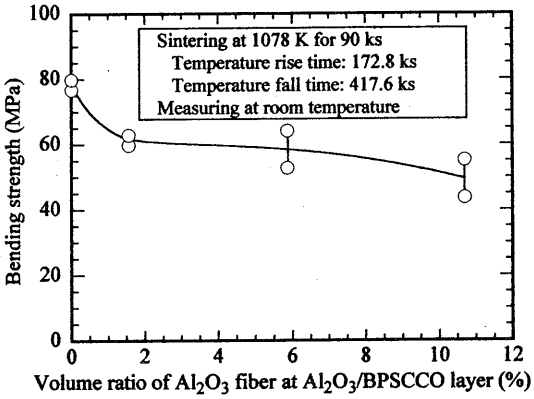

Fig. 2 Relation between bending strength and volume ratio of Al_2O_3 fiber at Al_2O_3/BPSCCO layer.

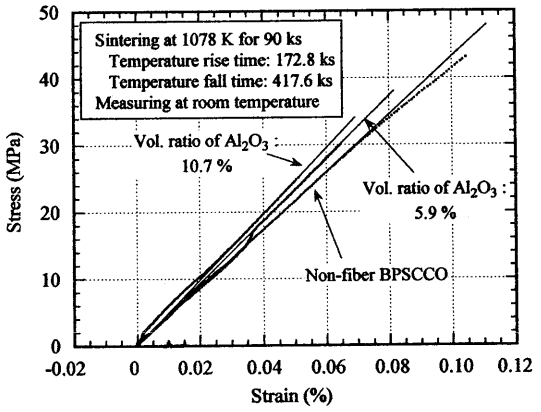

Fig. 3 Stress - strain curves of BPSCCO and composites.

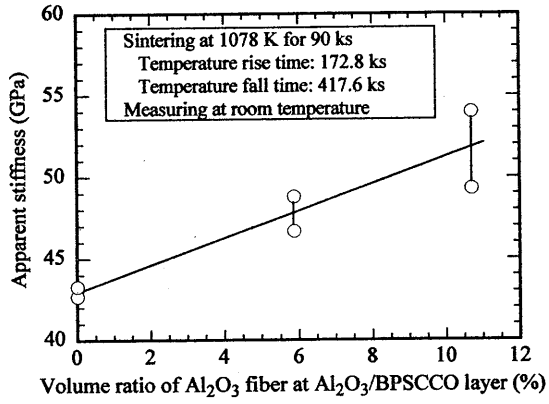

Fig. 4 Apparent stiffness against volume ratio of fiber.

Reference

1) Matsunaga, K., et al., Adv. in Superconductivity X, Springer-Verlag, Tokyo (1998) p861.