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17 July 1980

USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 4/80)

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JPRS L/9197

17 July 1980

USSR REPORT

MATERIALS SCIENCE AND METALLURGY

(FOUO 4/80)

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DEVELOPMENTS IN METAL ELECTROPLATING

Vil'nyus ISSLEDOVANIYA V OBLASTI OSAZHDENIYA METALLOV in Russian 1978 pp 230-233

[Foreword and Table of Contents from the symposium "Issledovaniya v oblasti osazhdeniya metallov. Materialy k XVI respublikanskoy konferentsii elektrokhimikov Litovskoy SSR" published by the Institute for Chemistry and Chemical Technology of the Academy of Sciences of the Lithuanian SSR, 233 pages]

[Text] Foreword

The papers published in the present collection deal with problems concerning the production of metal and conversion coatings; the papers were prepared for the 16th Republic Conference of Electrochemists of the Lithuanian SSR, which was organized by the Institute for Chemistry and Chemical Technology of the Academy of Sciences of the Lithuanian SSR.

Most of the papers are concerned with examining the principles and mechanism of metal and metal alloy electroplating processes. Some of the studies examine various problems in connection with metal plating by chemical reduction and with the processes of chrome plating. A few reports are concerned with the anodizing of aluminum and with the electrochemical staining of steel and aluminum.

For the most part, the material of the collection is arranged in accordance with the metals deposited. The first study, which is concerned with general problems concerning electrochemical reactions, is followed by studies of two major processes--copper and nickel plating--the subject of most of the papers submitted. A few papers report on research concerning single-crystal electrodes. In addition, there are reports on electrodeposition of cobalt, cadmium, tin, manganese, gold, and several alloys. The following section of the collection contains papers on research concerning production of coatings without the use of an external power source--chemical metal plating, plating of plastics, chrome plating--and also studies on the electrochemical surface treatment of aluminum and steel.

The collection reflects certain research trends in the fields of electrochemistry and plating, which are being pursued at the Institute for Chemistry and Chemical Technology of the Academy of Sciences of the Lithuanian SSR and at the universities of the republic. We hope that the material presented will be useful to the scientists and the workers in industry who are engaged in research in the field of electrolytic metallurgy.

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TECHNICAL PROGRESS AT CONSTRUCTION PROJECTS OF FERROUS METALLURGY

Moscow TEKHNICHESKIY PROGRESS NA STROYKAKH CHERNOY METALLURGII in Russian 1980 signed to press 4 Dec 79 pp 3-4, 255-256

[Introduction and Table of Contents from the book "Tekhnicheskiy progress na stroykakh chernoy metallurgii" by V. I. Buresh, G. P. Klimenko and G. V. Mochalova, Stroyizdat, 1,600 copies, 256 pages]

[Text] General Secretary of the CPSU Central Committee, Chairman of the Presidium of the USSR Supreme Soviet L. I. Brezhnev said in his report "The Great October Revolution and Human Progress": the 24th and 25th CPSU Congresses determined the strategy and tactics of communist construction at the modern, very important stage of our history. A course was taken in the field of economics toward intensive growth of social production and toward an increase of efficiency and quality of all economic activity. An even more effective factor of developing the national economy is scientific and technical progress."

In implementing this course, Soviet ferrous metallurgy has achieved significant successes. It now represents a highly developed sector of industry, equipped with powerful modern units.

The Soviet Union occupies first place in the world in production of iron ore, coke, agglomerate, pig iron, steel, steel pipe and ferroalloys.

The world's first powerful continuous stripping complexes using self-propelled rotary excavators, mainline transporter belt conveyors and cantilevered spreaders were developed at the iron ore and manganese quarries of the Soviet Union. For example, rotary complexes with productivity of 5,000 m^3/hr are operating at the Mikhaylov Mining-Enrichment Combine.

The Soviet Union surpasses the major capitalist countries in the number of blast furnaces operating under increased gas pressure at the furnace top. There were approximately 110 of these blast furnaces operating in our country by the beginning of the Ninth Five-Year Plan and more than 95 percent of pig iron was smelted on them.

Natural gas began to be used for the first time in the world in blast-furnace production in the USSR, which permitted a significant reduction of the specific consumption of coke.

Tens of converters with capacity of 25, 100 or more tons are now operating in the country.

