

INVESTIGATION OF THE CERAMIC WINDOWS USED IN LINEAR ELECTRON ACCELERATORS OF THE NSC KIPT

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The results of investigations of HF windows on the basis of ceramic cones (CC) from klystrons KIU-12AM are presented. Phenomena of "locking" of the windows and stationary shining of CC are studied. Their physical models are proposed.

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I. INTRODUCTION

In this paper the results of investigations of HF-windows on the basis of ceramic cones (CC) from klystron KIU-12AM are presented. Investigations are conducted with the aim of determining the possibility to increase the electrical strength of CC, their working time, reliability and simplicity of manufacturing, to determine the causes of breakdowns at a high-mean power and to clear the mechanism of some phenomena such as "locking" and stationary shining by full passing of HF-power.

II. BREAKDOWN OF CC

At $P_{\text{pulse}}=12...14$ MW and $P_{\text{mean}}=14...15$ kW the breakdowns take place not in the zone of vertex of a cone (as supposed earlier) but in the zone of ceramic-metal soldering. Causes of breakdown in these cases are not in the electrical failure of the ceramic, but in the temperature cracking at a high-mean power. Breakdowns on the vertex of the cone, probably, take place at $P_{\text{imp}}>17$ MW, and $P_{\text{mean}}>2$ kW, that was observed at 2 GeV LA and are caused, very likely, by reflections in the waveguides by breakdowns in the acceleration sections or on the adjusting pivots (see below).

III. ADJUSTING ELEMENT (AE) IN CC. METALLIZATION

Tests showed that the weak places in CC are the AE-two capacitance pivots compensating the reflection from the metal partition, to which the ceramic cone is soldered. On these pivots the breakdowns take place by HF-training and here the roentgen radiation (RR) is formed, sputtering of metal (Cu) and metallization of surfaces CC placed near the pivots occur.

When in 60^s years in the department of LAE one encountered with "Locking" of CC, one supposed that it is countered by Ti metallization owing to the use of Ti-pumps. Then the version of metallization as a cause of "locking" was not confirmed because of unsuccessful attempt to use the chemical cleaning of CC surfaces. At present, it is clear, that the version of metallization was right, but the source of metallization is the breakdown in waveguides and, in particular, on adjusting pivots. This understanding became possible thanks to upgrading the construction of CC block with AE and distinguishing AE in the element separate from CC [1]. This gave a large advantage in comparison with a previous CC construction: convenient access to CC surfaces by examina-

tion, cleaning, chemical treatment, removing leaks, and also thanks to excluding the soldering or welding operations by manufacturing the updated CC (UCC).

IV. "LOCKING" OF CC, ITS PHYSICAL MECHANISM

Accidentally, on manufacturing UCC for the replacement HF-window one have used CC (from KIU-12 AM having exhausted resource in which after 5000 hours of operation "locking" of CC occurred) and it became very interesting for the investigation of "locking" phenomenon. It turned out, that in this CC, ordinary having on the side of nitrogen atmosphere a red-rose color, on the side of the vacuum space was covered with white-gray rough-mat color, as a "silver paint", and near the ceramic-metal junction there was a half melting strip of the light metal like Ni. This strip made metallization of CC surfaces on the vacuum side (vacuum space of the klystron). It should be noted the following:

1. This "locking" of CC did not differ from the ordinary CC by the coefficient of standing wave (CSW).
2. Resistance between any two points of the metallized CC surface was 8...10 MΩ.

This means, that metal is deposited on the bulges of the surface profile, and his hollows remains either not filled or metal does not "reach" metal on the bulges. This structure of the CC surface, by our opinion, gives very favorable conditions for the auto-emission and secondary emission processes and for the ionization of the residual gases, i.e. for the HF-discharge at a power level of some MW in the pulse that is observed by "locking". Thus, "locking" is the self-supported auto-emission secondary-emission process of residual gas ionization, HF-discharge and generation of the reflection wave at the front of the HF-discharge. Under these conditions only a little and instable part of the HF-power passes through "locking" of CC. During "locking" we not observed RR that means, that in this case low-energy electrons and, probably, also second-emission electrons are working.

