Application of SLEEM for Observation of Al based Composite Materials

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In the present study, the scanning low energy electron microscopy (SLEEM) method has been developed for assembling to a conventional SEM with W-filament and normal vacuum system, and applied to confirm morphologies of α-Al_2O_3 particles and $MgAl_2O_4$ spinel crystals grown on the alumina particles in the Al_2O_3/Al -1.0 mass% Mg_2Si alloy composite material, boride particles in Al based composite material, and $SrAl_2O_4$ particles / Al composite material. The SLEEM detector and the necessary modifications to the specimen stage had been specially designed for our SEM (Hitachi S3500H). The detector was manufactured at ISI Brno, while Hitachi Science Technology performed the stage modification. The energy of electrons landing on the samples is controlled by a negative potential applied to the sample.

For example, the morphology of α-Al_2O_3 particles before fabrication of the composite material was observed without charging-up, and it was like a facetted barrel with 2 hexagonal {0001} and 6 trapezoidal $\{\bar{1}101\}$ planes (see Fig. 1). In metal matrix composite materials consisting of oxide particles and Al alloys, including Mg as a solute atom, $MgAl_2O_4$ spinels are formed at the interface between the particles and the matrix. Spinels were formed on facets of Al_2O_3 as small particles, and their shape was an octahedron consisting of 8 equiaxial triangles. Spinels and Al_2O_3 particles keep their orientation relationship which was concluded by our recent TEM study:

$$(111)_{MgAl_2O_4} // (0001)_{Al_2O_3},\ [2\bar{1}\bar{1}]_{MgAl_2O_4} // [2\bar{1}\bar{1}0]_{Al_2O_3},\ [1\bar{1}0]_{MgAl_2O_4} // [1\bar{1}00]_{Al_2O_3}$$

The SLEEM method provided much better readable and detailed images of all particles, their shapes and mutual orientations, in comparison with conventional SE and BSE images at the electron energies usually used in the SEM. This is due to the much smaller interaction volume of signal exciting electrons in the target and hence more localized information, together with a favorable comb ination of secondary (SE) and backscattered (BSE) electron signals.

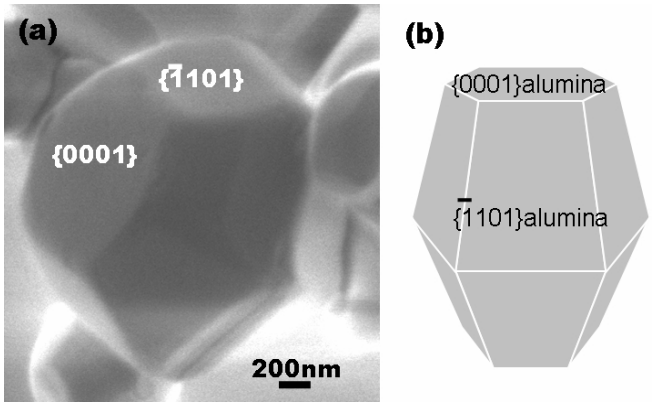

Fig. 1 (a) SLEEM image of alumina particle and (b) a schematic illustration of alumina particle.