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STRUCTURAL ANALYSIS OF SOME Bi-Ga-Ni ALLOYS

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ABSTRACT
The results of structural analysis of selected alloys in Bi-Ga-Ni system, obtained using SEM-EDX analysis, are presented in this paper as a contribution to the better knowledge of this ternary system.
Keywords: *Bi-Ga-Ni alloys, ternary system, structural analysis, SEM-EDX*

1. INTRODUCTION
Nickel-based alloys have significant contribution to our present-day society, promising to continue to supply materials for an even more demanding future [1].

According to some statistics of the Nickel Institute [2], nickel is used in over 300,000 products for consumer, industrial, military, transport, aerospace, marine and architectural applications. So, the application of nickel is wide – it is mostly used for production of stainless steels - about 65%, but also for super alloys, corrosion and heat-resisting alloys, other alloys with special magnetic properties, for aircraft gas turbines, steam turbine power plants, medical applications, decorative plating or plating for engineering uses, batteries, nuclear power systems, chemical and petrochemical industries, electronics, etc. [1-4]

Some of Ni-based alloys exhibit shape memory effect, i.e. Al-Ni-Fe [5]. Also, Ga-Ni-based alloys became recently very interesting to the researchers, because Ga-Ni-Me (Me= Mn,Fe,Co) alloys exhibit magnetic shape memory effects [6-9] and form very interesting group of advanced ferromagnetic shape memory alloys with specific fields of applications.

One of interesting systems, belonging to mentioned Ga-Ni-base alloys, is ternary Ni-Ga-Bi system. It is still not completely examined and there is only one reference up to now [10], dealing with its thermodynamic and phase equilibria. In order to give more information on its structural characteristics, the results of SEM-EDX examination of selected Ni-Ga-Bi alloys are presented in this paper.

2. EXPERIMENTAL

Experimental investigation of some Ni-Ga-Bi alloys was done using SEM-EDX method.

Selected alloys [10] and their compositions are presented in Table 1. They were prepared by melting in an induction furnace under protective atmosphere, using bismuth, gallium and nickel, which purity was 99.99%.
The mass loss, measured during the preparation of alloys, was kept less than 1%.

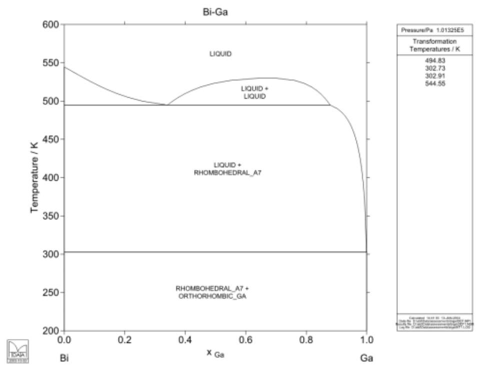
Table 1. Molar composition of investigated samples in Bi-Ga-Ni system

Alloy	xBi	xGa	xNi
E1	0,9	0,07	0,03
E2	0,9	0,04	0,06
E4	0,8	0,16	0,04
E6	0,8	0,04	0,16

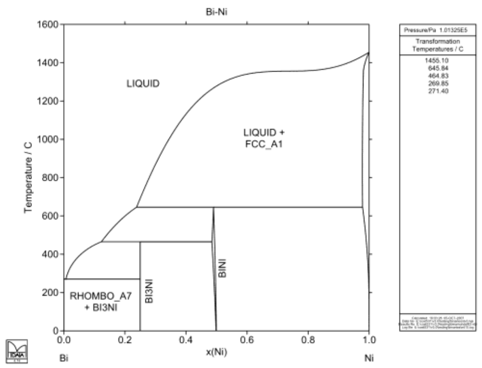
JEOL JSM-6460 scanning electron microscope, equipped with Oxford Instruments energy dispersive spectrometer, was used for structural analysis and phase chemical compositions examination. The experiments were done under following conditions: EDX resolution up to 10 nm, acceleration voltage 0.2-30 kV and magnification up to 300000 x. No etching was applied.

3. RESULTS AND DISCUSSION

The properties of ternary system Ni-Ga-Bi are based on the properties of three constitutive binary systems – Bi-Ga, Bi-Ni and Ga-Ni. Their phase diagrams [11] are given in Fig.1.



(a)



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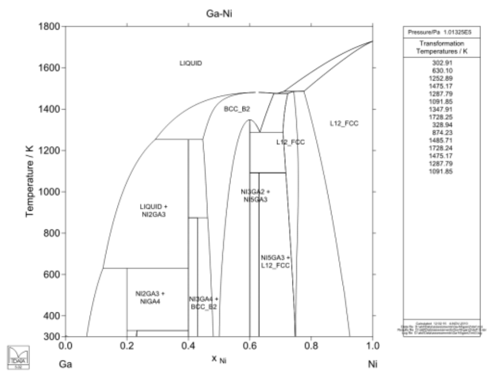


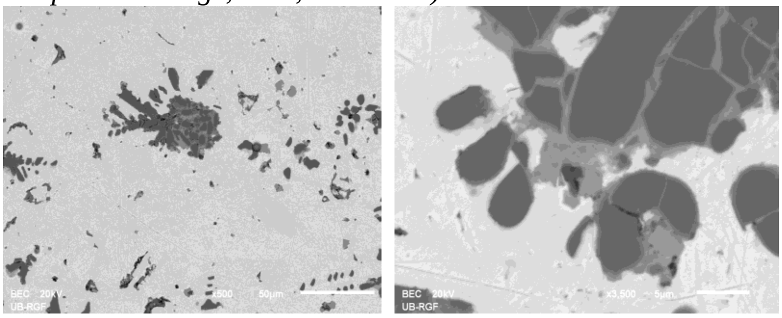
(c)

