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Triple Juncture Sapphire - Glassy Dielectric – Bottom Layer for Creation of a Protective Coating

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Abstract

The research paper covers production of triple junction sapphire - glassy dielectric - bottom for protective coatings. The variant of usage of glassy dielectric as a binding element which allows obtaining a reliable connection of the junction components is suggested.

Keywords: triple junction, sapphire, glassy inorganic dielectric, ceramics, composition, centrifugation, mechanical strength.

INTRODUCTION

The important requirement for protective coatings manufacture is to create structures of high protection levels with a minimum weight. Almost all developers of equipment investigate in the field of weight characteristic of protective coatings. In this regard, the problem of creating protective coatings for microelectronics and machine building increases year by year [1-3].

Effective method of weight reduction of high protection levels are applying of sapphire as "an external layer". This material has hardness close to diamond according to Mohs scale (about 8-9) that is very effective protection against destroying mechanical action [4].

Usually glue junction of "external" (sapphire) and "inner" (ceramics) layers of the triple juncture is subject to destruction in the course of time and does not maintain long operation at high temperature.

For protective coating production, which base is the multilayer structure, it is proposed to apply glassy inorganic dielectric as a binding component.

METHODS

Let us consider one of variants of fusible uncrystallizable glass application for welding with sapphire and ceramics. Every mix (of proposed composition (1-3), table 1) alloys separately in corundum crucibles in electric furnaces equipped with glass ceramic heaters at temperature of 1100–1250°C during 4 hours.

Melts of glasses are cast in the form of samples for measurement of linear-thermal expansion coefficient (LTEC), electric parameters, and also in distilled water for obtaining granulated material.

Granulated material is crushed in jasper drums for obtaining of powder with a specific surface of 5000 cm^2/g. On basis of glass powders working suspensions are prepared by a wet grinding in jasper drums with jasper spheres at presence of isobutyl spirit. Coating of glass powder from suspension to substrates from sapphire and ceramics is made in a centrifuge of Labtex firm (model OPN-16) at rotor speed 3000 - 6000 rpm during 3 min. Heat treatment of the received powder glass layer is made in electric furnaces at T <600°C with cooling speed 3 deg/min up to 150 °C. The crystallization capacity of films was estimated by an electronic microscope. The thickness of a coating of a glassy inorganic film varied from 1 to 5 micron.

For production of strong threefold juncture sapphire - glassy inorganic dielectric - ceramics the whole complex of specific requirements is made to physical - chemical properties of glassy inorganic dielectric which is used as a binding element for production of threefold joint. For obtaining of the reliable working juncture sapphire - glassy inorganic dielectric - ceramics it is necessary to consider LTEC of the materials being welded. Use of inorganic glassy dielectric demands the coordination of values of LTEC of glass and two other components of the juncture which will lead finally to the minimum tension in the juncture.

The components which are a part of glass influence greatly on mechanical reliability of the juncture. In annealed junctures there are tensions basically caused by various values of LTEC. The stretching effort in the structure can cause cracking of the construction at the subsequent stages of mechanical treatment, infringement of linearity or degradation of properties of a used material.

Except LTEC essential influence is rendered by a thickness of glassy inorganic dielectric which is used as a binding element.

Therefore, the centrifuge method is used, which allows to receive films of homogeneous thickness from glassy inorganic dielectric of size 1-5 microns which provides strong connection of the threefold juncture.

DISCUSSION AND RESULTS

Glassy inorganic dielectric, that provides solution of the task, of the system PbO - B_2O_3 - ZnO with additive R_2O (Na_2O, K_2O, Mg_2O) including weight of % in limits from 1.0 - 8.0, has the following properties: possibility of obtaining on its basis of not crystallizing films, coordination of LTEC between components of juncture, formation temperature in limits up to 600°C and the durability of mechanical destructions, increased mechanical durability of the threefold juncture.

Component R_2O added in the general structure of glass, can influence more or less actively the condition of boric anhydride in glass, and at sufficient increase of R_2O quantity in glass, durability of the glass and the components of the juncture increases.

Developed glassy inorganic dielectric with addition of component R_2O on the basis of system PbO - B_2O_3 - ZnO, should lead to the minimum mismatch of the welded materials, have LTEC (80 - 90 $\times 10^{-7}$ K^{-1}) close to LTEC of ceramics (90 - 101 $\times 10^{-7}$ K^{-1}), and of sapphire (56 - 75 $\times 10^{-7}$ K^{-1}).

For improvement of mechanical durability of the juncture sapphire - glassy inorganic dielectric - ceramics, R_2O (in limits from 1.0 to 8.0 weight %) is added in composition of the used fusible not crystallizing glass.

The proportion of the specified components in the described composition of fusible glass allows production of glassy dielectric which provides durable threefold juncture sapphire - glassy inorganic dielectric - ceramics. Variants of the composition and physicochemical properties of the described glass are presented in table 1.

Table 1: Variants of the composition and physicochemical properties of the described glass

Glass composition		1	2	3
Content, weight %	PbO	64.0	83.0	61.5
	B_2O_3	15.0	5.0	14.6
	ZnO	7.3	6.5	11.0
	SiO_2	0.2	0.2	2.0
	Al_2O_3	4.0	0.1	0.1
	Bi_2O_3	1.0	2.7	1.5
	CuO	0.5	0.5	1.3
Additive	R_2O	8.0	2.0	8.0

The estimation of the crystallization capacity of the initial monolithic synthesized glasses was carried out by a method of mass crystallization and by a method of differential thermal analysis (DTA). Electro physical parameters of glasses were measured according to standard techniques. The obtained glasses have following characteristics (see tab. 2).

Table 2: The obtained glasses

Compo-sition, No	Softening temperature, °C	LTEC $\times 10^{-7}$ K^{-1}	tgδ $\times 10^4$	Crystallization capacity
1	380	86.3	23	absent
2	386	83.6	20	absent
3	390	83.1	18	absent

CONCLUSION

Therefore, the experimental research of obtaining of composition of fusible not crystallizing glass for welding with sapphire and ceramics was made. The developed fusible glass provides improved mechanical durability of the threefold juncture sapphire - glassy inorganic dielectric - ceramics. It is determined, that the additive of component R_2O improves mechanical durability of the glassy inorganic dielectric, as a part of threefold juncture sapphire - glassy inorganic dielectric - ceramics.

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