Phase equilibria in the Gd–Al–Ge system at 873 K

S. Pukas[1], R. Gladyshevskii[1]

[1]*Department of Inorganic Chemistry, Ivan Franko National University of Lviv, Kyryla i Mefodiya St. 6, UA-79005 Lviv, Ukraine*

svitlana.pukas@lnu.edu.ua

The interaction of the components in the ternary system Gd–Al–Ge was investigated by X-ray powder diffraction, scanning electron microscopy, and energy-dispersive X-ray spectroscopy. The isothermal section of the phase diagram at 873 K was constructed in the full concentration range, based on phase analysis of 48 alloys (Fig. 1). Samples were prepared by melting pure metals in an arc furnace under an argon atmosphere and annealed in evacuated quartz tubes for 720 h at 873 K.

According to literature data [1,2] eight gadolinium aluminides and twelve gadolinium germanides form in the binary systems Gd–Al and Gd–Ge, respectively, and ten ternary gadolinium alumogermanides are known in the system Gd–Al–Ge. The existence and crystal structures of ten binary gadolinium aluminides ($GdAl_3$, $GdAl_2$, Gd_3Al_2, GdAl, and Gd_2Al) and germanides (Gd_3Ge_5, $GdGe_{1.56}$, GdGe, Gd_5Ge_4, and Gd_5Ge_3) at the temperature of investigation was confirmed by X-ray diffraction. The solubility limits of the third component in several of the binary compounds were determined: $GdAl_3$ and $GdAl_2$ dissolve ~5 at.% Ge each, whereas Gd_3Ge_5, $GdGe_{1.56}$, and GdGe dissolve ~12, ~6, and ~5 at.% Al, respectively. The formation of seven ternary compounds was observed and their unit-cell parameters were refined: $GdAl_2Ge_2$ (structure type Ce_2SO_2, Pearson symbol *hP*5, space group *P*-3*m*1, a = 4.2425(7), c = 6.699(1) Å), $Gd_2Al_{1.6}Ge_{5.4}$ (La_2AlGe_6, *mS*36, *C*2/*m*, a = 8.047(3), b = 8.364(4), c = 10.572(2) Å, β = 100.78°), $Gd_2Al_3Ge_4$ ($Ba_2Cd_3Bi_4$, *oS*36, *Cmce*, a = 5.9578(7), b = 14.864(2), c = 7.762(1) Å), $Gd_2Al_{3.05}Ge_3$ ($Tb_2Al_{3.15}Ge_3$, *hR*234, *R*-3*c*, a = 7.2746(6), c = 88.583(9) Å), $GdAl_{0.15}Ge_{2.01}$ ($ErGe_{2.16}$, *oS*16, *Cmcm*, a = 4.174(1), b = 16.449(5), c = 3.982(1) Å), Gd_2AlGe_3 (Y_2AlGe_3, *oP*24, *Pnma*, a = 6.8031(2), b = 4.2283(1), c = 17.8166(5) Å), GdAlGe ht (α-$ThSi_2$, *tI*12, *I*4$_1$/*amd*, a = 4.1431(5), c = 14.338(2) Å). Three other compounds, $GdAl_{0.26}Ge_3$, Gd_2AlGe_2, and $Gd_{11}Al_2Ge_8$, mentioned in the literature, were not observed at 873 K.

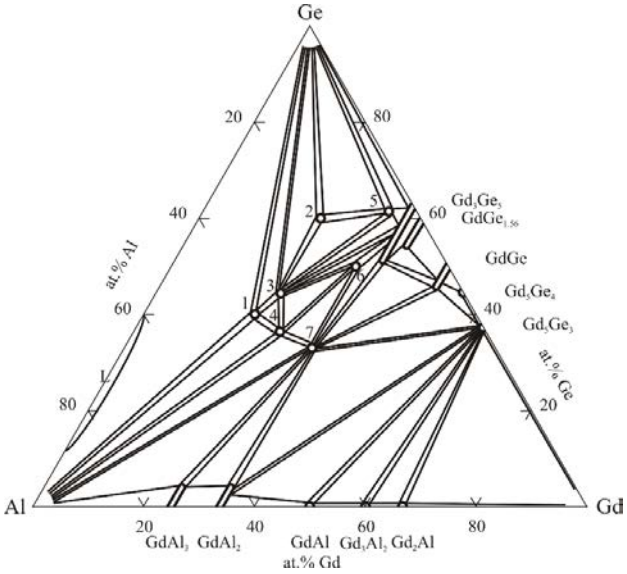

Figure 1. Isothermal section of the phase diagram of the system Gd–Al–Ge at 873 K; compounds: $GdAl_2Ge_2$ (1), $Gd_2Al_{1.6}Ge_{5.4}$ (2), $Gd_2Al_3Ge_4$ (3), $Gd_2Al_{3.05}Ge_3$ (4), $GdAl_{0.15}Ge_{2.01}$ (5), Gd_2AlGe_3 (6), GdAlGe ht (7).

[1] Villars, P., Cenzual, K., Daams, J. L. C., Hulliger, F., Okamoto, H., Osaki, K., Prince, A. & Iwata, S. (2002). *Pauling File Binaries Edition, Release 2002/1*. Bonn; Crystal Impact (Distributor).

[2] *Pearson's Crystal Data, Crystal Structure Database for Inorganic Compounds, Release 2024/25*, edited by P. Villars & K. Cenzual, 2024. Materials Park (OH): ASM International.

This work was carried out under the project "Search for new structure types" of the company Material Phases Data System, Vitznau, Switzerland.