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Spark-Plasma Sintering of Powder Mixture of Ni and Nanoscale Al

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NiAl is being expected as a promising high-temperature structural material due to its excellent properties such as high melting temperature, high specific strength, good oxidation, and creep resistance, etc. But, its poor workability at room temperature limits a wide application. Since it was reported that the ductility could be remarkably improved by decreasing grain size under a certain critical size, a great deal of works have been made to obtain fine structure of NiAl.

In this study a production of NiAl with fine grain size was tried through Spark-Plasma Sintering (SPS) of powder mixture of Ni and nanoscale Al. SPS is a similar process with a combination of conventional Electric-Current Sintering and Hot-Pressing. Electric current is applied to a specimen in pulse-form and the specimen is heated both by resistance heating of the specimen itself and the conductive die mold (usually graphite). We expected that self-propagating high-temperature synthesis (SHS) reaction could occur during SPS of powder mixture of Ni and nanoscale Al. This SHS reaction can enhance the densification process by rapid heating and hinder the grain growth. Additionally, the addition of nanoscale Ni powder would initiate the SHS reaction at lower temperature than in conventional process using several tens μmstarting powders.

Sintering was carried out in a SPS facility under the following conditions: Sintering temperature of 1150℃, heating rate of 100℃/min., holding for 5 min. at sintering temperature, and applying pressure of 50 MPa. Sintered density was measured by an electronic densimeter. Shrinkage along the pressure axis, temperature, and electrical power input was automatically stored through a data-acquisition system into PC. Stored data was further processed in a form of densification rate (% relative density/sec.) vs. temperature. Crystallite size of starting powders and sintered bodies were measured by X-ray line broadening method and TEM observation. Densification behavior, phase formation and developments of microstructure during SPS process were discussed.

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