Sino-Russia meeting on frontiers of neutron scattering (SRNS-2024)
October 8–11, 2024, Ekaterinburg

In situ neutron diffraction study of phase transitions in $Fe_{68}Ga_{32}$ alloy

T.N. VERSHININA[1,], B. YERZHANOV[1], R.N. VASIN[1], A.M. BALAGUROV[1], I.S. GOLOVIN[2], J. HAO[3], H. LU[3], L. HE[3]

[1] Joint Institute for Nuclear Research, Dubna, Russian Federation

[2] National University of Science and Technology "MISIS", Moscow, Russian Federation

[3] Spallation Neutron Source Science Center, Dongguan, China

Phases in high-gallium Fe-Ga alloys (RT)

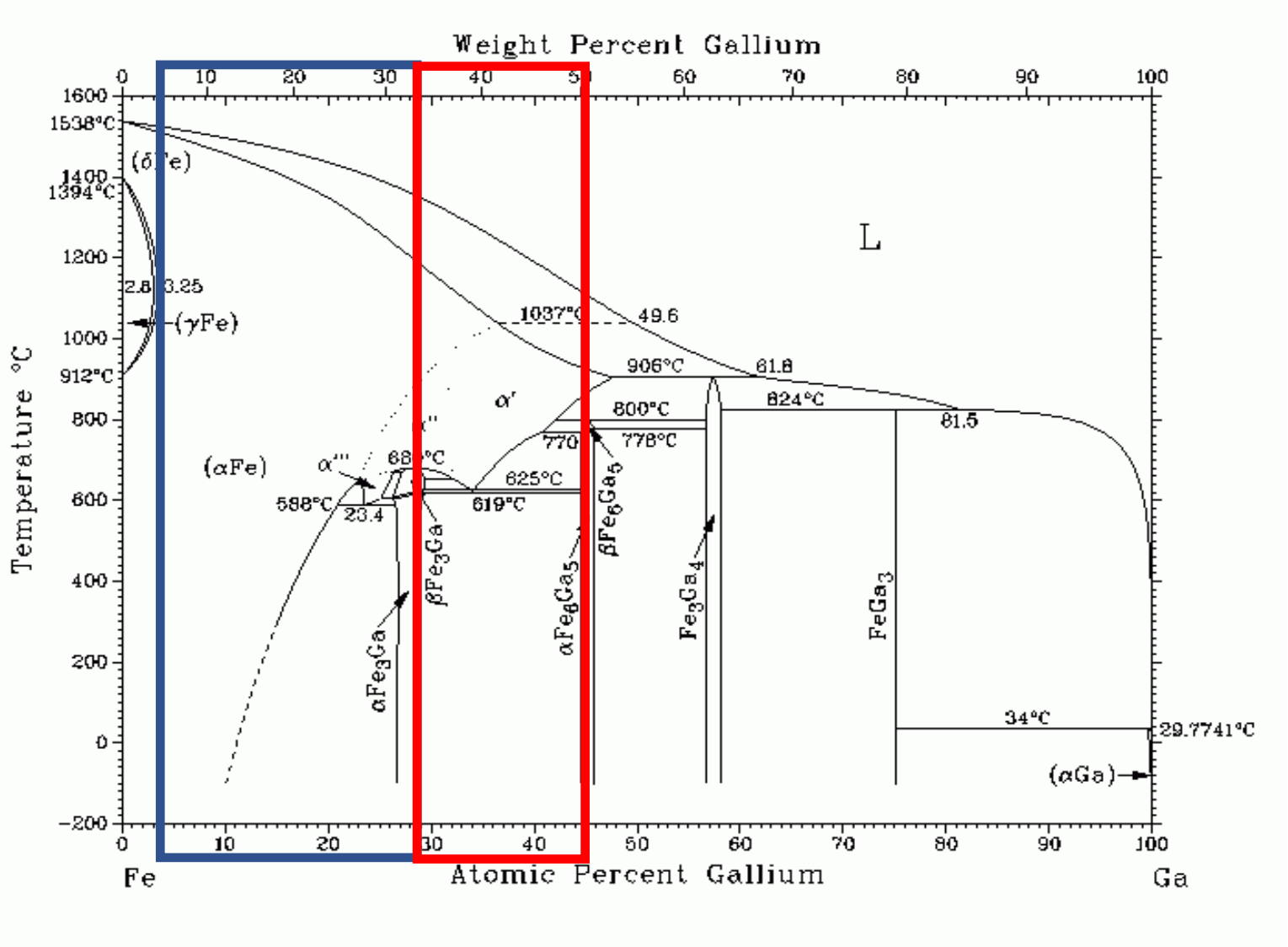
Stable phases:

$L1_2$ (sp.gr. $Pm\bar{3}m$)
α-Fe_6Ga_5 (sp.gr. $C2/m$)

Metastable phases:

BCC phases: A2 (sp.gr. $Im\bar{3}m$),
B2(sp.gr. $Pm\bar{3}m$),
$D0_3$ (sp.gr. $Fm\bar{3}m$)

$Fe_{13}Ga_{13}$ (sp.gr. $R\bar{3}m$)
$Fe_{13}Ga_9$ (sp.gr. $C2/m$)
ω - ?