Fig.1. The phase diagrams of constitutive binaries – Bi-Ga, Bi-Ni and Ga-Ni, according to Ref. [11]

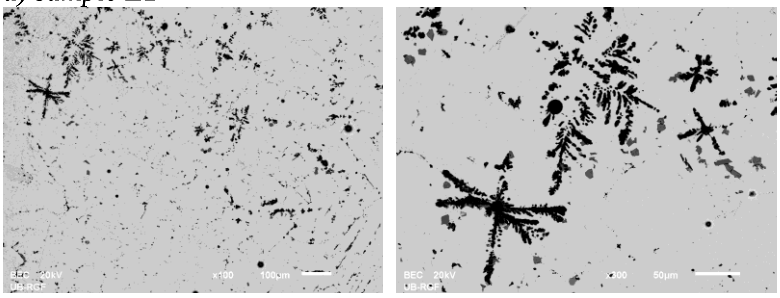
As can be seen from Fig.1a, besides small mutual solubility of the components in the solid and liquid state, a miscibility gap in the Bi-Ga phase diagram can be noticed in composition area with 38.5-91.5 at% Ga. The intermetalic compound Bi_3Ni and intermediate phase BiNi are present in the Bi-Ni phase diagram (Fig.1b), with solubility of Bi in solid (Ni) of about 29-29 at% of Bi and solubility of Ni in solid (Bi) from 5 to 21 a5% Ni [11]. The Ni-Ga system (Fig.1c) is rather complex, having several intermediate phases, such as Ni_2Ga_3, Ni_3Ga_4, Ni_3Ga_2, Ni_5Ga_3 and $NiGa_4$.

According to our previous results on Bi-Ga-Ni system [10], two invariant effects occur at the temperatures of 267 °C (ternary eutectic reaction) and at 227 °C, in the Bi-rich part of the ternary phase diagram. The SEM photographs of the selected samples are shown in Fig.2.

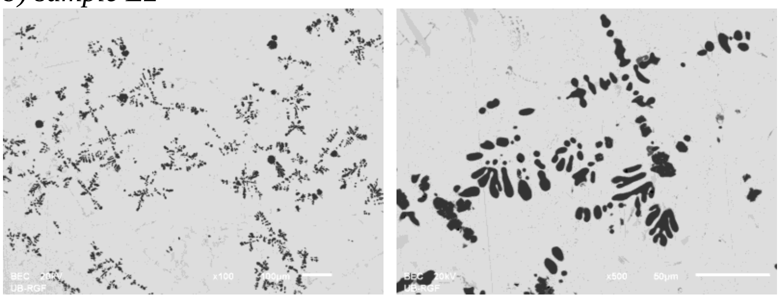
Fig.2. Characteristic SEM photographs of the selected samples (the back-scattered electron composition image, BEC, are shown)



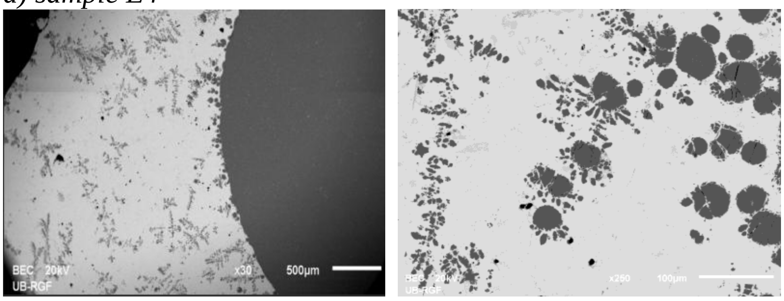
a) sample E1



b) sample E2



d) sample E4



e) sample E6

The elemental compositions of experimentally determined phases were determined using EDX [10], and obtained results are presented in Table 2.

Table 2. The phases determined by EDX

Sample	Phases determined by EDX
E1	(Bi)-based solid solution
	Ni_2Ga_3
	$NiGa_4$
E2	(Bi)-based solid solution
	(Bi,Ga)-based solid solution
	Bi_3Ni

E4	(Bi)-based solid solution
	$NiGa_4$
	Ni_2Ga_3
E6	(Bi)-based solid solution
	Ni_2Ga_3
	(Bi,Ga)-based solid solution

Based on obtained SEM and EDX experimental results and their comparison, following phases were defined in the investigated samples of Bi-Ga-Ni system: for the samples E1and E2, (Bi)-based solid solution (light phase), Ni_2Ga_3 (dark phase) and $NiGa_4$ (grey phase), while for the samples E4 and E6 phases (Bi)-based solid solution (light phase), Bi_3Ni (grey phase) and (Bi,Ga)-based solid solution (dark phase), which is in accordance with data given in [10].

4. CONCLUSIONS

The results of structural analysis of some Ni-Ga-Bi alloys, obtained experiment ally by application of SEM-EDX method, are presented in this paper. They confirmed the existence of present phases in the structure and are in accordance with our previous work on this system [10].

5. REFERENCES

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