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А.А. Михайличенко

СВЧ ОКНО ДЛЯ ЛЮБОЙ МОЩНОСТИ

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НОВОСИБИРСК

RF WINDOW FOR ANY POWER

A.A.MIKHAILICHENKO

G.I.Budker Institute of Nuclear Physics
630090, Novosibirsk, Russia

Abstract

There is described new type of RF windows, based on full coupled waveguides with many small holes. *Each* of these holes covered by dielectric vacuumed window.

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А. А. МИХАЙЛИЧЕНКО

G.I.Budker Institute of Nuclear Physics
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АННОТАЦИЯ

Описан новый тип СВЧ окна, основанный на использовании волноводов с полной связью, создаваемой большим числом отверстий, *каждое* из которых закрыто вакуумноплотным диэлектрическсм окном.

INTRODUCTION

The RF window, used in a powerful generator, is one among important components of this device. Such a window makes possible easiest manipulation with RF generator, connection with the load and mainly, such a generator can be prepared for operation at the factory with heat treatment. This is very important for operation of High Energy Linear Accelerators , which are under consideration in all laboratories for High Energy Physics.

Typical value of transferred power through the window is around 100 MW for wavelengths of X and S band. For this frequencies the rectangular waveguides are used.

In simple case the window is a dielectric vacuumed wall across the waveguide. The numerous types of windows are described in tutorials. The main idea for such devices, used for extra high power, is to decease the electric field strength in the media of insulator, cause namely here occurs limitation of transferred power. RF window also can produce minimal reflection.

The other well known device for X and S band techniques is a coupler. Such a coupler connect in simplest case two waveguides. The mostly used 3 dB coupler split the power from main waveguide and divide the power between two waveguides half to half.

The subject of our paper connected with *multihole* couplers. For such a coupler the common wall of two rectangular waveguides has a lot of small holes distributed along longitudinal direction. The distance between these holes are chosen integer and a quarter of wavelength in the waveguide. This defines *direction*, in which coupled wave are propagated (co-directed coupler).

The description of such a coupled waves in two waveguides is the same as for any coupled systems. For any value of coupling, which is defined by diameter of the hole, there exists a distance

along the coupled waveguides, when the power from the first waveguide, fully comes to the second one and after doubled distance again to the fist one and so on. If the length is that the power from the first waveguide fully comes to the second, we talk abut *full coupling*. Number of the holes which provide a full coupling, from the other side, defined the level of the power, which is passing though each small hole.

Now if we closed *each* of the holes by small dielectric vacuumed window, we obtain this new type of RF window.

PARAMETERS OF COUPLING

Let λ_0 - will be the wavelength of transferred RF in free space. In waveguide the wavelength will be $\lambda = \lambda_0/\sqrt{1 - (\lambda_0/2a)^2}$, where a is the width of waveguide, see Fig.1. If the distance between centers of the holes l is equal $\lambda/4$, then the phase shift will be $\theta = 2\pi l/\lambda = \frac{\pi}{2}$.

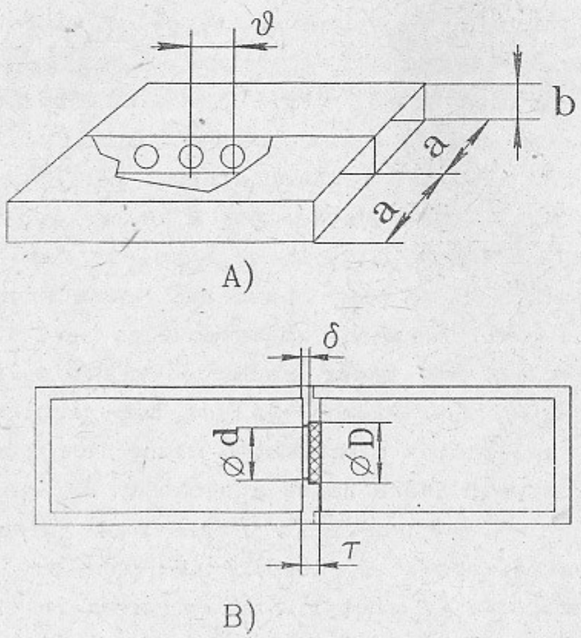

Fig.1. Fully coupled waveguides, A) and cross-section of the hole, covered by individual window, B). $\theta = 2\pi l/\lambda = \pi/2$.

Equivalent conductance Y of the hole can be expressed by the formula [1]

$$Y = \frac{\pi}{6} \cdot \frac{\lambda}{b} \cdot (d/a)^3, \qquad (1)$$

where d - is diameter of the hole, b is a height of the waveguide. This conductance must be equal to conductance at the middle wavelength

$$Y = \frac{\pi}{2\theta} \operatorname{Sin}\left(\frac{\pi}{k}\right) = \operatorname{Sin}\left(\frac{\pi}{k}\right),$$

where k is the number of the holes. So, if the number of the holes are defined, the diameter of the holes can be calculated as following

$$d = a \sqrt[3]{\frac{6}{\pi}\frac{b}{\lambda} \cdot \operatorname{Sin}\left(\frac{\pi}{k}\right)} .$$

This formulas are valid for infinitely thin wall. As it can be seen from the Fig.1, the real thickness of the wall are defined by the value δ. Decrement for one hole, which can be calculate from (1) is equal $C = 20\ lg2Y$, and additional decrement, due to finite thickness can be expressed [1]

$$\Delta C_{dB} \cong 32 \cdot \frac{\delta}{d} \sqrt{1 - \left(\frac{1.71 \cdot d}{\lambda}\right)^2}$$

EXPERIMENTAL RESULTS

This type of the window was investigated by the Author in 1982, when it was made natural model of such window.

Wavelength was about 4.28 cm (7 GHz), waveguide has cros-section 35 x 15 mm^2 (close to WG-14 type). Thickness of the common wall $\tau \cong 1.5$ mm. For this waveguide $\lambda \cong 5.41$ cm, $\lambda/4 = 1.35$. Initially there was chosen $k = 50$, so the length of the common wall with the holes was $49 \cdot 1.35 = 66$ cm. Diameter $d \cong 1.12$ cm. Total length of this window was 800 mm. For fabrication there was used two standard waveguides. From one of the waveguides there was milling one narrow wall, and holes were drilled in walls of other waveguide. One waveguide to another was mounted by soldering with help of some special holders. These holders were used for preliminary holding the waveguides when this system was tuning.

There was fabricated ceramic discs from red ceramics (22XC). Thickness of this discs are about 1 mm and diameter $D \cong 12$ mm. Cylindrical surfaces of these discs were covered by Molibdenian paste and go trough diffusion annealing. After that these surfaces were covered by Tin by galvanic process. This windows were soldered in it places. The thickness of the wall δ was about 0.5 mm, so the resulting number of the holes was increased to 55. This number was defined experimentally, add one hole after another for obtaining full coupling.

For measuring there were used standard equipment for X band wavelength.

CONCLUSION

Author are sure, that the windows of such type is possible candidate for ultrahigh power window, especially in frequency region about 11÷12 GHz, where waveguide of 10 x 23 mm^2 can be used. It is evident, that some improuvements can be done immediately, such as diameter variation of the holes from very small to normal and small again. Also the sides were these windows are mounted also can be changed at he different sides of the common part.

It is evidend the advantage of such type of window if compare with, for example, horn type. In our window trough small hole only $1/k$ part of the power are passed. The reference point for estimation of the possibility to pass this amount of the power gives the *cutput hole of the RF generator* (Klystron), which is also small, passing *all* power.

LITERATURE

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