Solid State Synthesis of Al-based Al-Si-Ni Amorphous and/or Nanostructured Materials

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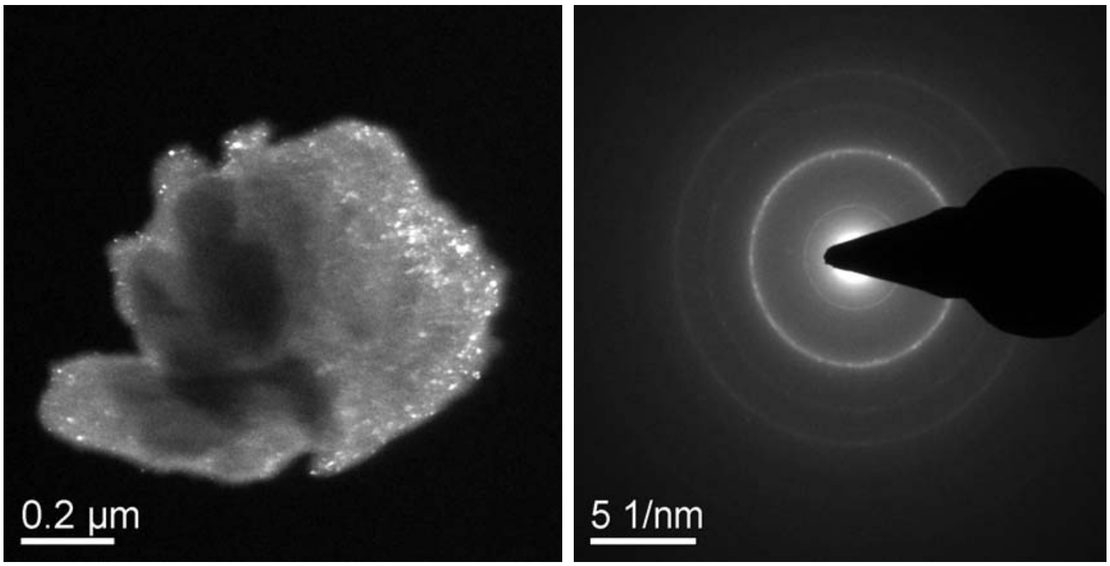
Extended Abstract