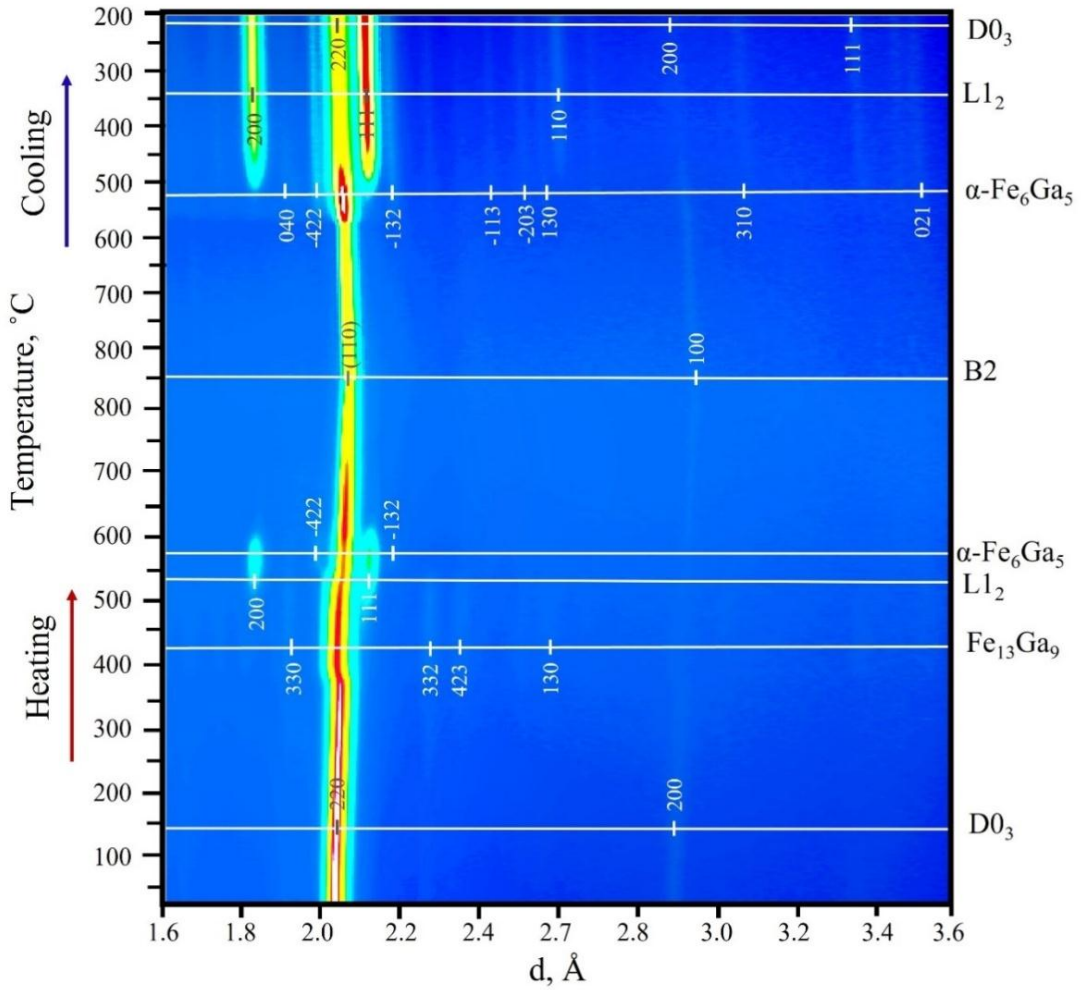
O. Ikeda, R. Kainuma, I. Ohinuma, et al., J. of Alloys and Compounds 347 (2002) 198.

High-Resolution Fourier Diffractometer (HRFD, JINR)
General-Purpose Powder Diffractometer (GPPD, CSNS)

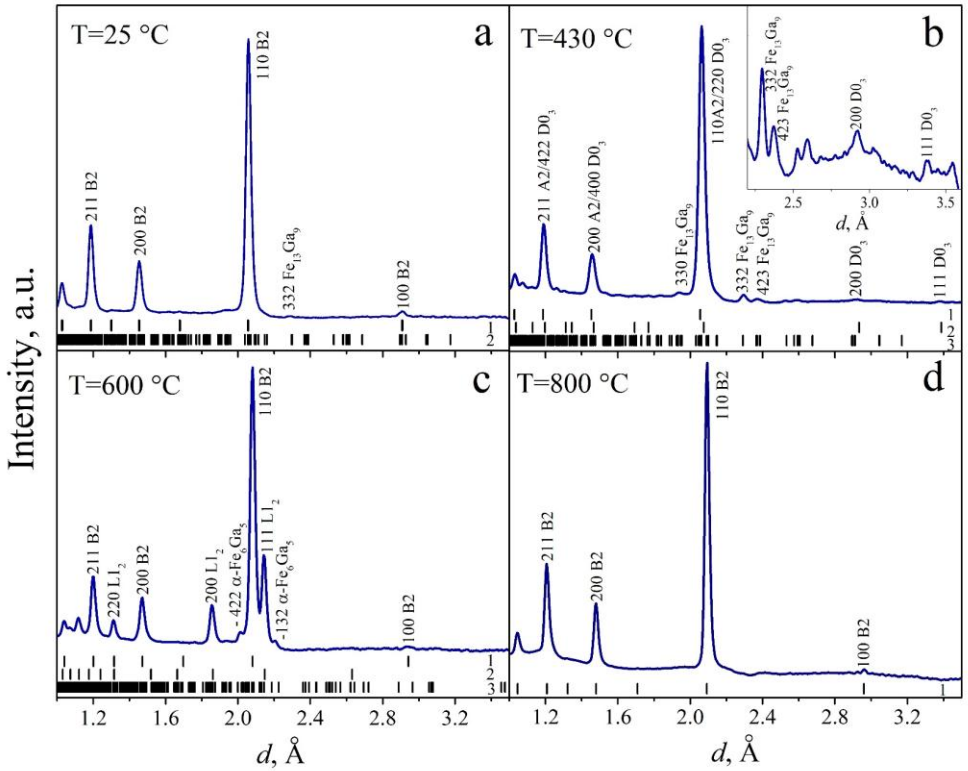
	HRFD (JINR)		GPPD (CSNS)
	High-resolution mode	High-intensity mode	High-resolution mode
Resolution (Δd/d) , %	0.1	1.5	0.15
d-space range, Å	0.7 - 4	1 - 16	0.05–50.48
Neutron flux at sample position, n/cm^2/s	4*10^6	~1.3*10^7	10^7
Flight path, m	29.6		30
Detector position, deg	152, 90		150, 90, 30
t, min	60	1	3+1