The attempt was made to remove the metallized CC surface by chemical way. It was successful and after the phenomenon of "locking" disappeared and through CC the HF-power $P_{\text{imp}}=14$ MW by $\tau=4,5$ μsec and $N=150$ Hz passed. Thus, the experiment confirmed, that metallization is the cause of "locking".

V. STATIONARY SHINING OF CC

In some CC the stationary shining (SS) is observed when passing the HF-power without noticeable losses and all parameters are stable. Commonly SS appears already "from zero", at low values of HF-power, pulse length and number of pulses per second in SS and is stable at all the parameters by changing the power from minimal to maximal values, at the HF-pulse none breakdowns and roentgen radiation are observed. But these SS ceramic cones are slightly more warmed than "darker" CC. However there are not reliable data about this fact. Apparently, the reason of shining and warming is the same and probably, not all ceramics is shining on the whole, but some its parts, or, "centers of shining" by the solid-state terminology, are shining.

Three versions of SS are proposed.

1. This is one of stages of surface metallization after which "locking" of CC can be expected;

2. This is the particular form of the surface HF-discharge, by which the metallization also may play some role.

Probably, versions 1 and 2 are not convincing – mainly, that is not clear – it is a high stability of shining of all the parameters that, scarcely, may take place in such stochastic processes as auto emission and second emission. More convincing seems the version, according to which:

3. Shining of CC takes place when there are in ceramics metallic micro particles which are regularly distributed on the volume of ceramics. They may be sources of shining due to their ohmic warming by HF-currents with their free electrons. Confirmation may be the data on the losses in shining and dark cones. But so

far they are absent. By measurements at a low power the losses may be other than at a high power, when metal particles are red-hot. If HF-losses in the CC=1%, it is necessary (by the method grand CSV) to measure CSV=200, that is not simple. By the Stefan-Boltzman law the warm radiation around the ceramic cone with a temperature =1000 K is =600 W. If the input power equals to 15 kW then the dissipation power =1% (absolute) equal to 150W, if 2% - 300 W etc. But the supposition, that the temperature of all cone is 1000⁰ K contradicts to experimental facts of rapid extinction of the shining by turning out the HF-power (mass 80 gram). On the other side this fact corresponds to the supposition that only microparticles are shining and red color takes place owing to the color of ceramic, which served as red light filters.

Attempt to measure the "temperature" of ceramics of CC by the help of the pyrometer was made in the working mode. It gave the temperature 920...970°C. Such a cone was illuminated by the electric bulb (150 W) on the passing of the light across of the cone (at room temperature and without HF-power with the same pyrometer). The temperature was 920...930°C. Thus CC, of course, is hot (temperature of its wave guide reached 80 °C), but it is not so.

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ИССЛЕДОВАНИЕ КЕРАМИЧЕСКИХ ОКОН, ИСПОЛЬЗУЕМЫХ В ЛИНЕЙНЫХ ЭЛЕКТРОННЫХ УСКОРИТЕЛЯХ ННЦ ХФТИ

А.Н. Довбня, Э.С. Злуницын, А.И.Зыков, Г.Д. Крамской

Приведены результаты исследований СВЧ-окон на основе керамических конусов (КК) от клистронов КИУ-12АМ. Изучены явления «запирания» и стационарного свечения КК, предложены их физические модели.

ДОСЛІДЖЕННЯ КЕРАМІЧНИХ ВІКОН, ВИКОРИСТОВУВАНИХ У ЛІНІЙНИХ ЕЛЕКТРОННИХ ПРИСКОРЮВАЧАХ ННЦ ХФТІ

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Наведено результати досліджень СВЧ-вікон на основі керамічних конусів (КК) від клістронов КИУ-12АМ. Вивчено явища «замикання» і стационарного світіння КК, запропоновані їхні фізичні моделі.