

# Table of Contents

<b>1. FORMATION OF A CHEMICAL COMPOUND LAYER AT THE INTERFACE OF TWO ELEMENTARY SUBSTANCES .....</b>	<b>1</b>
1.1 Description of the kinetics of solid-state heterogeneous reactions.....	1
1.2 Reaction diffusion.....	3
1.3 Growth of the $A_pB_q$ layer at the expense of diffusion of component $B$ .....	7
1.3.1 Critical thickness of the $A_pB_q$ layer with regard to component $B$ .....	13
1.3.2 Growth regime of the $A_pB_q$ layer with regard to component $B$ : theoretical definition.....	16
1.3.3 Stationary point.....	17
1.4 Growth of the $A_pB_q$ layer at the expense of diffusion of components $A$ and $B$ .....	19
1.4.1 Critical thickness and growth regime of the $A_pB_q$ layer with regard to component $A$ .....	21
1.4.2 One compound layer: general kinetic equation.....	23
1.4.3 Separate determination of reaction-diffusion constants.....	28
1.5 Linear growth of the $Cu_6Sn_5$ layer in the copper-tin reaction couple.....	31
1.6 Parabolic growth of the $AlSb$ layer in the aluminium-antimony diffusion couple.....	34
1.7 Linear-parabolic growth of the $SiO_2$ layer between silicon and oxygen.....	38
1.8 Growth kinetics of the $NiBi_3$ layer at the nickel-bismuth interface.....	41
1.8.1 Experimental details.....	42
1.8.2 Intermetallic layer composition.....	43
1.8.3 The main diffusing component during growth of the $NiBi_3$ layer.....	45
1.8.4 $NiBi_3$ layer growth kinetics.....	49
1.9 Interconnection between the reaction- and self-diffusion coefficient of the components of a chemical compound.....	52
1.10 Single compound layer: short conclusions.....	68
<b>2. GROWTH KINETICS OF TWO COMPOUND LAYERS BETWEEN ELEMENTARY SUBSTANCES .....</b>	<b>69</b>
2.1 Partial chemical reactions at phase interfaces.....	70
2.2 A system of differential equations describing the rates of formation of two chemical compound layers .....	73
2.3 Initial linear growth of the $A_pB_q$ and $A_rB_s$ layers.....	80

2.4	Minimal thickness of the $A_rB_s$ layer necessary for the $A_pB_q$ layer to occur.....	84
2.5	Non-linear growth of the $A_pB_q$ layer .....	86
2.6	Effect of the critical thickness of the $A_pB_q$ layer with regard to component $A$ on the process of growth of the $A_rB_s$ layer.....	88
2.7	Paralinear growth kinetics of two compound layers.....	90
2.8	Diffusion controlled growth of the $A_pB_q$ and $A_rB_s$ layers.....	96
2.8.1	Late diffusional stage of formation of two compound layers: system of differential equations.....	98
2.8.2	Late diffusional stage of formation of two compound layers: ratio of their thickness .....	99
2.8.3	Simultaneous diffusional growth of the $Al_3Mg_2$ and $Al_{12}Mg_{17}$ intermetallic layers between aluminum and magnesium .....	106
2.9	NiBi layer: missing or too thin?.....	112
2.10	Two compound layers: short conclusions.....	114
<b>3.</b>	<b>OCCURRENCE OF MULTIPLE COMPOUND LAYERS AT THE <math>A-B</math> INTERFACE .....</b>	<b>117</b>
3.1	Chemical reactions at phase interfaces in a multiphase binary system.....	120
3.2	A system of differential equations describing the growth process of three chemical compound layers between elementary substances $A$ and $B$ .....	122
3.3	Initial linear growth of three compound layers.....	126
3.4	Transition from linear to non-linear layer-growth kinetics.....	128
3.5	Critical values of compound-layer thicknesses and their influence on layer-growth kinetics.....	130
3.6	Diffusional stage of formation of compound layers .....	132
3.7	Sequence of compound-layer formation at the $A-B$ interface .....	135
3.7.1	Phase-diagram predictions .....	135
3.7.2	Thermodynamic predictions.....	140
3.7.3	Reasons for the formation of multiple compound layers at the $A-B$ interface .....	145
3.8	Formation of intermetallic layers in Ni-Zn and Co-Zn diffusion couples .....	152
3.8.1	Ni-Zn and Co-Zn phase diagrams.....	153
3.8.2	Materials, specimen preparation and experimental methods .....	153
3.8.3	Layer identification .....	156