B2/A2 + $Fe_{13}Ga_9$	**$D0_3$+ $Fe_{13}Ga_9$ + α-Fe_6Ga_5**

$Fe_{68}Ga_{32}$ alloy (B2/A2 + $Fe_{13}Ga_9$)

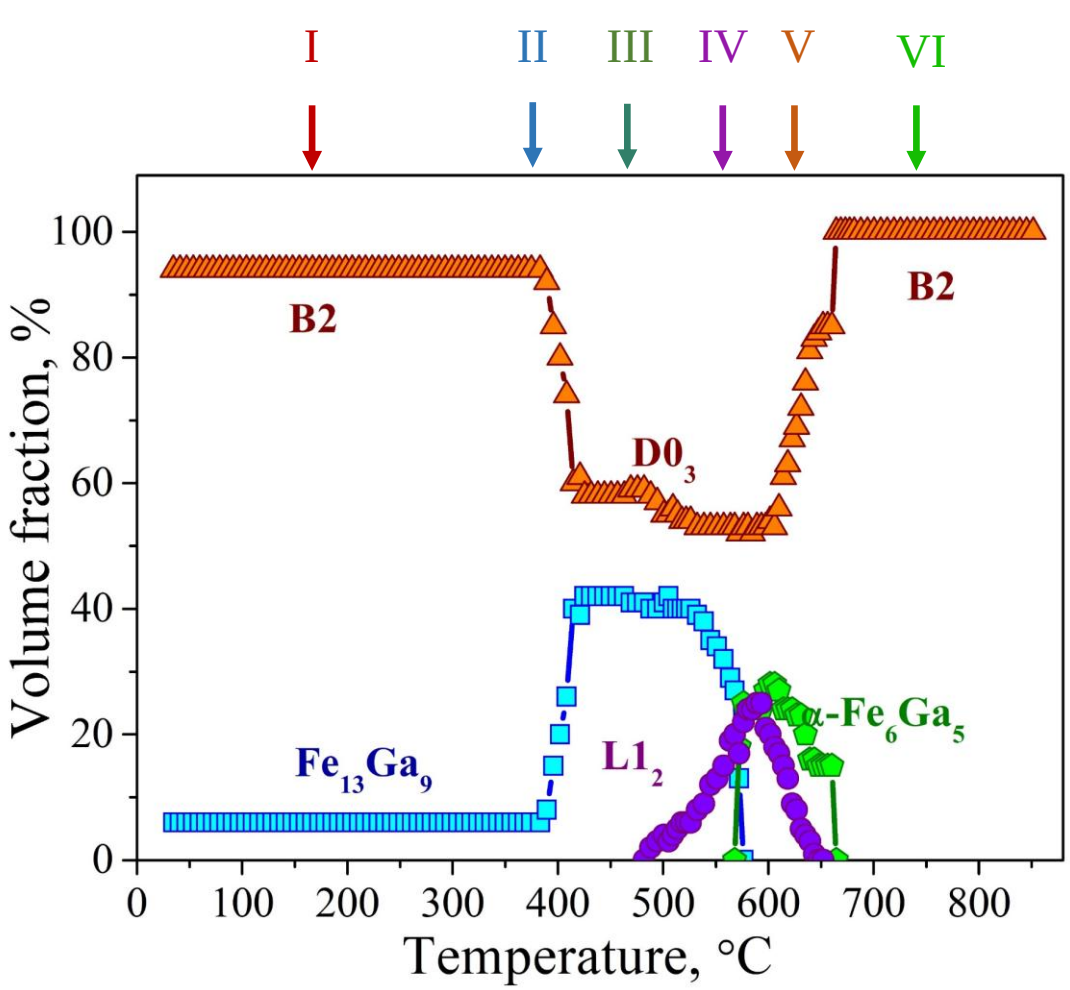


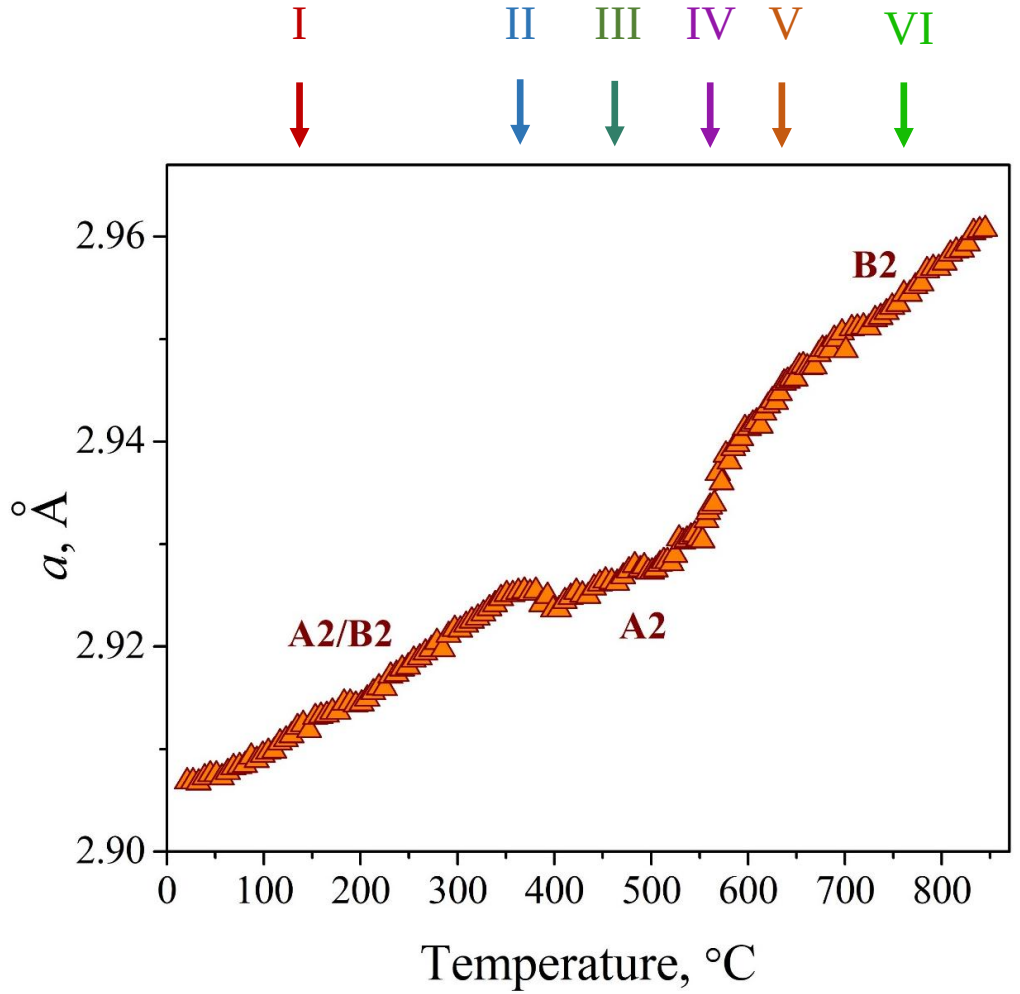
2D visualization of the evolution of the neutron diffraction pattern of the Fe-32Ga sample in the as-cast state, measured upon slow heating up to 850 ºC. The temperature (and time) axis goes from bottom to top. Heating and cooling were performed at a rate close