

**THE TERNARY SYSTEM Yb–Ga–Sn AT 600 °C  
IN THE CONCENTRATION RANGE 0–33.3 AT.% Yb**

*Ohonovskiy I. K.*, Tokaychuk Ya. O., Gladyshevskii R. E.

Department of Inorganic Chemistry, Ivan Franko National University of Lviv,  
Kyryla i Mefodiya St. 6, 79005 Lviv, Ukraine  
illia.ohonovskiy@lnu.edu.ua

The isothermal section of the phase diagram of the ternary system Yb–Ga–Sn at 600 °C was constructed in the concentration range 0–33.3 at.% Yb by means of X-ray diffraction and energy-dispersive X-ray spectroscopy.

14 alloys were synthesized from high-purity metals (Yb  $\geq$  99.8 mass%, Ga  $\geq$  99.99 mass%, Sn  $\geq$  99.9 mass%) by arc melting under argon atmosphere using a water-cooled copper hearth, a tungsten electrode and Ti sponges as a getter. The alloys were wrapped into tantalum foil, sealed in quartz ampoules under vacuum and annealed at 600 °C for 720 hours and finally quenched into cold water.

Phase analysis and structure refinements were performed using X-ray powder diffraction data collected at room temperature on a diffractometer DRON-2.0M (Fe  $K\alpha$ -radiation, angular range  $20^\circ \leq 2\theta \leq 140^\circ$ , step  $0.05^\circ$ ). The profile and structural parameters were refined by the Rietveld method using the FullProf Suite program package [1]. Energy-dispersive X-ray spectroscopy was carried out on a Tescan Vega3 LMU scanning electron microscope.

The existence of 6 binary compounds at 600 °C was confirmed in the boundary systems Yb–Ga and Yb–Sn: YbGa<sub>4</sub> (structure type CaGa<sub>4</sub>), Yb<sub>0.89</sub>Ga<sub>2.97</sub> (own structure type), YbGa<sub>2.64</sub> (own structure type), YbGa<sub>2</sub> (CaIn<sub>2</sub>), YbSn<sub>3</sub> (Cu<sub>3</sub>Au), and Yb<sub>3</sub>Sn<sub>5</sub> (Pu<sub>3</sub>Pd<sub>5</sub>). At the temperature of investigation (600 °C) Ga and Sn are liquid, *i.e.* a continuous liquid region is observed along the Ga–Sn side of the isothermal section of the phase diagram of the system Yb–Ga–Sn. The binary stannide YbSn<sub>3</sub> with cubic Cu<sub>3</sub>Au-type structure dissolves 12 at.% Ga forming a solid solution of substitution type. The unit-cell parameter decreases upon the replacement of large Sn atoms by small Ga atoms ( $a = 4.6386(6)$  Å for YbGa<sub>0.48</sub>Sn<sub>2.52</sub> compared with  $a = 4.682$  Å for YbSn<sub>3</sub> [2]). The other binary compounds do not dissolve noticeable amounts of the third component.

The existence and crystal structure of the ternary compound YbGaSn [3] were confirmed at 600 °C: structure type YPtAs, Pearson symbol  $hP12$ , space group  $P6_3/mmc$ ,  $a = 4.4397(4)$ ,  $c = 17.3005(18)$  Å. The structure is characterized by ordered distribution of the atoms over four sites: Wyckoff positions  $2a$  and  $2b$  for the Yb atoms, one site  $4f$  for the Ga atoms, and one site  $4f$  for the Sn atoms. The structure of YbGaSn derives from the binary type AlB<sub>2</sub> and is characterized by trigonal-prismatic coordination of the  $p$ -element atoms, which form corrugated graphite-like nets in the  $ab$  plane of the hexagonal structure. X-ray phase, structural and spectral analyses of multicomponent samples of different compositions indicated absence of any significant homogeneity range for YbGaSn at 600 °C. This phase forms the largest number of equilibria (6) at 600 °C in the investigated range of the ternary system Yb–Ga–Sn.

[1] J. Rodríguez-Carvajal, *Commission on Powder Diffraction (IUCr), Newsletter* 26 (2001) 12–19.

[2] G. Zanicchi, D. Mazzone, M. L. Fornasini, P. Riani, R. Marazza, R. Ferro, *Intermetallics* 7 (1999) 957–966.

[3] J. R. Salvador, F. Guo, T. P. Hogan, M. G. Kanatzidis, *Nature (London)* 425 (2003) 702–705.