Special Feature: Advanced Alloy Design and Processing of Metallic Materials for Weight- and Energy-saving of Automobiles

Overview

Shinji Mitao
Department Manager
Laboratories Infrastructure Administration Dept.

Metals are the primary materials used in automobiles, not only because of their excellent mechanical properties and formability as structural materials, but also because of their electrical and thermal conductivities, magnetic properties as functional materials, and environmental merits, such as excellent recyclability.

This special issue includes six papers on advanced alloy design and processing of metallic materials that enable further improvement in ecological sustainability of automobiles through weight reduction and improved energy efficiency. The first paper introduces the newly developed Cu-base alloy for the laser-clad valve seat (LCVS). LCVS has contributed to the achievement of unprecedented energy efficiency due to the ideal port design in the cylinder head. The second paper is on the development of Cu- and Ni-free, high-strength sintered steels for heavy-duty automotive parts. Precise microstructural control was a key factor in obtaining the optimal combination of hardness and impact properties. The third paper is on the improvement of the formability of steel sheets through a hot stamping process. Ensuring suitable temperature distributions in a steel sheet before hot stamping, which were derived using computer aided engineering (CAE), greatly improved the deep drawability compared to that provided by a conventional hot stamping process. The fourth paper describes the development of an ultra-high strength steel with high ductility. The alloy design of the lattice-softened Fe-24%Ni base alloy to give proper stacking fault energy and the martensitic transformation temperature around ambient temperature has brought about multimodal deformation. The multimodal deformation appeared to play an important role in the extraordinary combination of the high yield stress and large elongation in the cold rolled alloy. The fifth paper reports improvement in the corrosion resistance of recycled Mg alloys containing Cu impurities, which greatly deteriorates corrosion resistance. Addition of Zn was found to reduce the unfavorable effects of Cu. The last paper is on improving the reliability of bonding properties between a Cu lead frame and Sn-Cu solder. Formation of Kirkendall voids during operation along the bond interface greatly deteriorates bond reliability. Addition of Ni to the Cu lead frame effectively suppressed the formation of Kirkendall voids. The mechanism is discussed in terms of the change in the chemical potentials of Cu and Sn in each phase due to the Ni addition.