TAILORED MICROSTRUCTURE OF CERAMICS BY USING ELECTRIC AND MAGNETIC FIELDS

Tohru S. Suzuki, National Institute for Materials Science
suzuki.tohru@nims.go.jp
Tetsuo Uchikoshi, National Institute for Materials Science

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The mechanical and functional properties of ceramics can be improved by designing their microstructures, such as grain size, grain geometry, crystallographic orientation, second phase and so on. Tailoring the crystallographic orientation in ceramics is one of effective ways for improving their properties. Layered structure with different crystalline orientation layer by layer has been proposed as an alternative for the design of structural ceramics. Grain sliding during the high temperature deformation depends on the grain boundary structure and misorientation angle between grains. The energy release mechanisms during the crack propagation such as crack deflection and crack bifurcation can improve the crack growth resistance in the laminar ceramics. The residual stress generated in each layer during cooling down from the sintering temperature has an influence on the crack deflection and crack bifurcation, hence the control of the residual stress is important for the crack growth resistance in order to improve the mechanical properties. There are some reports about the laminate composite materials with different components for controlling the thermal expansion coefficients in order to generate the residual stress. Our concept is that the crystalline axis depending on the thermal expansion coefficients aligns for controlling the residual stress in the monolithic ceramics. We controlled the layered structure in the monolithic ceramics, such as alumina and silicon carbide for control the crack deflection.

The starting materials were spherical α-Al_2O_3 powder and α-SiC powder with trigonal and hexagonal crystal structure, respectively. These powders were dispersed in ethanol using an ultrasonic homogenizer and a magnetic stirrer. The suspension was placed in a superconducting magnet with a room temperature bore of 100mm, and then a strong magnetic field of 12T was applied to the suspension to rotate each particle due to the magnetic torque. The magnetic field was maintained in the suspension during the electrophoretic deposition (EPD) at room temperature. The crystalline-oriented laminate ceramics were produced by alternately changing the angle between the vectors E and B, $\varphi_{B\text{-}E}$, layer by layer during EPD in the 12 T magnetic field.

Figure 1 illustrates the EBSD map of alumina/alumina laminate composite with different crystalline-oriented layers. This composite was fabricated by alternately changing the angle between the directions of the magnetic and electric fields ($\varphi_{B\text{-}E}$ =0° and 90°) layer by layer during EPD in 12T. The grains in alternate layers are aligned differently in the multilayer composite.

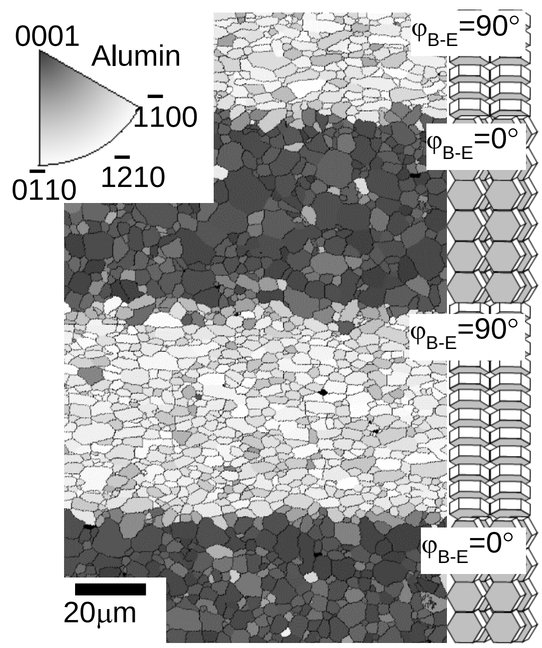

Fig.1 EBSP map in multilayered Al_2O_3 composite with different crystalline-oriented layers.

The crack deflection was observed at the boundary between the layers with different orientation. The angle of the crack deflection depended on the layer thickness and orientation angle in each layer. This is because the residual stress was introduced due to the deferent coefficient of the thermal expansion depending on the crystal axis. The fracture behavior depended on each layer. The intergranular fracture and the intragranular fracture were observed in the 0° layer and 90° layer, respectively.

This technique could be applied to SiC and the layered structure with alternatively different orientation could be fabricated.