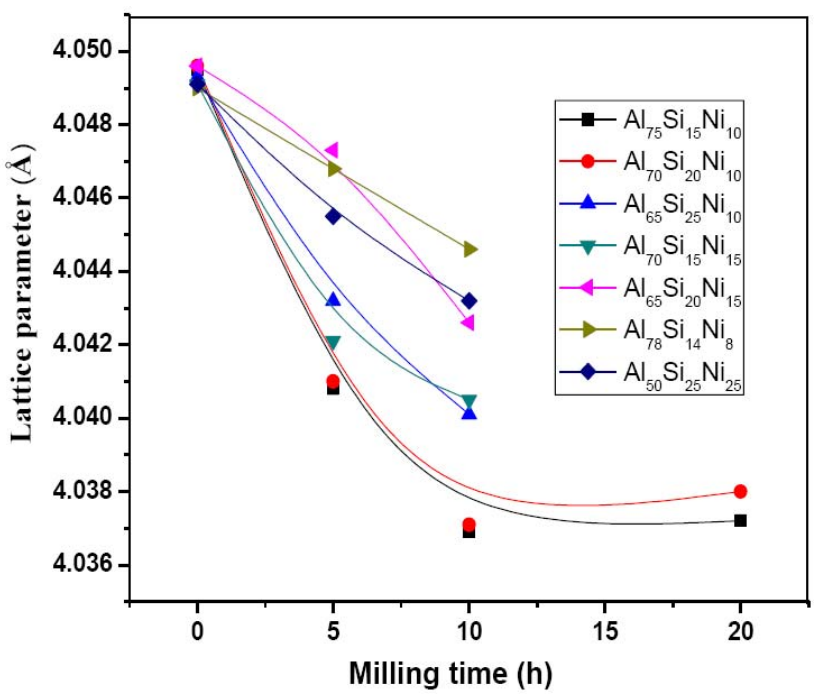
An attempt was made to synthesize Al-alloy based Al-Si-Ni amorphous and/or nanostructures by mechanical alloying (MA). The Al-Si-Ni alloys containing 14 to 25 % Si and 8 to 25 % Ni was known to generate amorphous phase by rapid solidification processing. Elemental powders of Al, Si and Ni (purity Ni ≥ 99.8%, Al ≥ 99.7%, Si ≥ 98.5%) having an average particle size <70 µm were blended to obtain nominal composition of $Al_{75}Si_{15}Ni_{10}$, $Al_{70}Si_{20}Ni_{10}$, $Al_{65}Si_{25}Ni_{10}$, $Al_{70}Si_{15}Ni_{15}$, $Al_{65}Si_{20}Ni_{15}$, $Al_{78}Si_{14}Ni_{8}$ and $Al_{50}Si_{25}Ni_{25}$. Mechanical alloying was carried out in a Fritsch high energy planetary ball mill using Cr-steel grinding media at 300 *r.p.m.* up to 50 h. Toluene was used as the process control agent. The ball to powder weight ratio was maintained at 10:1. The microstructural characterization of the milled powder was followed by X-ray diffraction (XRD), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The particle size distribution of the 50 h milled samples was carried out using a nano zeta sizer (NZS). Percentage transmittance of the milled sample was evaluated using Fourier transform infrared spectroscopy (FTIR). Partial amorphous structure was obtained in $Al_{75}Si_{15}Ni_{10}$ and $Al_{70}Si_{20}Ni_{10}$, whereas, Al-rich solid solution was observed in $Al_{65}Si_{25}Ni_{10}$, $Al_{70}Si_{15}Ni_{15}$ and $Al_{65}Si_{20}Ni_{15}$. Predominantly crystalline structure with intermetallic phases was observed in terminal compositions of $Al_{78}Si_{14}Ni_{8}$ and $Al_{50}Si_{25}Ni_{25}$. SEM micrographs showed that the powder morphology was changed from coarse layered structure obtained by very short period of milling to finer as the milling time increased. XRD and energy dispersive X-ray analysis (EDX) showed the formation of a homogeneous phase for all the compositions after milling for 50 h. The crystallite size, lattice microstrain (%) and lattice parameter were analyzed from major Al-peaks of the Al-rich solid solution. The crystallite size decreased very rapidly up to 10 h of milling and then became nearly constant (15-35 nm) with further milling, whereas, lattice microstrain (%) increased gradually up to 10 h very rapidly and then became nearly constant (0.5-0.6 %) with progress of milling. The variation of crystallite size and lattice microstrain (%) of Al-rich solid solutions with milling was found to be similar whereas, variation of lattice parameter of the Al-rich solid solutions was different. The

variation of lattice parameter with progress of milling possibly plays an important role in the amorphous phase formation by mechanical alloying.

Keywords: Amorphous; Nanostructures; X-ray diffraction (XRD); Transmission electron microscopy (TEM), nano zeta sizer (NZS), Fourier transform infrared ray (FTIR).



Dark field TEM micrograph and ED pattern of 50 h milled powder of $Al_{70}Si_{20}Ni_{10}$



Variation of lattice parameter of Al-rich solid solutions

Abstract

Solid state synthesized Al-Si-Ni nanostructures showed partial amorphous phase formation in $Al_{75}Si_{15}Ni_{10}$ and $Al_{70}Si_{20}Ni_{10}$, and solid solution in $Al_{65}Si_{25}Ni_{10}$, $Al_{70}Si_{15}Ni_{15}$ and $Al_{65}Si_{20}Ni_{15}$, compared to complete amorphous structures reported by RSP. Variation of lattice parameter of the Al-rich solid solution with progress of milling possibly plays the pivotal role in the amorphous phase formation by mechanical alloying.