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学位論文の概要及び要旨

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題　　目　Processing, Microstructure, and Thermal/Mechanical Properties of Al/Carbon Composites
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In recent years, due to continuing miniaturization and increasing power density of various electronic devices, the high heat generation rate has become a serious issue in the fields of electronic package and thermal management applications. In order to satisfy the requirements of rapid heat removal, long service life, and high reliability, it is important to develop efficient heat-dissipation materials with high thermal conductivity (TC) and low coefficient of thermal expansion (CTE).

Al/carbon composites have been widely used in the fields of electronic package and thermal management applications because of their good thermal and mechanical properties. However, conventional fabrication techniques, such as squeeze casting and hot pressing, are difficult to simultaneously meet the needs of mass production and good thermal/mechanical properties. In the present work, from the viewpoints of mass production and orientation control, a hot-extrusion technique was proposed to fabricate Al/carbon composites. The objective of this research was to understand the relationships among processing conditions, microstructure, thermal and mechanical properties.

Sound and dense Al/graphite composites were fabricated by a hot-extrusion process in a temperature range of 400-500˚C. The effects of processing conditions such as graphite particle size, graphite content, and extrusion temperature on extrusion behavior, microstructure, and TC have been systematically investigated. During the hot extrusion, the graphite was subjected to deformation and hence distributed along the extrusion direction in the extruded Al/graphite composites. The (00*l*) basal planes of the graphite were preferentially orientated along the

extrusion direction. The preferred orientation of the graphite resulted in an anisotropy of TC in the extruded samples.

In order to simultaneously improve the thermal and mechanical properties of Al/graphite composites, Al/graphite composites with small amounts of Al-Si alloy were consolidated by spark plasma sintering and hot-extrusion processes. The effect of Al-Si alloy addition on densification behavior, microstructure, TC, CTE, and compressive strength has been systematically investigated. The results showed that the addition of Al-Si alloy resulted in improvements in relative density of the composites, interfacial bonding between Al and graphite, and orientation degree of graphite. The composites with Al-Si alloy showed improved TC and reduced CTE values in comparison with those without Al-Si alloy. Moreover, the hot-extruded Al/graphite composites containing Al-Si alloy exhibited higher compressive strength compared to conventional squeeze-cast composites and hot-extruded composites without Al-Si alloy.

Aluminum/carbon fibers (CFs) composites have been successfully prepared by a hot-extrusion technique. The effects of processing conditions such as CFs size, CFs content, and extrusion temperature on extrusion behavior, microstructure, and TC have been systematically investigated. The extruded samples with less than 30vol% CFs exhibited good appearances with high relative density of > 97%, while those with 40vol% show some cracks and reduction in relative density. Microstructure observation showed that the CFs were mainly aligned along the extrusion direction in all the samples The measured TC along the extrusion direction of extruded samples showed that long CFs exhibited larger improvement in TC compared with short CFs.

To improve the interfacial bonding between Al and CFs, Ni-coating was introduced, and Al/Ni-coated CFs composites were fabricated by SPS process as a basic work. The effects of Ni-coating on microstructure and thermal/mechanical properties were investigated. The results showed that Ni-coating can effectively enhance the interfacial bonding between Al and CFs, thus resulting in higher density, TC, compressive strength, and lower CTE. The optimum coating time, sintering pressure, sintering temperature, and sintering time were clarified.

To further improve the thermal/mechanical properties of Al/Ni-coated CFs composites, the SPSed Al/Ni-coated CFs composites were extruded by hot-extrusion. The microstructure and thermal/mechanical properties of the extruded Al/Ni-coated CFs composites were investigated. The Ni-coated CFs were mainly distributed along the extrusion direction. In comparison with the SPSed samples, the hot-extruded samples showed higher TC, compressive strength, and lower CTE.