Soviet ferrous metallurgy has at its disposal for rolled steel production modern hot and cold rolling mills, including powerful cogging mills, the highly productive wide-sheet hot rolling mills 2,000 and 1,700 and the four-spanned wide-sheet cold rolling mill 2,500. Approximately 85 percent of thin sheets are produced in the USSR on continuous and semicontinuous mills.

The Soviet Union has occupied first place in the world since 1961 in the volume of steel pipe production. Almost all methods of pipe manufacture known in worldwide practice have been assimilated in Soviet industry.

New Soviet pipe-rolling and pipe-welding units correspond in their specifications to the world's best models and some units even surpass them.

An effective method of thermal rolling of pipe, developed for the first time in our country, has been introduced at enterprises where cold-deformed pipe is produced. This method includes preliminary heating of the billets and treatment of them on cold-rolling mills. This permitted a 1.5-1.8-fold increase of cold-rolling mill productivity for pipe manufacture from stainless and some alloy steels.

Metal product production has a wide nomenclature of articles. Approximately 80 percent of metal products and calibrated steel are produced at ferrous metallurgy enterprises. Calibrated steel is manufactured in new shops on automated production lines; the drawing operation has been combined with metal shot cleaning of the rolled steel of scale. Installations for induction recrystallization annealing of bars and also through furnaces with roller hearth have achieved wide distribution in combination shops. Multi-position automatic combines and automatic production lines are used to manufacture fasteners.

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FORMING

ELECTROHYDRAULIC IMPULSE PRESSURE SHAPING OF METALS

Kiev ELEKTROGIDROIMPUL'SNAYA OBRABOTKA METALLOV DAVLENIYEM in Russian 1979 signed to press 22 May 79 pp 2, 152-153

[Annotation and table of contents from collection of scientific works, Izdatel'stvo Naukova Dumka, 160 pages]

[Text] This collection presents the results of theoretical and experimental investigations of processes of the electrohydraulic impulse (EG) pressure shaping of metals. Questions relating to the physics of the EG effect on metals and to the technology for the high-speed shaping of metals are discussed. Special equipment is described and results are given of experiments. The economic effectiveness of introducing EG shaping is considered.

The collection is intended for scientific and engineering/technical personnel. The collection may also be useful to teachers, graduate students, and students at VUZ's specializing in the EG pressure shaping of metals.

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WELDING

MICROPLASMA WELDING

Kiev MIKROPLAZMENNAYA SVARKA in Russian 1979, 248 pp

[Foreword and table of contents from the book by B. Ye. Paton, V. S. Gvozdetskiy, D. A. Dudko, et al. Izdatel'stvo "Naukova Dumka"]

[Text] A significant volume of welding works involve welding thin (0.05-1.5 mm) metals and alloys. Among the known methods gas welding, brazing, and arc welding with a nonconsumable electrode in continuous and pulse modes [1] have received the most use. However, a slow heating rate, large heat-affected zone and, during arc welding, low stability of the arc at low currents and a strong relationship of seam to arc length parameters hinder the welding process and make it impossible in a number of cases. The shortcomings of thin-wall designs made using gas and arc welding can lead to scrap which in series production amounts to a significant percentage.

In electron-beam welding the quality of joints is significantly higher than in argon-arc welding. However, the high cost and equipment complexity, requiring highly qualified attendants, in a number of cases hinders the use of electron-beam welding. Moreover, not all instruments, according to technological requirements, permit vacuum sealing and many parts, due to their dimensions, generally cannot be positioned in a vacuum chamber. The use of other known methods of welding, for example contact and diffusion welding, under conditions of mass production is limited by the configuration of parts, properties of the materials, requirements guaranteeing hermeticity of the weld seam, and other factors.

At the start of the sixtieth year at the Scientific Research Institute of Aviation Technology (NIIAT) under the direction of A. V. Petrov and in a number of foreign firms (Switzerland, England, USA, and France) works were started on using a compressed arc to weld thin metals. This method was called microplasma welding. However, the lack of purposeful research on low amperage arc and technology as well as the lack of specialized equipment repressed development of this process and did not make it possible to set about making wide use of it in industry. At the Institute of Electric Welding (IES) imeni Ye. O. Paton, Ukrainian

SSR Academy of Sciences, during these same years, the problem was solved by studying the physical processes of the welding arc and development, on this basis, of new methods of microplasma welding of thin metals and equipment for its broad application. To solve this problem, features were studied and a theory of contraction of a low amperage welding arc has been developed for different media including a vacuum. Investigations of cathode welding arc processes were carried out and the conditions determined for stable burning of a low-amperage arc with a cold cathode. Results of theoretical and experimental research made it possible to develop new methods of microplasma welding of metals including aluminum at normal and low pressure.

