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# Al-Ga-Y (Aluminum-Gallium-Yttrium)

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The phase equilibria of this system were first investigated by [1969Dzy], who presented a partial isothermal section at 400 °C. Recently, [2003Spe] reinvestigated the system at the same temperature and found substantial differences in the equilibria.

## Binary Systems

The Al-Ga phase diagram [Massalski2] is a simple eutectic system with the eutectic temperature and composition at 26.6 °C and 97.9 at.% Ga. The Al-Y phase diagram [Massalski2, 2006Liu] depicts the following intermediate phases: αYAl$_3$ ($D0_{19}$, $Ni_3Sn$-type hexagonal), βYAl$_3$ ($BaPb_3$-type rhombohedral), YAl$_2$ ($C15$, $MgCu_2$-type cubic), YAl ($B_f$, CrB-type orthorhombic), $Y_3Al_2$ ($Al_2Zr_3$-type tetragonal), and $Y_2Al$ ($C23$, $Co_2Si$-type orthorhombic). The Ga-Y phase diagram [Massalski2, 2003Spe] has the following intermediate phases: YGa$_6$ ($PuGa_6$-type, tetragonal), YGa$_2$ ($C32$, $AlB_2$-type hexagonal), $Y_3Ga_5$ ($Ga_5Tm_3$-type orthorhombic), $Y_3Ga_2$, YGa ($B_f$, CrB-type orthorhombic), and $Y_5Ga_3$ ($D8_8$, $Mn_5Si_3$-type hexagonal).

## Ternary Compounds

[2003Spe] identified four ternary compounds at 400 °C in the 0-33.3 at.% Y range, in addition to the two metastable ternary compounds found in the as-cast condition. Their findings are substantially different from those in the earlier

**Table 1 Al-Ga-Y crystal structure and lattice parameter data [2003Spe]**

| Phase | Composition, at.% | Pearson symbol | Space group | Prototype | Lattice parameter, nm |
|---|---|---|---|---|---|
| $YAl_{2.75-2.6}Ga_{1.25-1.4}$ ($\tau_1$) | 55-52 Al | *oP*80 | *P*222 | ··· | *a* = 1.6888-1.6876 |
| | 25-28 Ga | | | | *b* = 0.8358-0.8342 |
| | 20 Y | | | | *c* = 0.9769-0.9789 |
| $YAl_{1.9-1.6}Ga_{2.1-2.4}$ ($\tau_2$) | 38-32 Al | *oP*60 | *P*222 | ··· | *a* = 0.8374-0.8362 |
| | 42-48 Ga | | | | *b* = 1.2561-1.2543 |
| | 20 Y | | | | *c* = 0.9766-0.9750 |
| $YAl_{0.40}Ga_{2.60}$ ($\tau_3$) | 10 Al | *hP*8 | $P6_3/mmc$ | $Ni_3Sn$ | *a* = 0.6273 |
| | 65 Ga | | | | *c* = 0.4520 |
| | 25 Y | | | | |
| $YAl_{0.9-0.7}Ga_{1.1-1.3}$ ($\tau_4$) | 30-23.3 Al | *hP*3 | *P*6/*mmm* | $AlB_2$ | *a* = 0.4440-0.4388 |
| | 36.7-43.3 Ga | | | | *c* = 0.3624-0.3692 |
| | 33.3 Y | | | | |

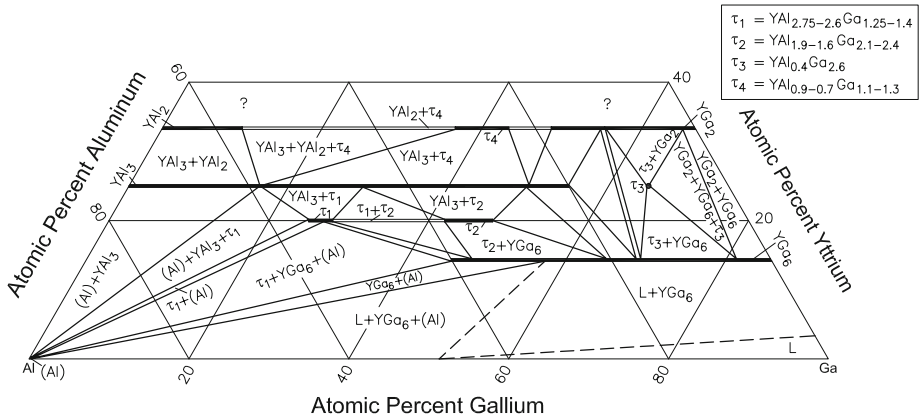


**Fig. 1** Al-Ga-Y partial isothermal section at 400 °C [2003Spe]

work of [1969Dzy]. The stable compounds are: $YAl_{2.75-2.60}Ga_{1.25-1.40}$ ($\tau_1$), $YAl_{1.90-1.60}Ga_{2.10-2.40}$ ($\tau_2$), $YAl_{0.40}Ga_{2.60}$ ($\tau_3$), and $YAl_{0.90-0.70}Ga_{1.10-1.30}$ ($\tau_4$). The structural characteristics of these compounds are listed in Table 1. The notations $\tau_1$, $\tau_2$, etc. given above in brackets correspond to the numbers 1, 2, etc. used by [2003Spe]. The structure of $\tau_1$ and $\tau_2$ phases is related to the orthorhombically-distorted $AlBa_4$-type of structure.

## Isothermal Section

With starting metals of 99.99% Al, 99.999% Ga, and 99.8% Y, [2003Spe] arc-melted under Ar atm 79 binary and ternary alloy samples with Y concentration up to 33.3 at.%. The alloys were annealed at 400 °C for 1200 h and quenched in water. The phase equilibria were studied with x-ray powder diffraction.

The isothermal section at 400 °C constructed by [2003Spe] in the concentration range of 0-33.3 at.% Y is shown in Fig. 1. The four ternary compounds $\tau_1$ to $\tau_4$ are present. The binary compounds $YGa_6$, $YGa_2$, $YAl_3$, and $YAl_2$ are stable in this composition range. Instead of $\alpha YAl_3$, $\beta YAl_3$ was found by [2003Spe]. $YGa_6$ and $YGa_2$ dissolve up to 40 and 18 at.% Al, respectively, at constant Y content. $YAl_3$ and $YAl_2$ dissolve up to 55 and 10 at.% Ga, respectively, at constant Y.

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