to 2 °C/min. The dashes indicate the peaks' positions from the phases pointed on the right.



ND patterns of the Fe-33Ga alloy measured upon heating for several characteristic temperatures. The vertical bars indicate the peak positions of the presented phases (from top to bottom): a – B2, $Fe_{13}G_9$; b –A2, $D0_3$, $Fe_{13}G_9$; c – B2, $L1_2$, α-Fe_6G_5; d – B2.

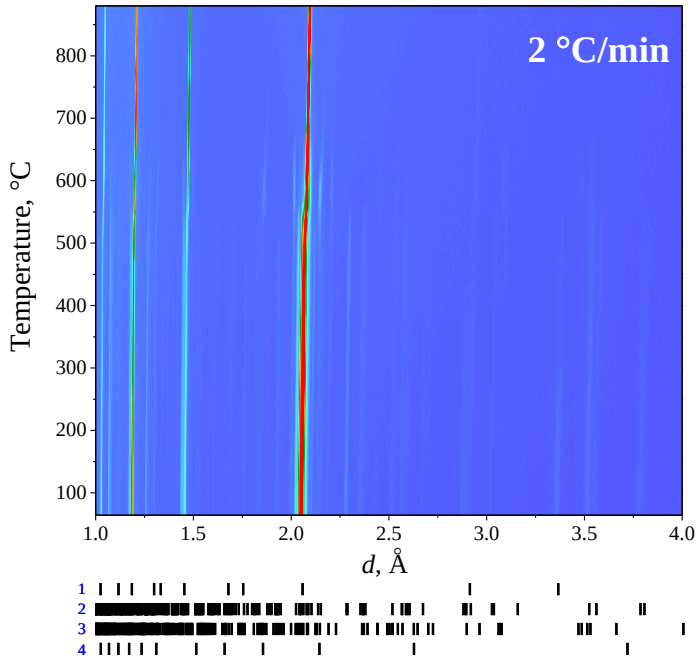
$Fe_{68}Ga_{32}$ alloy (B2/A2 + $Fe_{13}Ga_9$)

