

# Characteristics of the interaction between components in the $RGe_2 - R'Ge_2$ cross-sections

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Intermetallic compounds serve as the basis for many new materials. These compounds are formed through the chemical interactions between different metals and certain semi-metallic elements. This study investigates the phase diagrams of various ternary systems that include two different rare-earth metals from the cerium or yttrium subgroups. The specific systems examined include: Ce–{Sc, Y, La, Gd, Lu}–Ge, Sc–{Nd, Y, Dy}–Ge, Sm–Dy–Ge, Tm–{Gd, Er}–Ge, DyGe<sub>2</sub>–RGe<sub>2</sub> (R = Sm, Y, Gd, Tb, Ho, Er, Tm, Lu), RGe<sub>2</sub>–LuGe<sub>2</sub> (R = Sm, Pr, Nd, Gd, Dy), and SmGe<sub>2</sub>–RGe<sub>2</sub> (R = Gd, Tb, Ho, Er, Tm) [1–4].

The alloys were synthesized through arc melting a metal charge, ensuring that the primary component's content was at least 99.7 wt.%. This process was conducted in an argon atmosphere, using sponge titanium as a getter. To achieve better homogenization, the samples were remelted twice. Homogenizing annealing of the alloys occurred in vacuum-sealed quartz ampoules at a temperature of 600°C for 720 hours, followed by rapid cooling in cold water. The phase composition of the synthesized samples was determined by analyzing experimental powder diffraction patterns (utilizing a DRON–2.0M diffractometer with Fe K $\alpha$  radiation) and comparing these patterns with theoretical diffraction data. Structural calculations were carried out using the WinCSD [5] program package.

The studied samples Tb<sub>10</sub>Ce<sub>24</sub>Ge<sub>66</sub>, Tb<sub>20</sub>Ce<sub>14</sub>Ge<sub>66</sub>, Ho<sub>18</sub>Ce<sub>16</sub>Ge<sub>66</sub>, and Ho<sub>12</sub>Ce<sub>22</sub>Ge<sub>66</sub> belong to the homogeneity region of solid solutions with the  $\alpha$ -ThSi<sub>2</sub> structural type. It is noteworthy that the Ho<sub>12</sub>Ce<sub>22</sub>Ge<sub>66</sub> sample contains a small amount of a phase with the AlB<sub>2</sub> structural type. In addition, the Ho<sub>10</sub>Lu<sub>24</sub>Ge<sub>66</sub> and Ho<sub>20</sub>Lu<sub>14</sub>Ge<sub>66</sub> samples belong to the homogeneity region of a solid solution based on LuGe<sub>2</sub>, and Ho<sub>20</sub>Lu<sub>14</sub>Ge<sub>66</sub> also contains a small amount of a phase with the  $\alpha$ -ThSi<sub>2</sub> structural type. The Ho<sub>20</sub>Tm<sub>14</sub>Ge<sub>66</sub> sample is from the homogeneity region of a solid solution based on the digermanide HoGe<sub>1.85</sub>, while the Ho<sub>10</sub>Tm<sub>24</sub>Ge<sub>66</sub> alloy contains an unidentified phase. The unit cell parameters and volume for all synthesized samples were refined and presented in Table 1.

**Table 1.** Cell parameters of the alloys of HoGe<sub>2</sub>–RGe<sub>2</sub>, R = Ce, Tm, Lu and TbGe<sub>2</sub>–RGe<sub>2</sub>, R = Ce, Pr cross sections

Sample	Structure type	Space group	Pearson code	Cell parameters, Å			V, Å <sup>3</sup>
				a	b	c	
Tb <sub>10</sub> Ce <sub>24</sub> Ge <sub>66</sub>	$\alpha$ -ThSi <sub>2</sub>	<i>I4<sub>1</sub>/amd</i>	<i>tI12</i>	4.226(4)		13.974(4)	250.0
Tb <sub>20</sub> Ce <sub>14</sub> Ge <sub>66</sub>	$\alpha$ -ThSi <sub>2</sub>	<i>I4<sub>1</sub>/amd</i>	<i>tI12</i>	4.211(6)		13.923(5)	247.0
Ho <sub>12</sub> Ce <sub>22</sub> Ge <sub>66</sub>	$\alpha$ -ThSi <sub>2</sub>	<i>I4<sub>1</sub>/amd</i>	<i>tI12</i>	4.225(7)		13.900(4)	247.0
	AlB <sub>2</sub>	<i>P6/mmm</i>	<i>hP3</i>	3.937(4)		4.064(3)	54.5
Ho <sub>18</sub> Ce <sub>16</sub> Ge <sub>66</sub>	$\alpha$ -ThSi <sub>2</sub>	<i>I4<sub>1</sub>/amd</i>	<i>tI12</i>	4.237(6)		14.019(2)	251.6
Ho <sub>10</sub> Lu <sub>24</sub> Ge <sub>66</sub>	ZrSi <sub>2</sub>	<i>Cmcm</i>	<i>oS12</i>	3.989(1)	15.669(4)	3,788(7)	236.8
Ho <sub>20</sub> Lu <sub>14</sub> Ge <sub>66</sub>	ZrSi <sub>2</sub>	<i>Cmcm</i>	<i>oS12</i>	4.007(8)	15.784(4)	3.812(1)	241.1
	$\alpha$ -ThSi <sub>2</sub>	<i>I4<sub>1</sub>/amd</i>	<i>tI12</i>	4/185(2)		13.988(8)	245.0
Ho <sub>20</sub> Tm <sub>14</sub> Ge <sub>66</sub>	YGe <sub>1.82</sub>	<i>Cmcm</i>	<i>oS28</i>	4.116(4)	29.682(3)	3.894(3)	475.7
Ho <sub>10</sub> Tm <sub>24</sub> Ge <sub>66</sub>	X-phase						
Tb <sub>18</sub> Pr <sub>16</sub> Ge <sub>66</sub>	$\alpha$ -GdSi <sub>2</sub>	<i>Imma</i>	<i>oI12</i>	4.200(4)	4.192(2)	13.855(2)	243.9

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