LASER FORMATION OF CHANNELS ON A SURFACE OF AlN CERAMICS.

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ABSTRACT

With the use of X-ray microanalysis and electronic microscopy is established that making channels on a surface of AlN ceramics by laser beam is caused by decomposition of AlN and metallization of the channel surface.

Keywords: AlN ceramics, laser formation of channels, microscopy.

INTRODUCTION

Aluminum nitride ceramics (AlN) has a good combination of physical and electrical properties: high heat conduction, good insulating properties, moderate factor of thermal expansion, and a rather low cost [1-3].

In this work, we present results of laser obtaining of holes and tracks in AlN ceramics.

EXPERIMENTAL

AlN ceramic plates containing 5 wt. % Y_2O_3 (as activator of sintering) were investigated. The plates were obtained by a method of a hot-pressing of aluminum nitride powders by cleanliness 98 % and with several values of heat conductivity: 140, 150 and 180 W/ (m.deg.). For study of geometrical form of tracks (channels) the ceramic plates were destroyed in a direction, perpendicular their surfaces and direction of a track.

The laser processing of an AlN-surface was carried out in a pulse mode on a rich atmosphere on oxigen. On an axis of a beam into a place of irradiation a stream current of argon was supplied. In Table I the conditions of an irradiation are submitted.

Table I. Characteristics of pulsed irradiation of ceramics.

Laser	Solid-state
Length of a wave, λ	1.06 μ m
Energy of radiation, Q	4,10, 12, 14, 60 mJ
Duration of pulse, τ	100 μ s, 50 ns
Frequency of generation of pulses, ν	12, 17 kHz
Parameter of focusing	2.5 mm

The quantitative and qualitative chemical microanalysis and micrographies of sample surface and tracks were carried out with the use of x-ray electron pound microanalyzer on installation “Comebax SX-50”. The quantitative analysis was carried out or at the fixed position of a probe, or at scanning in the certain square. In the first case the area of scanning made 0.1 x 0.1 microns.

RESULTS AND DISCUSSION

The laser processing results in formation of channels on the AlN-plates surface, the depth and width of changes (i.e. morphology) depends on the mode of irradiation and the thermal conduction of the material (Fig. 1).

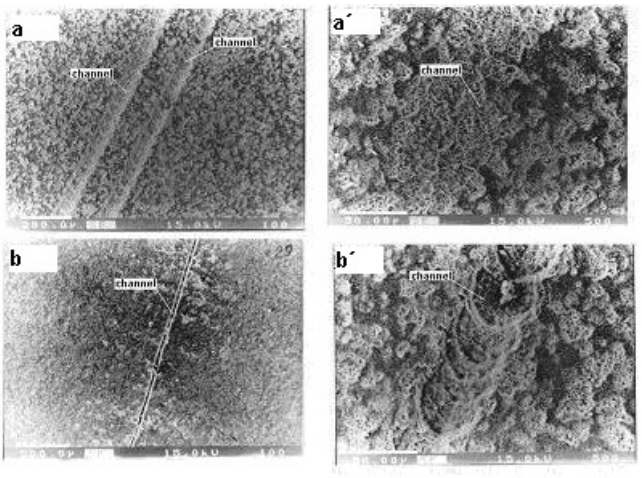

Fig. 1. SEM images of AlN-surface after irradiation at different powers of radiation. (a, b,) view from above; (a', b') inside the channel. For (a, a') Q= 4 mJ; (b, b ') Q= 10 mJ.

The results obtained from microanalysis specify that at a laser irradiation the contents of elements in channels (in comparison with the raw surface) change and the increase of the contents of oxygen is registered (Fig. 2a y b).

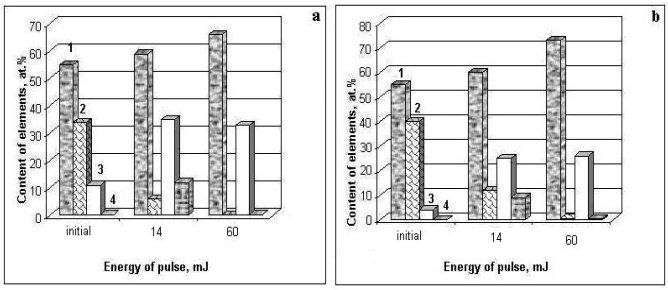

Fig. 2. The change on contents of elements in a zone of the channel depending on energy of a pulse. λ = 150 W/ (m· degree); U = 380 V. (1) Al; (2) N; (3) O; (4) Y. For (a): S = 40 x 40 μ m. For (b): S = 12 x 12 μ m, (c) The change of thickness on a metallyzed layer in a zone of channel depending on energy of pulse. An irradiation of the not polished sample S = 40 x 40 μ m; λ = 150 W/ (m· degree); U = 380 V.

This means that occurs a modification of AlN target and aluminum oxidized. In comparison with the surface of the initial sample, the damage resulted of irradiation process, was well visible (see Fig. 3). The metallization" of the superficial layer of the channel occurs. As a result of techniques [4, 5], and by X-ray analysis of an effective volume of sample, it is possible to approximate the value of thickness of the metallized layer.

There is as decomposition of aluminum nitride in the zone of channel, aluminothermic reduction of yttrium oxide, formation of alloys, and formation of alumina, i.e. process of oxidation.

The influence of laser irradiation on surface of AlN-ceramics can be described by the following reactions:

$$AlN + Q \rightarrow Al + N\uparrow \quad (1);$$

$$4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3 \quad (2);$$

$$Al + Y_2O_3 \rightarrow Al_2O_3 + Y \quad (3);$$

$$Al + Y \rightarrow \text{alloys of variable composition} \quad (4).$$

CONCLUSIONS

-The analysis of experimental results shows that at an irradiation of AlN-ceramics it is possible to make tracks of various width and depths by selection of a mode (parameters) of a laser irradiation, heat conductivity and composition of AlN-ceramics.

-The basic process of formation of channels is the decomposition of AlN as a result of development in a zone of an irradiation of temperature ~ 3000 °C.

-At cooling of channel on its surface a metallized layer of aluminium is forming.

-The presence of Al in the channel initiates aluminothermic reduction of yttrium oxide and formation of yttrium.

-On the base of Al and Y in zone of channel the alloys Al-Y of variable composition are forming.

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