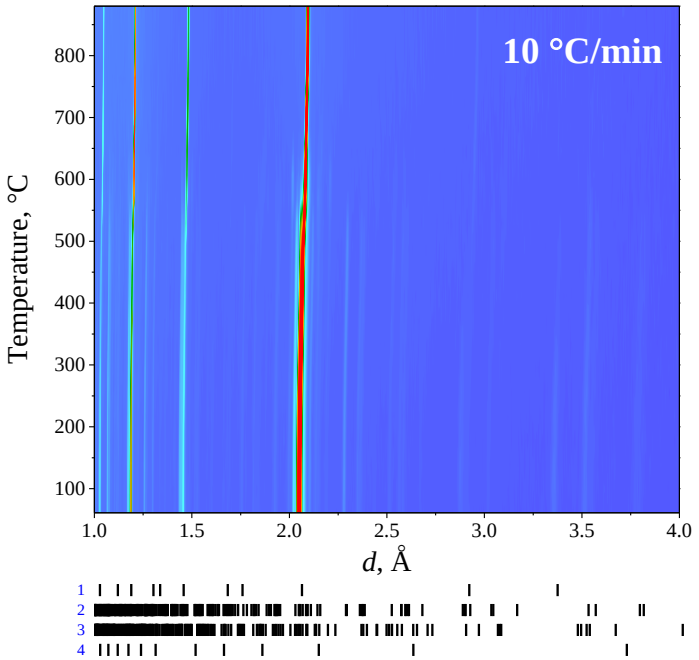


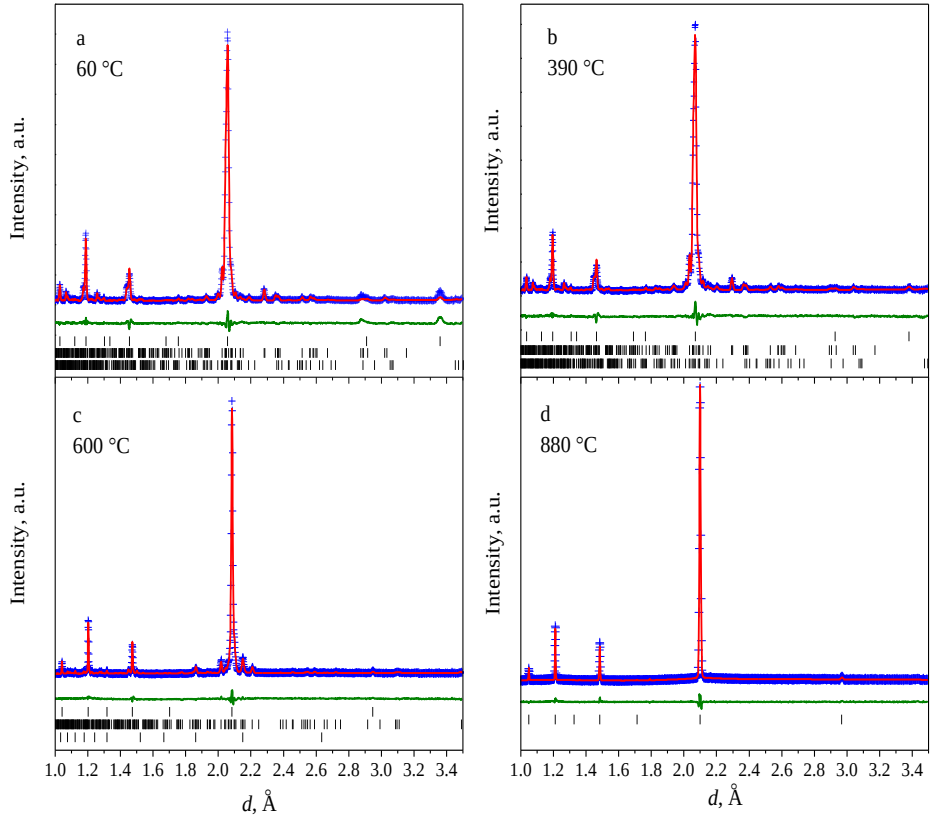


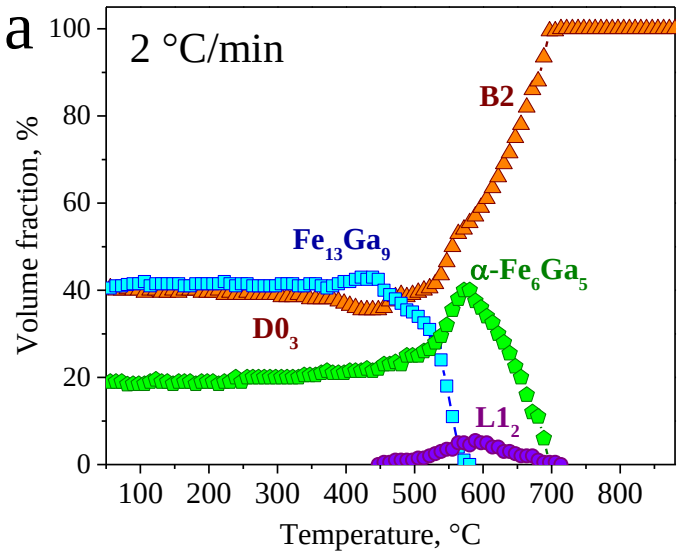
Evolution of the phase composition of the Fe-32Ga alloy in the as-cast state and the lattice parameter upon heating to 850 °C. For the $D0_3$ phase the value $a' = a/2$ is shown.

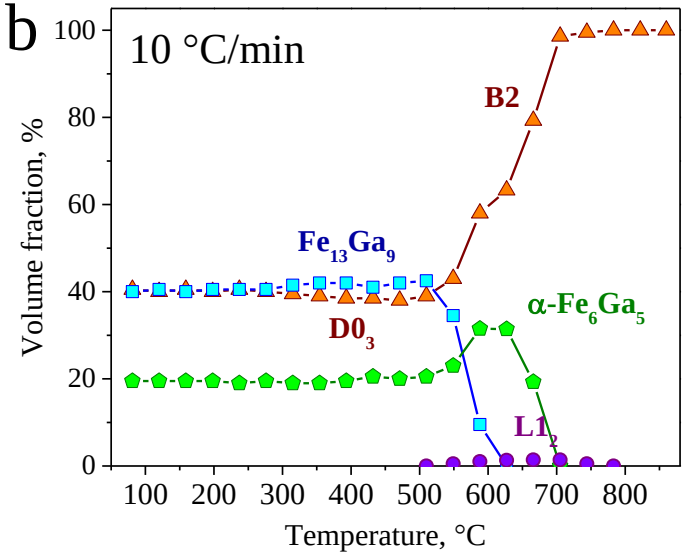
$Fe_{68}Ga_{32}$ alloy (B2/A2 + $Fe_{13}Ga_9$ + α-Fe_6Ga_5)











ND patterns of the Fe-32.3Ga alloy, measured upon heating for several characteristic temperatures. The vertical bars indicate the peak positions of the presented phases (from top to bottom): a – $D0_3$, $Fe_{13}G_9$, α-Fe_6Ga_5; b – $D0_3$, $Fe_{13}G_9$, α-Fe_6Ga_5; c – B2/A2, α-Fe_6Ga_5, $L1_2$; d – B2/A2.