3.8.4	Chemical composition of intermetallic layers.....	159
3.8.5	Layer-growth kinetics .....	165
3.9	Multiple compound layers: short conclusions .....	171
<b>4.</b>	<b>GROWTH KINETICS OF THE SAME CHEMICAL COMPOUND LAYER IN VARIOUS REACTION COUPLES OF A MULTIPHASE BINARY SYSTEM.....</b>	<b>173</b>
4.1.	Growth of the $A_rB_s$ layer in the $A-B$ reaction couple.....	173
4.2	Growth of the $A_rB_s$ layer in the $A_pB_q-B$ reaction couple .....	174
4.2.1	Growth of the $A_rB_s$ layer between $A_pB_q$ and $B$ at the expense of diffusion of component $A$ .....	175
4.2.2	Growth of the $A_rB_s$ layer between $A_pB_q$ and $B$ at the expense of diffusion of both components .....	178
4.3	Growth of the $A_rB_s$ layer in the $A_pB_q-A_lB_n$ reaction couple .....	181
4.4	Comparison of the growth rates of the $A_rB_s$ layer in various reaction couples of the $A-B$ multiphase binary system.....	183
4.5	Duplex structure of the $A_rB_s$ layer .....	194
4.6	Growth of the chemical compound layer in various reaction couples: short conclusions .....	201
<b>5.</b>	<b>REACTION-DIFFUSION KINETICS IN SOLID-LIQUID AND SOLID-GAS SYSTEMS .....</b>	<b>203</b>
5.1	Main relationships governing dissolution of solids in liquids .....	203
5.2	Experimental investigation of the dissolution process of a solid in a liquid .....	208
5.2.1	Determination of the saturation concentration.....	211
5.2.2	Evaluation of the dissolution-rate constant.....	217
5.2.3	Estimation of the diffusion coefficient.....	221
5.3	Growth kinetics of the chemical compound layer under conditions of its simultaneous dissolution in the liquid phase .....	223
5.4	Growth kinetics of intermetallic layers at the transition metal-liquid aluminum interface.....	232
5.4.1	Formation of the $Fe_2Al_5$ layer between Fe and Al .....	232
5.4.2	Occurrence of the $MoAl_4$ layer between Mo and Al.....	235
5.4.3	Formation of intermetallics between Fe-Ni and Fe-Cr alloys and liquid aluminum.....	237
5.5	Interfacial interaction of nickel and cobalt with liquid Pb-free soldering alloys .....	251
5.5.1	Interaction of solid nickel with liquid bismuth and bismuth-based alloys.....	251

---

5.5.2	Interaction of solid nickel with liquid Sn–Bi–In–Zn–Sb alloys .....	256
5.5.3	Reactions of solid cobalt with liquid Sn–Bi–In–Zn–Sb alloys .....	260
5.6	Peculiarities of kinetic dependences in solid-gas systems .....	272
5.6.1	Layer thickness-time relationships.....	272
5.6.2	Influence of evaporation on the growth rate of a chemical compound layer .....	276
5.6.3	Partial oxidation of chemical compounds .....	281
5.7	Reaction-diffusion kinetics in solid-liquid and solid-gas systems: short conclusions.....	285
<b>CONCLUDING REMARKS.....</b>		<b>287</b>
<i>REFERENCES.....</i>		<i>291</i>
<i>KEYWORD INDEX.....</i>		<i>313</i>