For practical realization of the developed methods of microplasma welding at optimum conditions analysis was undertaken into thyristor commutators of the welding current and new circuits of unipolar and varying polar current pulses of commutators, condensor accumulators, and circuits for alternating current supply were proposed.

The successful resolution of the complex problem created the reasons for broad introduction of the new welding methods. Through the efforts of the authors and many other associates of the institute, primarily G. N. Ignatchenko, V. I. Skrypnik, L. M. Yarinich, V. Ye. Paton, E. I. Shmakov, L. N. Kozlov, Yu. F. Shevchenko, D. M. Rabkin, Yu. Ye. Godlin, V. V. Shcherbak, D. M. Pagrebiskiy, A. S. Svetsinskiy, A. P. Zaparovanyy, V. F. Lapchinskiy, Yu. I. Saprykin, V. A. Zrazhevskiy, V. N. Samilov and B. V. Danil'chenko, development of equipment and technology was accomplished for microplasma welding at normal and low pressure. At a number of enterprises, owing to the initiative of G. B. Asoyanets, D. M. Tuzov, S. K. Kuzovkin, V. I. Savel'yev, et al., in a short time the series output of specialized equipment was mastered, including welding stands, power sources, and a plasmatron. The Institute of Electric Welding imeni Ye. O. Paton, in cooperation with branch scientific-research institutes, enterprises and, certain higher institutes of learning at enterprises of the country have introduced more than 2500 units for microplasma welding. The annual economic effect is calculated in the tens of millions of rubles.

The foreword and Chapters I and II of this monograph were written by B. Ye. Paton and V. S. Gvozdetskiy; sections 1-8 of Chapter III and section 6 of Chapter IV--by D. A. Dudko and V. Ye. Sklyarevich; section 9 of Chapter III and sections 1-3, 5 of Chapter IV-- by N. M. Voropay; and section 4 of Chapter IV--N. M. Voropay and B. I. Shnayder. All the authors participated in the writing of Chapter V.

The authors thank V. K. Lebedev and I. K. Pokhodna for useful advice and L. M. Yarinich, V. Ye. Zinchenko, and V. Yu. Petrov for help in preparing the manuscript.

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MISCELLANEOUS

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THE SYNTHESIS OF TITANIUM NITRIDE IN A NITROGEN ATMOSPHERE WITH HIGH PRESSURES AND LASER RADIATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 251, No 2, 1980 pp 336-338 manuscript received 20 Nov 79

[Paper by A.L. Galiyev, L.L. Krapivin, L.I. Mirkin and A.A. Uglov, USSR Academy of Sciences Institute of Metallurgy imeni A.A. Baykov, Moscow, presented by academician N.N. Rykalin, 14 May 1979]

[Text] The synthesis of materials with the action of laser radiation on matter in an atmosphere of various gases at elevated pressures is a new and promising trend [1-3].

When powders are applied to the surface of solid metals or powders are sintered [3], solid solutions and compounds such as described above have been obtained in forms nonexistent under equilibrium conditions, for example, solid solutions in a very wide range of concentrations [2].

The results of an investigation of the structure in the case of a new kind of coating application using laser heating are presented in this paper, where the saturating element is in the gaseous phase. With the action of laser radiation on metal, which is located in a transparent gaseous medium, first just the substrate is heated and then a plasma is ignited close to the substrate surface which increases the activity of the saturating element. In fact, in the region contiguous with the substrate, having a thickness on the order of the Debye radius, the substrate is negatively charged up to various potentials by virtue of the ambipolar diffusion of particles (from the volume of the plasma):

$$\Delta\varphi \approx \frac{kT_e}{c\ln(m_i/m_e)} \approx 4\text{–}6\ \text{B, volts}$$

where T_e is the temperature of the electrons, °K; m_i is the ion mass; e and m_e are the charge and mass of an electron.

The appearance of a negative potential at the substrate causes the accelerated motion of ions toward the surface of the sample, increasing the rate of interaction of the material surface with the ambient medium. This process is apparently impossible with an external power source in the case of other kinds of heating other than laser heating.

