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Ag-Al-Gd (Silver-Aluminum-Gadolinium)

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Recently, [2004Ste] determined an isothermal section for this ternary system at 497 °C for Gd content up to 50 at.%. Seven ternary phases are present at this temperature.

Binary Systems

The Ag-Al phase diagram depicts three intermediate phases: Ag_3Al (20.5-29.8 at.% Al; denoted β, body-centered cubic; stable between 778 and ~600 °C), Ag_2Al (22.9-41.9 at.% Al; denoted δ, close-packed hexagonal), and μ (21-24 at.% Al, stable below 450 °C; *A*13, βMn-type cubic). In the Ag-Gd system, the intermediate phases are: $Gd_{14}Ag_{51}$ ($Gd_{14}Ag_{51}$-type tetragonal), $GdAg_2$ ($C11_b$, $MoSi_2$-type tetragonal), and GdAg (*B*2, CsCl-type cubic). The Al-Gd system has the following intermediate phases $GdAl_3$ ($D0_{19}$, Ni_3Sn-type hexagonal), $GdAl_2$ (*C*15, $MgCu_2$-type cubic), GdAl (ErAl-type orthorhombic), Gd_3Al_2 (Zr_3Al_2-type tetragonal), and Gd_2Al (*C*23, Co_2Si-type orthorhombic). See [Massalski2] for the above binary diagrams.

Ternary Isothermal Section

With starting metals of 99.95% Ag, 99.99% Al, and 99.5% Gd, [2004Ste] arc-melted under Ar atm 60 alloys with Gd content up to 50 at.%. The samples were annealed at 497 °C (770 K) for 1000 h and quenched in water. The phase equilibria were studied by x-ray powder diffraction. The isothermal section at 497 °C (770 K) constructed by [2004Ste] is shown in Fig. 1, to agree with the accepted binary data. The structural details of the seven ternary compounds (denoted τ_1 to τ_7 here and as 1 to 7 by [2004Ste]) are listed in Table 1. The compounds τ_1, τ_4, and τ_5 show a significant homogeneity range. The other ternary compounds

Table 1 Ag-Al-Gd crystal structure and lattice parameter data [2004Ste]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
$Gd_{1.85}Ag_{8.2\text{-}9.4}Al_{8.8\text{-}7.6}$ (τ_1)	43.5-49.9 Ag 46.7-40.3 Al 9.8 Gd	*hP*38	*P*6$_3$/*mmc*	Th_2Ni_{17}	*a* = 0.93026* *c* = 0.90991
$Gd_8Ag_{20}Al_{46}$ (τ_2)	27 Ag 62.2 Al 10.8 Gd	*tI*?	*I*4/*mmm*	$Yb_8Cu_{17}Al_{49}$	*a* = 0.88177 *c* = 1.68624
~$GdAg_{3.5}Al_{1.5}$ (τ_3)	58.3 Ag 25 Al 16.7 Gd	*h*??	Hex.	…	*a* = 0.5400 *c* = 0.9268
$GdAg_{2.2\text{-}2.8}Al_{2.8\text{-}.2.2}$ (τ_4)	36.7-46.7 Ag 46.7-36.7 Al 16.7 Gd	*hP*?	*P*6$_3$/*mmc*	$DyAg_{2.4}Al_{2.6}$	*a* = 0.92305* *c* = 0.94111
$Gd_3Ag_{2.0\text{-}2.7}Al_{9.0\text{-}8.3}$ (τ_5)	14.3-19.3 Ag 64.3-59.3 Al 21.4 Gd	*oI*28	*Immm*	αLa_3Al_{11}	*a* = 0.43306* *b* = 1.26706 *c* = 1.00145
$Gd_3Ag_2Al_7$ (τ_6)	16.7 Ag 58.3 Al 25 Gd	*hR*12	$R\bar{3}m$	$Ca_3Cu_2Al_7$	*a* = 0.55668 *c* = 2.6382
$GdAg_{0.8}Al_{1.2}$ (τ_7)	26.7 Ag 40 Al 33.3 Gd	*oI*12	*Imma*	$CeCu_2$	*a* = 0.45899 *b* = 0.72479 *c* = 0.7889
$GdAg_{5.2}Al_{6.8}$	40 Ag 52.3 Al 7.7 Gd	*tI*26	*I*4/*mmm*	$ThMn_{12}$	*a* = 0.91555 *c* = 0.54318

* Lattice parameters are at $Gd_{1.85}Ag_{9.3}Al_{7.7}$, $GdAg_{2.3}Al_{2.7}$, and $Gd_3Ag_{2.55}Al_{8.45}$ respectively

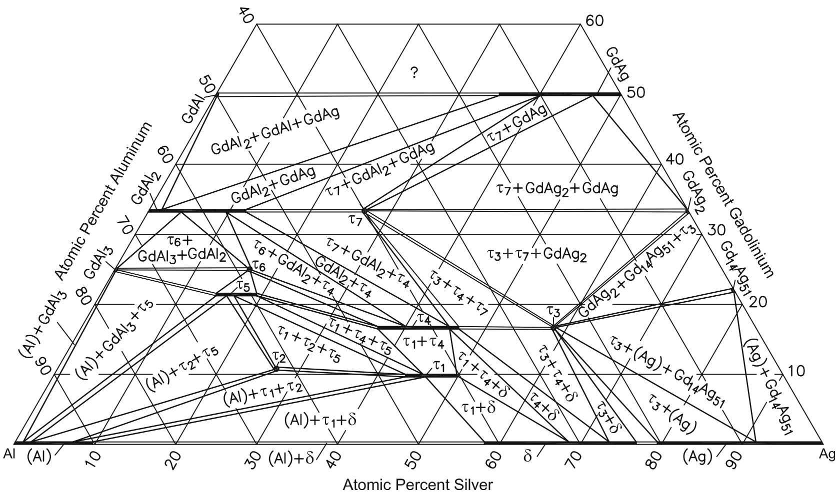

Fig. 1 Ag-Al-Gd isothermal section at 497 °C (770 K) for Gd ≤ 50 at.% [2004Ste]

are stoichiometric. The ternary compound $GdAgAl_3$ (not listed in Table 1) with the $CeNi_{2+x}Sb_{2-x}$-type structure reported earlier, was not found. However, τ_5, close in composition with a related structure-type (αLa_3Al_{11}), is present. The last-listed ternary compound in Table 1, $GdAg_{5.2}Al_{6.8}$ with $ThMn_{12}$-type structure reported earlier at 597 °C, was not found at this temperature. AgGd and $GdAl_2$ dissolve 15 at.% Al and 12 at.% Ag respectively. The third component solubility at the other binary phases is very small.

Reference

2004Ste: B.M. Stelmakhovych, O.V. Zhak, N.R. Bilas, and Yu.B. Kuzma, The Gd-Ag-Al System, *J. Alloys Compd.*, 2004, **363**, p 243-248