Summary

1.The region of existence of the metastable intermetallic compound $Fe_{13}Ga_9$ in both studied alloys with different initial phase compositions completely coincides under the condition of the same heating rate of 2 °C/min and is limited to a temperature of 570 °C.

2. The presence of the intermetallic compound α-Fe_6Ga_5 in the initial state leads to a change in the nature of the transition $Fe_{13}Ga_9$ → α-Fe_6Ga_5.

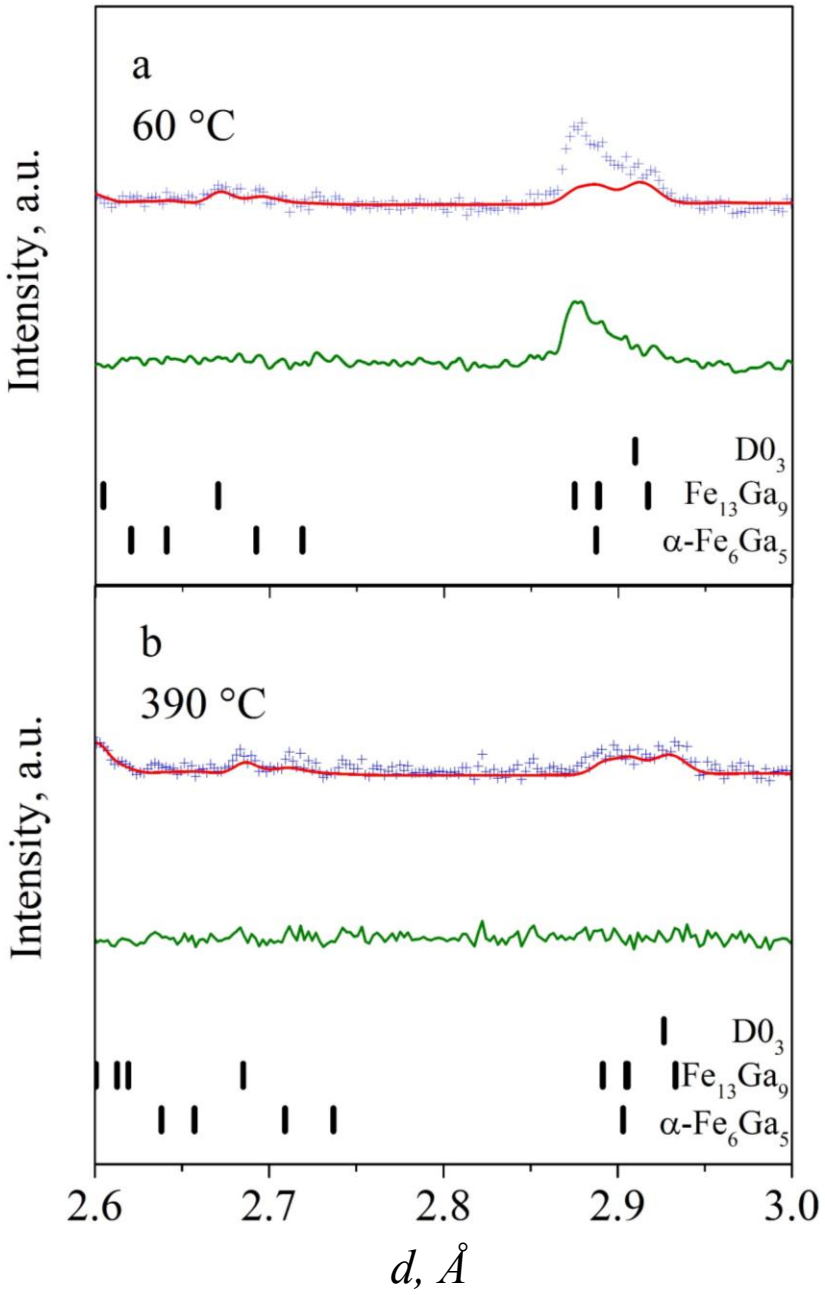
3. An increase in the heating rate of the $Fe_{68}Ga_{32}$ alloy with the phase composition $D0_3$ + $Fe_{13}Ga_9$ + α-Fe_6Ga_5 does not lead to a qualitative change in the order of phase reactions. A shift to higher temperatures of the range of existence of the $L1_2$ phase, as well as the $Fe_{13}Ga_9$ phase, was detected. The maximum achievable values of the volume fractions of the α-Fe_6Ga_5 and $L1_2$ phases are lower in the case of heating at a rate of 10 °C/min compared to a rate of 2 °C/min.

