Synthesis and performance investigation of carbide reinforced TiAl matrix composites

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[Introduction] Recently, TiAl-matrix composites have drawn attention as high-temperature structural materials because of their excellent high-temperature properties and low density. However, their mechanical properties still need to be improved in comparison with those of widely-used Ti-based and Ni-based alloys. Fabrication of TiAl-matrix composites with ceramic particles is one way to improve their mechanical properties, and their merits of low density can still be kept. Layered ternary Ti$_2$AlC ceramic is a typical reinforcement phase exhibiting excellent mechanical properties. Therefore, introduction of Ti$_2$AlC particles into the TiAl matrix to form TiAl/Ti$_2$AlC composites can be helpful to achieve great mechanical properties.

[Method] Ti-Al and Ti-Al-C alloy powders were made by Self-propagating High-temperature Synthesis (SHS) from elemental powders. Powders are refined by ball milling for 24 hours, then sintered by Spark Plasma Sintering (SPS) in the following conditions; sample size: diameter: 10 mm, thickness: about 5 mm, temperature: 1265 °C, heating rate: 50 °C/min, pressure: 50 MPa, holding time: 5 min. In Ti-Al-C powders, atomic ratio of Ti:Al was fixed at 54:46 and the carbon content was set to 7, 14, 21 and 28 vol. %. Obtained samples were cut along axial direction and observed by OM and SEM. Bending test is conducted under the following conditions: temperature: R.T, crosshead speed: 0.001 mm/sec, set distance: 8 mm.

[Results] In the TiAl/Ti$_2$AlC composites, Ti$_2$AlC and TiAl particles are distributed uniformly in TiAl/Ti$_3$Al matrix as shown in Fig.1. Mechanical properties including Vickers hardness, bending strength are tested. Results are shown in Fig.2. The sample with 21 vol. % of carbide has the best performance. Its hardness was about 820 HV and bending fracture strength was about 1090 MPa which is significantly higher than the sample without Ti$_2$AlC.

Fig. 1 SEM photo of composite. Fig. 2 Hardness and bending strength of composite.

[Conference]  (1) Hokkaido Branch Winter Meeting of the Japan Institute of Metals, Dec. 2015
(2) AGH-HU Joint Symposium, July. 2016 (submitted)
(3) PRICM9, Aug. 2016 (submitted)