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Al-Co-Sc (Aluminum-Cobalt-Scandium)

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This ternary system was investigated by [2001Buk], who presented a partial isothermal section at 600 °C and two vertical sections along the $ScAl_3$-Co_2Al_9 and $ScAl_3$-$Al_9Co_3Sc_2$ joins. This system depicts three ternary compounds.

Binary Systems

The Al-rich region of the Al-Co phase diagram was investigated by [1996God], who reported three modifications of Co_4Al_{13}, all occurring in a narrow range of composition between 24 and 24.7 at.% Co. The other phases on the Al-rich side are: Co_2Al_9 ($D8_d$-type monoclinic), $CoAl_3$ ($D0_{11}$, Fe_3C-type orthorhombic), and Co_2Al_5 ($D8_{11}$-type hexagonal). On the Co-rich side, CoAl (*B*2, CsCl-type cubic) has a wide range of homogeneity from 48 to 78.5 at.% Co. The Al-Sc phase diagram [Massalski2] depicts the following intermediate compounds: $ScAl_3$ ($L1_2$, $AuCu_3$-type cubic), $ScAl_2$ (*C*15, $MgCu_2$-type cubic), ScAl (*B*2, CsCl-type cubic) and Sc_2Al($B8_2$, Ni_2In-type hexagonal). The Co-Sc phase diagram [Massalski2] depicts the following compounds: Co_2Sc (*C*15, $MgCu_2$-type cubic), CoSc (*B*2, CsCl-type cubic), $CoSc_2$ (*C*16, $CuAl_2$-type tetragonal), and $CoSc_3$ ($CoSc_3$-type orthorhombic).

Ternary Phases

Three ternary compounds exist in this system: AlCoSc (denoted τ_1 here) has an extended homogeneity range from 33 to 45 at.% Al and from 28 to 37 at.% Sc. It has the *C*14, $MgZn_2$-type hexagonal structure, with the lattice parameters of $a = 0.511$ nm and $c = 0.823$ nm at the composition 30Al-37Co-33Sc (at.%) [2001Buk]. It forms from the melt at 1370 °C. The second compound $Al_{15}Co_8Sc_6$ (denoted τ_2 here) has the $D8_a$, $Mn_{23}Th_6$-type cubic structure with the lattice parameter of $a = 1.2094$ nm at 55Al-23Co-22Sc [2001Buk]. A third compound $Al_9Co_3Sc_2$ (denoted τ_3 here) has the $Ga_9Co_3Y_2$-type of orthorhombic structure (space group *Cmcm*), with $a = 1.2550$ nm, $b = 0.7317$ nm and $c = 0.9084$ nm, with a small homogeneity range [1987Mar, 2001Buk].

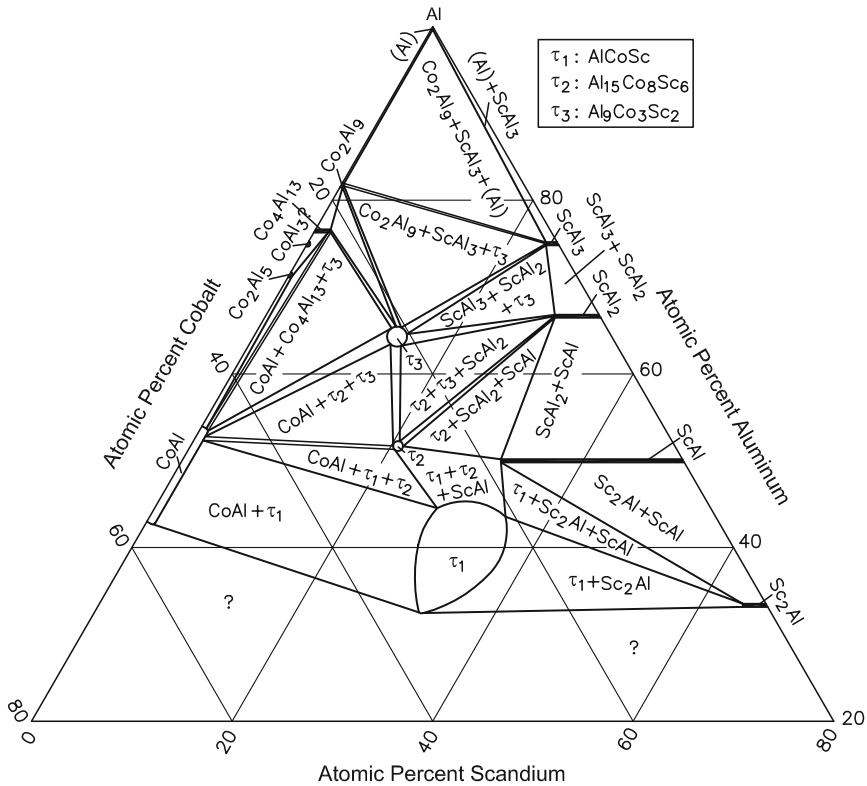

Fig. 1 Al-Co-Sc isothermal section at 600 °C in the Al-rich region [2001Buk]

