DOI: 10.34854/ICPAF.52.2025.1.1.060

DEVELOPMENT OF THE MULTIJUNCTION ANTENNA WITH FREQUENCY 2.45 GHZ FOR GLOBUS-M2 TOKAMAK *)

Altukhov A.B., Varfolomeev V.I., Gurchenko A.D., Gusakov E.Z., Dyachenko V.V., Irzak M.A., Konovalov A.N., Mareev A.S., Nechaev S.A.

Ioffe Institute, St. Petersburg, Russia, a.altuhov@mail.ioffe.ru

In modern tokamaks, additional microwave heating and current drive (CD) microwave systems are essential components. CD in thermonuclear plasma by the slow lower hybrid (LH) wave using multi-waveguide antennae (MWA) of the multijunction (MJ) type [1-3] is an effective method, although it is localized at the periphery and has limitations in plasma density. The MWA is designed to excite waves slowed down along the toroidal magnetic field and propagating in the direction of the electron current. The refractive index spectrum $N_{||}$ of the excited waves is determined by the plasma properties, but is provided by the MWA design, which has a certain phasing sequence between the waveguides. The MWA, like the entire CD system, is constructed on a modular principle, in which each channel is powered by a klystron generator with a power of 200 kW, and is easily scalable to increase power. A two-channel CD system with LH waves at a frequency of 2.45 GHz and a power of 400 kW has been prepared for the Globus-M2 tokamak.

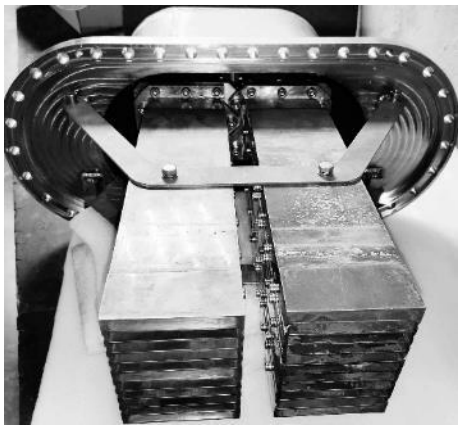

Fig. 1. *MJ-antenna*

An experimental MJ-type MWA, shown in figure 1 was developed and manufactured. Development was based on theoretical analysis and numerical calculations. Each of the two MJ-antenna modules is constructed as follows: the input waveguide of 90×45 мм^2 cross-section is divided into two waveguides of the same cross-section, then each of them is split into 4 channels in the H-plane using knife-edge splitters. As a result the output two sequences of 4 active radiating waveguides of 90×9.75 мм^2 cross-section are formed, with three passive waveguides installed at the edges, plugged at a quarter-wave depth. Special internal pieces provide a phase shift of π/2 between any two adjacent waveguides in the MWA, which effectively reduces the level of microwave power back reflected from the plasma surface, due to the multi-pass propagation implemented in the waveguide system of the antenna. The manufactured module is intended for testing the technology for creating the MJ-antenna, which is new for Russia, so on the one hand, the possibility of its development for the T-15MD tokamak conditions was checked, and on the other hand, the possibility of experimental testing in the Globus-M2 was included. According to calculations the developed MWA provides a maximum in the refractive index spectrum near $N_{||} = 2.8$, while at $N_{||} > 2.2$, the LH waves satisfy the accessibility criterion and are able to penetrate into the central zone of the discharge in the T-15MD tokamak, the power reflection coefficient at the antenna input is $R = 4\%$, and the spectrum directivity coefficient is $D = 43\%$. Due to the lower magnetic field on the Globus-M2 tokamak, only waves with $N_{||} > 3.3$ penetrate into the central region. For the same antenna module in the Globus-M2 only the shortest-wave part of the spectrum satisfies this condition while $R = 6.3\%$, $D = 53\%$.

The development of the MWA was carried out with the support of the State Assignment of the Ioffe Institute FFUG-2022-0002, and numerical calculations – FFUG-2024-0028.

References

[1]. Bibet P., Litaudon X., Moreau D., Nucl. Fusion, 1995, 35, 1213.
[2]. Kim J., Han J, Wang S., et al., Fusion Eng. Des., 2019, 144, 29.
[3]. Li M.H., Liu L., Tang Y.Y., et al., Fusion Eng. Des., 2019, 147, 111250.

*) abstracts of this report in Russian