The procedure of the experiments for the synthesis of titanium nitride consisted of the following. The laser beam ($\tau_i \simeq 0.8$ msec, $q \simeq 10^5 - 10^7$ W/cm^2) is introduced into a high pressure chamber and focused by a lens with f = 16 cm onto the surface of the sample being studied. The structural design of the chamber permits moving the samples by means of an electric motor without losing the seal, something which provides for good reproduceability of the results.

The radiation flux density throughout the entire range of gas pressures studied was sufficient to fuse the surface of the samples in the region of beam application, even with the formation of a plasma pinch which shields the laser beam.

The formation of compounds was studied for a number of metal--gas systems. The results presented here are for a study of the titanium--nitrogen system. The titanium--nitrogen system is of interest for a number of reasons.

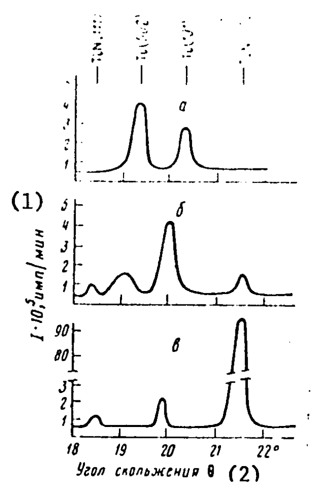

Figure 1.

Diffraction patterns of the titanium alloy VT1, recorded using copper radiation:

a. The original material;
b. Irradiation at atmospheric pressure;
c. Irradiation at a nitrogen pressure of 90 atm.

Key: 1. I $\cdot$ 10^5 pulses/min;
2. Blaze angle, θ.

Nitrogen, being an inert gas under normal conditions, is transparent to light. The nitriding of titanium is a rather difficult technological problem because of the low diffusion rates of nitrogen.

The alloy VT1 was studied in the state in which it was supplied, and the structure was investigated using X-ray and metallographic methods. The X-ray photographs were taken using copper radiation with the intensities recorded by both a scintillation counter (diffractometric method) and in an RKSO type chamber with the intensity recorded on X-ray film (photographic method). The diffraction patterns of titanium in the original state (a) and after irradiation in air at atmospheric pressure (b) are shown in Figure 1. The indexing of the intensity curves was based on reference data for titanium and titanium nitride.

It can be seen from a comparison of the intensity curves that following irradiation, there arises a small amount of titanium nitride, while the titanium lines are widened and shifted. The shifting of the lines can be related to the occurrence of residual macrostresses during tempering, as well as to the formation of a solid solution of titanium and nitrogen in accordance with the reference data of [4]. The widening of the lines in the X-ray patterns is related to the crushing of the blocks, the increase in the dislocation density and the occurrence of microdistortions of the crystal lattice during rapid heating and cooling.

Increasing the nitrogen pressure during irradiation leads to a rise in the intensity of the titanium nitride lines and a reduction in the intensity of the titanium lines in the X-ray pattern. The diffraction pattern recorded after irradiation at a nitrogen pressure of 90 atm is shown in Figure 1c as an example. A comparison with Figure 1b shows that the intensity of the titanium nitride line increased by almost two orders of magnitude. The intensity of the titanium line in this case is quite low, i.e., using the procedure makes it possible to obtain a practically solid coating of titanium nitride at the point of impact of the laser beam. A further analysis of the X-ray patterns recorded following irradiation at high pressures has shown that anomalous distribution of the intensity is observed in them among the individual titanium nitride lines, in particular, as can be seen from Figure 1c, the ratio of the intensities of the (002) and the (111) lines of titanium nitride amounts to about 100 while it should theoretically be about 2 [4].

The hypothesis was advanced that this effect can be related to the occurrence of a predominant orientation (texture) in the titanium nitride during crystallization. The occurrence of a predominant orientation with laser action has already been observed earlier in some alloys, but this was not related to the appearance of a new compound [5]. Azimuthal scanning of the intensity curves, as well as X-ray photography were used to check this hypothesis. Both methods confirmed the presence of a texture in the case of irradiation in a nitrogen atmosphere. By way of illustration, we shall consider the X-ray photographs of Figure 2. An X-ray photograph of the titanium in the original state is shown in Figure 2a. The dotted lines indicate the large grain structure of the material. Nonuniform intensity along the line is related to the residual structure from the rolling. After irradiation (Figures 2b), the lines become continuous because of the fragmentation of the grains and somewhat wider because of an increase in the defects in the material. Following irradiation at a high nitrogen pressure (110 atm), the nature of the X-ray photography changes fundamentally (Figure 2c). The (002) titanium nitride line has an intensity distribution which is typical of materials with a sharply pronounced texture. Practically all of the line intensity in azimuth is concentrated in a range of $\pm 10°$ from the equator of the X-ray photographic pattern. Similar phenomena, apparently, have not been previously observed.

