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Editorial

Intermetallic Alloys

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1. Introduction and Scope

Intermetallic alloys are defined as solids which are comprised of two components combined with an off-stoichiometric range or dissolution of other components and have different crystal structures from those of the two components. Metallic or semi-metallic elements are used as at least one of two components in intermetallic alloys. There are numerous amounts of intermetallic alloys with various kinds of crystal structures and different stoichiometric ranges. The intermetallic alloys are categorized into two groups, i.e., structural and functional materials. Shape memory, thermoelectric power, magnetic applications, catalysis, and hydrogen storage alloys belong to the latter group. The discovery or invention has continued, particularly in the group of functional intermetallic compounds and alloys, for last several decades. This Special Issue covers not only structural, but also functional intermetallic alloys, focusing on the understanding of and developments for alloy design, microstructure, processing, and the relationship between structures (defect) and properties for intermetallic alloys and multi-phase intermetallic alloys comprised with other intermetallic compounds (or alloys) as the major constituents. From the scientific point of view, there is a need to universally understand the significance of alloy design, processing, microstructural control and design, and the interrelation between microstructures and properties in various crystal structures and alloy systems. In addition, from the engineering point of view, it is meaningful to know the latest achievement attained in each intermetallic alloy.

2. Contributions

Six research articles have been published in this Special Issue of *Metals*. Two articles deal with functional intermetallic alloys and two articles with structural intermetallic alloys. Fe-, Ni-, Ti-, Cu-, and Al-based intermetallic alloys were studied. Additionally, multi-phase intermetallic alloys are dealt in five articles.

First, let us introduce a functional intermetallic alloy. In recent years, the development of a new shape memory alloy that can be used in a high temperature range is desired. The equiatomic CuZr alloy is expected to fulfill this demand. The effect of thermal cycling on the morphology and crystallography of martensites in an equiatomic CuZr alloy was investigated using a transmission electron microscope (TEM) by Hisada et al. [1]. A new transformation scheme and martensite phase (structure) were found, depending on thermal cyclic range, −100 °C to 400 °C or 500 °C. It was demonstrated that the new martensitic transformation is closely related to the strain and stress caused by thermal cycling. It was shown that CuZr alloys are promising as one of candidates for high-temperature shape memory alloys.

Responding to the expiration for the exemption of Pb-bearing automobile electronics in the end of life vehicle (ELV), Ban et al. [2] developed a new lead-free solder Sn-Cu-Cr alloy and assessed its performance by means of thermal shock. It was shown that the addition of Cr has the effect of inhibiting the growth of the interfacial Cu_3Sn layer and, consequently, resulted in higher shear strength than existing commercial solders after 2000 cycles of thermal shock. Therefore, it is reasonable to expect that the present solder alloy could perform well under vibration conditions in automotive applications.

Since Ni_3Al has been ductilized at ambient temperature by a doping of boron at 1979, a number of literature studies have been reported aiming at development of high-temperature structure materials. However, it seems that the development was unsuccessful until today because of insufficient strength and still low tensile ductility at high temperatures. Semboshi et al. [3] found that Ni_3Al alloy age-hardened by the precipitation of Ni_3V displayed high tensile strength, as well as high tensile elongation in a wide range of temperatures up to 800 °C. The results were demonstrated to be due to the suppression of intergranular fracture via enhancing grain boundary strength by V solutes largely dissolving in the Ni_3Al phase.

The Al-Si-Fe alloy system has been used as parts in several manufacturing industries and in transport equipments, but is known to be very sensitive to small additions of transition metals. Aranda et al. [4] evaluated the microstructure and hardness of Al-Si-Fe-X (X: Cr, Ti and Mn) alloys. Various kinds of dispersions that have different chemical compositions, crystal structures, and morphologies were found depending on the additive element. Either alloy showed higher hardness than the master Al-Si-Fe alloy. The results should be useful to further improve the microstructure and mechanical performance of the relevant alloy system.

TiAl based alloys have been considered as novel lightweight high-temperature structural materials since they possess high specific strength and stiffness, good resistance against oxidation and corrosion, and good creep properties. Among a number of TiAl based alloys, TiAl alloys with a $(\alpha_2 + \gamma)$ microstructure are known to be promising for high-temperature structural materials, such as aero components in air craft. On the Nb-containing TiAl with a $(\alpha_2 + \gamma)$ microstructure, Chu et al. [5] demonstrated that a high temperature deformation mechanism changes the dislocation creep to grain boundary sliding. The editor believes that the characterization of microstructures and the assessment of the deformation mechanism of the relevant alloy should be useful for developing the aero components.

The iron aluminides Fe_3Al have been of significant importance for high-temperature structural applications due to their low cost and excellent performance for physical, mechanical, and chemical properties. However, they suffered from brittle fracture at ambient temperatures. Ye and Ke [6] attempted to fabricate TiB_2/Al_2O_3-reinforced Fe_3Al by combustion synthesis with thermite reduction. Complete phase conversion from elemental Fe, amorphous boron, and a thermite mixture of $Fe_2O_3/TiO_2/Al$ to Fe_3Al-TiB_2-Al_2O_3 composites was achieved. Additionally, the fracture toughness increased from 5.32 to 7.92 $MPa{\cdot}m^{1/2}$.

3. Conclusions and Outlook

Some valuable articles have been compiled in the present Special Issue of *Metals*, although a variety of topics have not been covered. A lot of academic activities involving publication, work shopping, and international conferences are still going on in the relevant topic and field. Hopefully, this Special Issue can contribute to the discussion, scientific debate, and scope in the community of intermetallic alloys.

Finally, I would like to thank all the authors for their contributions and all the reviewers for their invaluable efforts to improve the academic quality of the published research in this Special Issue. I would also like to give special thanks to all the staff at the *Metals* editorial office, who managed and facilitated the publication process.

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