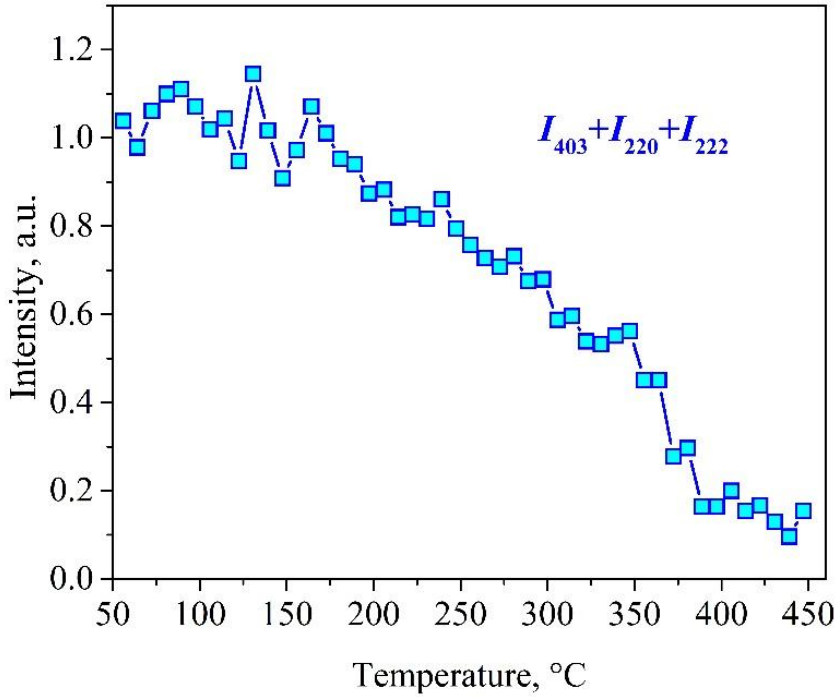
Thank you for attention!

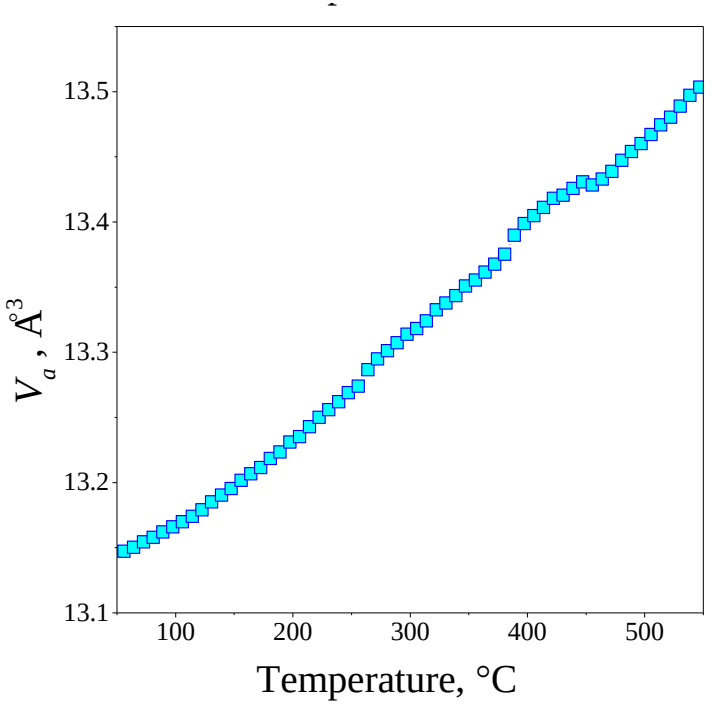
$Fe_{13}Ga_9$

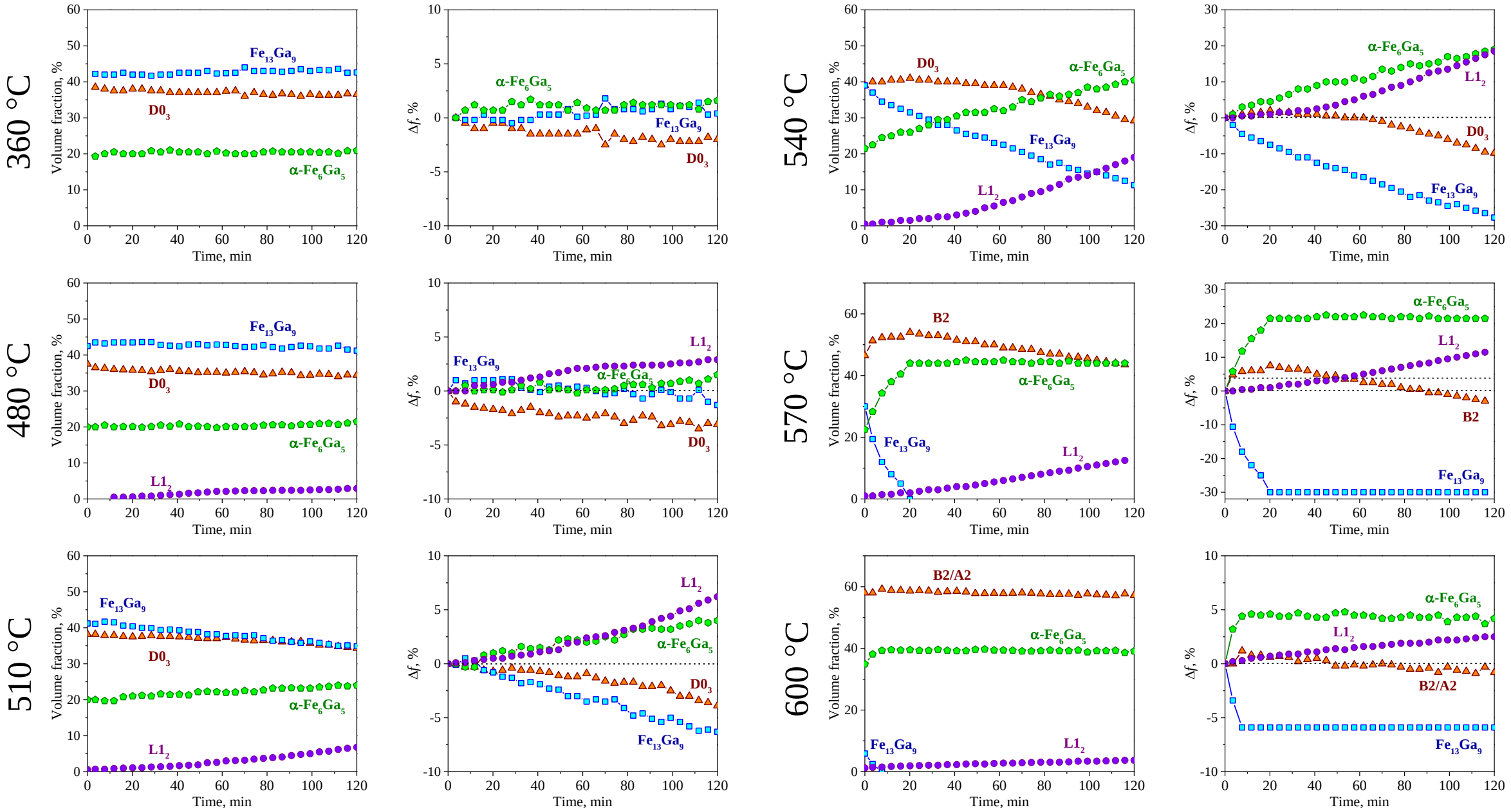
Space group: *C*2/*m*
Lattice parameters: a = 14.2243 Å,
b = 8.0924 Å, c = 8.6682 Å, β = 35.446°