The surface microhardness of the samples in the region of laser radiation impact reaches 2,300 kgf/mm^2 and remains constant (about 2,300 kgf/mm^2) in a wide range of pressures.

Figure 2 [not reproduced]. X-ray patterns of the titanium alloy VT1, obtained photographically: a. The original material; b. Irradiation at atmospheric pressure; c. Irradiation at a nitrogen pressure of 110 atm.

Under the conditions of our experiments, the sample layer thickness, d, which interacts with the nitrogen, amounts to 5 to 15 micrometers and has a poorly pronounced extremal nature as a function of pressure. The maximum of d corresponds to a pressure of 100 - 105 atm ($q \approx 3 \cdot 10^6$ W/cm^2). Experimental data on the absorption of nitrogen by steel are given in paper [6], where the maximum of the gas content (or the microhardness) corresponds to a pressure of 80 - 90 atm. The shift of the extremum of d(p) in the case of titanium in the direction of greater pressures is probably related to the fact that the lower value of the thermal conductivity coefficient of titanium (as compared to steel) makes it possible to maintain the surface temperature of the sample in optimal modes through radiative emission of the plasma.

An analysis of the experimental data makes it possible to conceive the following mechanism for the observed phenomena. The action of the laser radiation on the surface of a sample under high ambient gas pressures leads to the ignition of a plasma, which partially or completely shields the region of action from the laser beam. The shielding of the surface by the plasma continues until the onset of intense vaporization of the target material (the sample), something which prevents the scattering of condensed material. A further heating of the surface of the target is accomplished by the combined action of the laser beam and the radiative emission of the plasma. In the case of the interaction of a nitrogen plasma and fused titanium, titanium nitride formed, the crystallization of which takes place under conditions of intense heat removal in the cold substrate, which leads to directional crystallization and the appearance of texture. The layer thickness and the degree of orientation can be controlled by changing the gas pressure, the temperature and the texture of the substrate. This procedure does not preclude the possibility of obtaining, for example, more complex carbonitride phases by means of irradiating metals in gas mixtures at high pressures.

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[131-8225]

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MATERIALS AND PROCESSES IN SPACE TECHNOLOGY

Moscow MATERIALY I PROTSESSY KOSMICHESKOY TEKHNOLOGII in Russian 1980 signed to press 21 Nov 79 pp 3-4, 221-222

[Forword and table of contents from book edited by A. S. Okhotin, Responsible Editor, Izdatel'stvo "Nauka", 229 pages]

[Text] The analysis of materials formed in zero gravity has been reduced, in essence, to analyzing previously performed experiments and, in some cases, to attempts to explain the observed anomalies. This work is by no means complete and, evidently, the next step in the analysis will be the transition from particular interpretations to a generalized examination of all aspects of the problem. One of the basic factors here will be the construction of qualitative and quantitative theoretical models that explain the experimental results. This work has only just begun and, from the point of view of the experiments that have already been performed, theory can only describe the results obtained, since the anomalies that often arise in the materials of space technology are caused not by the peculiarities of a process per se, but by imperfections in the equipment. It is now important to "put everything in its place" (and this is already being done), i.e., theoretical studies must lead and determine the setup of an experiment. For this reason, theoretical studies in the area of space technology are now mainly directed toward analyzing the flow of transport processes in liquids and gases, as well as the processes of crystallization and condensation of substances in zero gravity for the most diverse structures.

The problems in preparing new experiments naturally involve a wider range of problems (ground-based studies of the most diverse materials that it would be expedient to produce in space; development of methods for modeling the properties of materials for space technology, as well as methods for studying these materials; development of equipment for processing in zero gravity). These problems are directly related to such problems as creating energy sources that are more powerful than those currently used on space stations, the behavior of various materials in space, and so on.

