2938
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High-entropy Alloys Fabricated Through Powder Metallurgy for Low-temperature Applications

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Current High-Entropy Alloys (HEAs) were born from the similarities of the multi-component alloys proposed by B. Cantor et. al.[1] and high-entropy alloys proposed by J. W. Yeh et. al.[2]. The HEAs are systems formed with at least 5 elements in an equiatomic composition or near equiatomic with a proportion less than 35 at%; besides, they need to reach the entropy of 1.5R, where R is the ideal gas constant. Unlike traditional metallurgical casting routes, powder metallurgical routes are favorable because it has much lower temperatures for material consolidation. However, most HEAs require relatively high sintering temperatures, so developing thermodynamically stable alloy powders that are susceptible to sintering at relatively low-temperatures (~500 °C) will open a new field of study.

The raw powders for fabricating the systems to study were aluminum at 99.5% of purity, copper at 99.5% of purity, nickel at 99.9% of purity, tin at 99.8% of purity, and zinc at 99.9% of purity. The millings were made in a Spex 8000M Mill by 10 hours, adding 1ml of n-Heptane as a process control agent and under argon controlled atmosphere. Two systems, $(AlCuNi)_{80}Sn_{10}Zn_{10}$ and $(AlCuNi)_{70}Sn_{15}Zn_{15}$, were obtained. The container and the miller balls employed were made of hardened steel; the relation weighs between the balls, and the powders were 5:1. By X-Rays Diffraction (XRD) and Transmission Electron Microscopy (TEM) were characterized the crystalline structure of powders. All samples were prepared using conventional micrographic technics.

Phase predictions corresponding to $\delta r/\Delta H_{mix}$, VEC, and e/a are presented in Figure 1, where δr is the difference of atomic ratio; ΔH_{mix} is the enthalpy of the system; VEC is valence electron concentration and e/a is electron per atom. The predictions showed a multiphasic BCC-FCC structure, an FCC structure, and a BCC structure for $\delta r/\Delta H_{mix}$, VEC, and e /a, respectively. However, analysis by XRD and TEM-SAED shows that the powders are multiphasic; both systems present a stable BCC and FCC crystalline structures how it is presented in Figure 2.

Phase prediction		
	$(AlCuNi)_{70}Sn_{15}Zn_{15}$	$(AlCuNi)_{80}Sn_{10}Zn_{10}$
e/a	BCC	BCC
VEC	FCC	FCC
δ_r / ΔH_{mix}	BCC/FCC	BCC/FCC

Figure 1. Phase prediction corresponding to δr/ΔHmix, VEC, and e/a

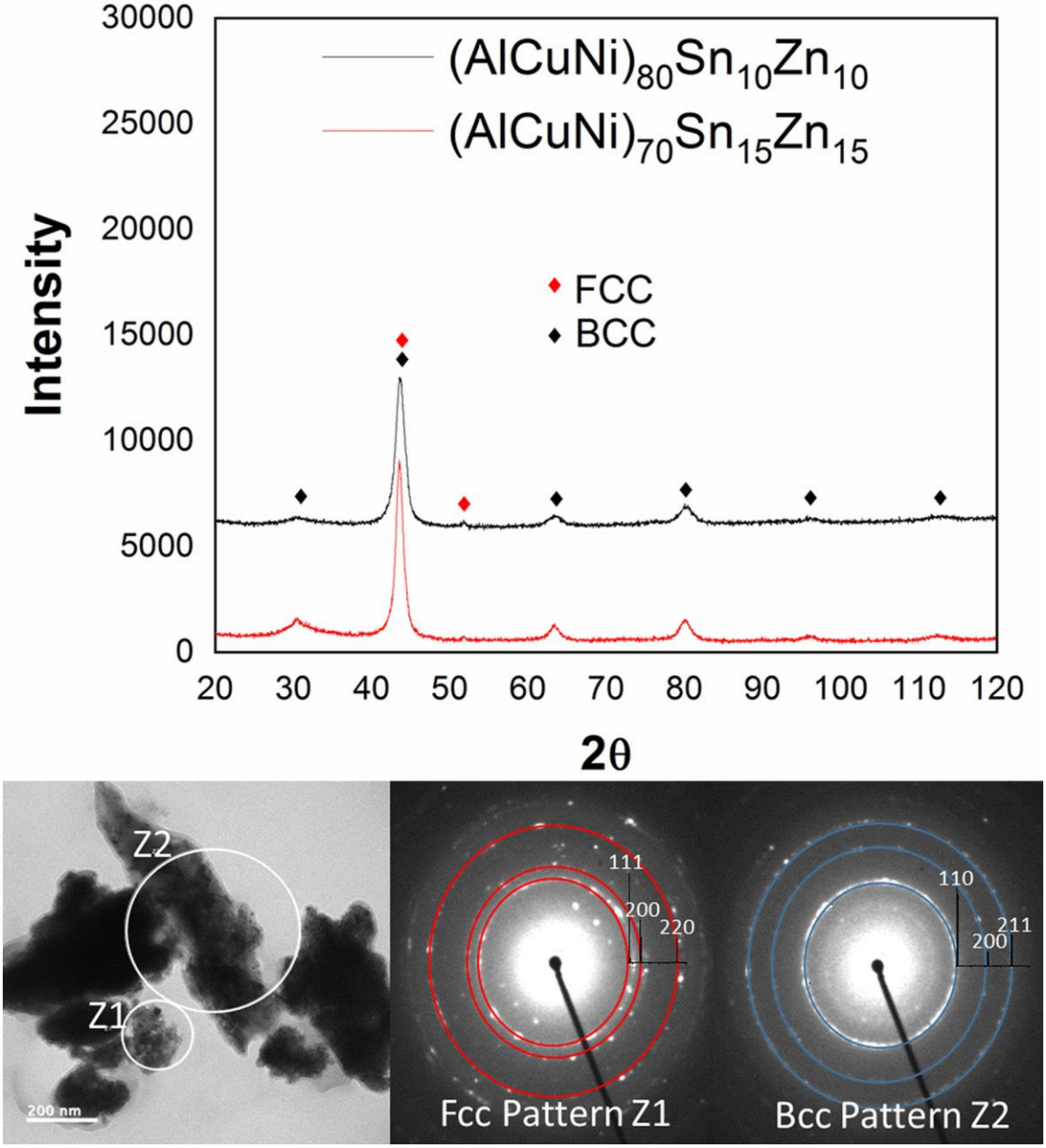

Figure 2. XRD patterns corresponding to (AlCuNi)80Sn10Zn10 and (AlCuNi)70Sn15Zn15, and TEM Micrograph and corresponding SAED of (AlCuNi)70Sn15Zn15 system

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