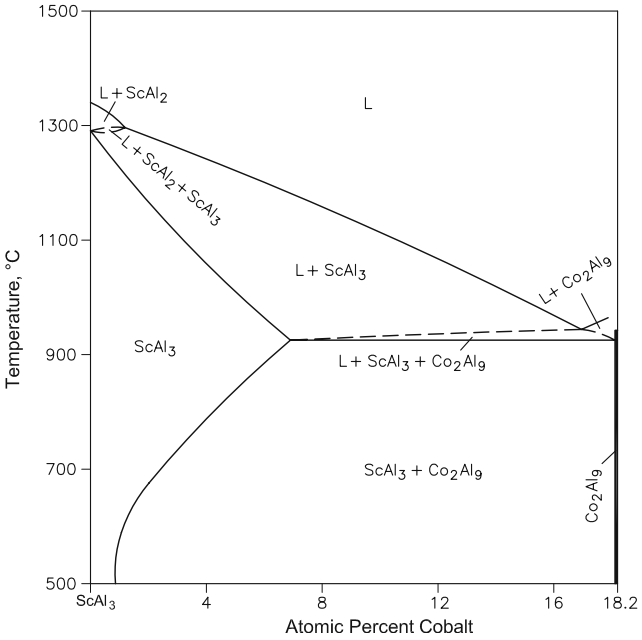

Fig. 2 Al-Co-Sc vertical section along the $ScAl_3$-Co_2Al_9 join [2001Buk]

Ternary Phase Equilibria

With starting metals of 99.999% Al, 99.6% Co, and 99.6% Sc, [2001Buk] arc-melted under Ar atm about 20 ternary alloys. The alloys were annealed at 600 °C for 1 month and quenched in water. The phase equilibria were studied with x-ray powder diffraction, metallography, hardness measurements, and differential thermal analysis at a heating rate of 80 °C per min. The compositions of coexisting phases were measured by electron probe microanalysis and listed.

The isothermal section at 600 °C constructed by [2001Buk] is redrawn in Fig. 1. All three ternary phases are present. The compounds τ_2 and τ_3 are shown in Fig. 1 with a small homogeneity region around the stoichiometric composition. These locations are slightly different from those shown by [2001Buk] in their figure. The homogeneity range of τ_1 is as indicated by [2001Buk]. The Al-Co compounds Co_4Al_{13} and CoAl dissolve 1.6 and 0.8 at.% Sc, respectively. The Al-Sc compounds $ScAl_3$, $ScAl_2$, ScAl, and Sc_2Al dissolve 1.2, 4.5, 18.2, and ~2.3 at.% Co respectively.

Two vertical sections were also determined by [2001Buk]. The section along the $ScAl_3$-Co_2Al_9 join is redrawn in Fig. 2. The end members undergo a eutectic type of solidification. The second vertical section (Fig. 3) is along the $ScAl_3$-$Al_9Co_3Sc_2$ (τ_3) join. Here also, the end members undergo a eutectic type of solidification.

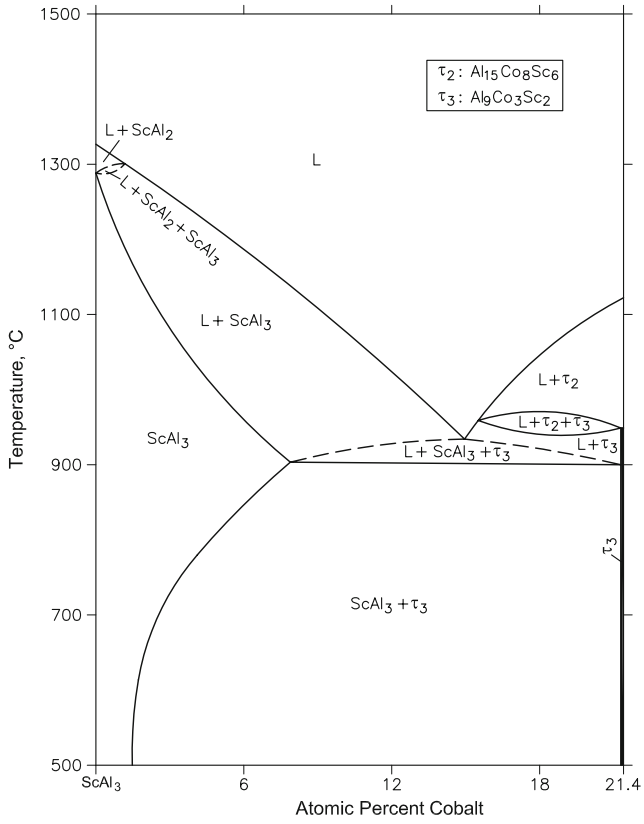

Fig. 3 Al-Co-Sc vertical section along the $ScAl_3$-$Al_9Co_3Sc_2$ join [2001Buk]

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