All the problems cited above are, to one degree or another, reflected in this collection of articles, which directs a great deal of attention toward a consideration of the processes for fabricating materials in space and studying their physicochemical properties. The experimental results concerning shaping during metallic fusion at the time of the "Soyuz-Apollo" flight, as well as the results of work on particular aspects of fabricating optical glass in zero gravity, are generalized. The causes of high porosity in metals smelted in space are studied. The peculiarities of crystal growth from vapor-gas media in zero gravity are examined. The effect of a gradient in the surface tension on the processes occurring in the meniscus while growing crystals from a melt, as well as the effect of the shape of the crystallization front on the concentration profile in a solid, and other similar problems are considered. Among the articles concerning material properties, a series of articles dealing with methods for studying the thermophysical characteristics of semiconducting film and bulk specimens are of interest. It is important that the techniques developed for studying the materials of space technology can be used for making measurements on a broad class of semiconductors and metals. The main articles dealing with the behavior of materials in space are concerned with the study of the effect of radiation on semiconductors and polymers. These works can be useful in creating models that simulate conditions in space, as well as for creating models of the mechanism for the action of radiation on solids.

In articles concerned with possible methods for providing energy for processes in space technology, several aspects of the prolonged operation of nuclear and isotopic thermogenerators are examined.

As a whole, this collection is a logical extension of two previous collections, Materials Processing and Technology in Space and The Fabrication and Behavior of Materials in Space, published by "Nauka" in 1977-1978.

The Editors

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FERRITES AND THEIR BONDING TO METALS AND CERAMICS

Moscow FERRITY I IKH SOYEDINENIYA S METALLAMI I KERAMIKOY in Russian 1979 signed to press 26 Jun 79 pp 2-4, 231-232

[Annotation, foreword and table of contents from book by Gennadiy Vladimirovich Konyushkov, Boris Mikhaylovich Zotov and Erlen Izrail'yevich Merkin, Izdatel'stvo Energiya, 232 pages]

[Text] This book presents data on the properties of polycrystalline microwave ferrites. An analysis is made of the properties of a ferrite and of the construction materials required for producing inseparable bonds of these materials by the methods of soldering, diffusion welding, cementing, spraying, etc. A discussion is presented of the physicochemical processes and technology of producing ferrite-metallic and ferrite-dielectric bonds by these methods.

Data are presented on the creation of electronic vacuum devices for the microwave band with the utilization of ferrites as non-mutual absorbers, and methods are discussed of monitoring the parameters of devices included in irregular high-power-level channels.

This book is intended for engineering and technical personnel involved in developing and fabricating ferrites and equipment based on them.

Foreword

Ferrites possess unique magnetic, electrical and dielectric properties, which have ensured their wide application in various fields of engineering. Ferrite materials designed for use in microwave equipment make it possible to construct ferrite devices for the entire microwave band. Extensive theoretical and experimental research has been conducted on various ferrites and a great number of devices based on them have been developed.

The effective utilization of ferrite devices and their reliability and life depend to a great extent on the quality of the bonds between ferrites and metals and ceramics. Furthermore, rather strict requirements with regard to stability and thermomechanical loads are often imposed on subassemblies. Especially high requirements are imposed on ferrite-metal bonds inside vacuum microwave devices.

For the purpose of producing inseparable bonds between ferrites and metals, cementing and soldering are usually employed. In recent years successful work has been done with regard to producing these bonds by the method of vacuum fusion welding.

Various methods of creating a ferrite-metal and ferrite-dielectric composite, such as thin-film technology, vacuum metallization, thermal deposition, etc., have found wide application in the development of a technology for ferrite devices for microelectronics.

The authors were confronted with the problem of generalizang and systematizing the data of scientific developments and production know-how with regard to the creation of ferrite-metal and ferrite-ceramic joints and composites. In this book the authors have tried to give an account of the properties of ferrites and metal and ceramic construction materials from the viewpoint of producing high-quality bonds between them by the methods indicated. In discussing the physicochemical processes and certain technological aspects of cementing, soldering, diffusion welding, spraying, sintering and other methods of joining ferrites to metals and ceramics, special attention was paid to questions relating to producing bonds by diffusion welding, as the most promising method for producing ferrite-metal joints possessing enhanced resistance to thermomechanical loads.

Taking into account the great dependence of the choice of bonding method on the type and design of the device, the authors believed it necessary to discuss the key types of linear ferrite devices. Questions are discussed, relating to the utilization of ferrite-metal joints in the electronic vacuum device industry--the creation of combined designs of electronic vacuum and ferrite devices. Aspects of monitoring the electromagnetic parameters of ferrite high-power-level devices operating under real conditions of various radioelectronic systems are discussed.

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