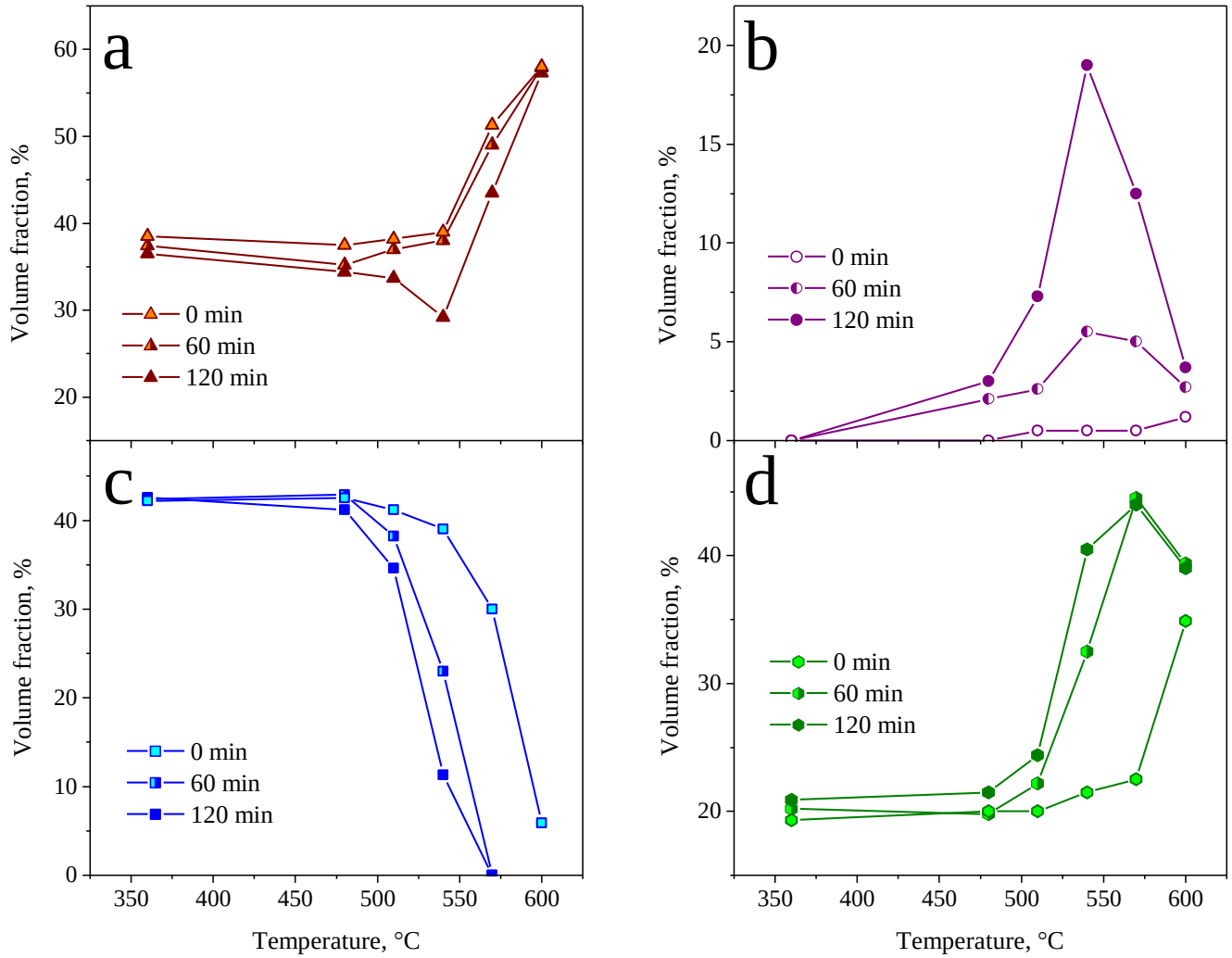
A. Leineweber et.al. Intermetallics, 131 (2020) 107059








360 °C
480 °C
510 °C
540 °C
570 °C
600 °C
Volume fraction, %
Δf, %
Time, min
Fe13Ga9
α-Fe6Ga5
D03
L12
B2
B2/A2


a
b
c
d
Volume fraction, %
Temperature, °C
0 min
60 min
120 min