Fabrication of the 0.346 THz BWO for plasma diagnostic

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***Abstract*—Nuclear fusion is probably the most demanding challenge the scientific community is facing. The plasma is a delicate material that has to be properly shaped to achieve a high efficiency fusion process. Unfortunately, the plasma is affected by microturbulences still not fully understood, detrimental for the reactor functioning. The diagnostic of plasma is a fundamental technique that needs advanced approaches for a full mapping of the plasma behavior. The 0.346 THz backward wave oscillator is the enabling devices for a high-k plasma diagnostic that will provide unprecedented insight on turbulences leading to full operational fusion reactors. This abstract describes the final fabrication phase of the 0.346 THz BWO for plasma diagnostic jointly performed in an international project, involving three leading institutions in vacuum electronics,**

Keywords—backward wave oscillator; vacuum electronics; nanoCNC milling, double corrugated waveguide; nuclear fusion;

I. Introduction

Plasma micro-turbulences are one of the main obstacles for a stable nuclear fusion process. Relevant efforts are devoted in the modeling and measurement of the plasma behavior. The delicate nature of plasma needs measurement approach not perturbing its behavior. The collective Thompson scattering has been proved to be a suitable diagnostic technique. The actual equipment is still not adequate to properly map the plasma. The availability of affordable and compact THz source will permit to extend the dimension of the plasma region to probe.

The 0.346 THz Backward wave oscillator (BWO) is a key device to provide adequate oscillator power to enable a large matrix of heterodyne detectors, to extend the region of plasma diagnostic. The BWO design phase was extensive and resulted in wide number of different solution and advancements in the field. The final design was then chosen on the basis of performance and feasibility. The fabrication phase is in progress. In the following, the fabrication of the different parts will be described.

Three main fabrication challenges will be described:

- Double corrugated fabrication
- RF window
- Electron gun and magnets
- BWO full assembly.

The final assembly will be presented at the IVEC2017.

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II. Final Simulations

A three-dimensional PIC simulation campaign was conduct to confirm the performance including the experimental data as the magnetic field values, the beam parameters and the expected dimensional variations. A sensitivity analysis was also performed. The BWO performance (Fig. 1) has been demonstrated, by 3-D Particle in cells simulations by CST-MWS, to very stable for a wide range of geometrical parameters. This provides a high level of confidence in the robust BWO behavior.

III. Double Corrugated Waveguide Fabrication

The double corrugated waveguide is in fabrication phase by using the NN1000 DCG HSC nano-CNC milling machine developed by Digital Technology Laboratory, subsidiary of DMG – MORI, in Davis CA as a prototype machine for

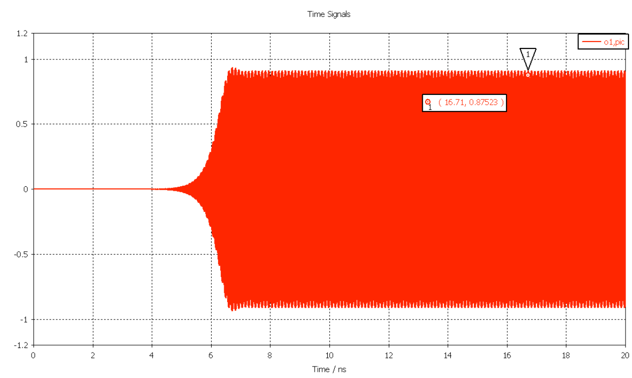

Fig. 1. Output power as function of time

advancement of nano-precision manufacturing capabilities. Fig. 2 shows the assembled DCW with the joint area for the coupler and RF windows.

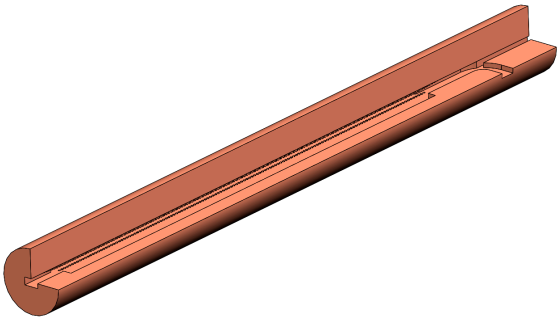

Fig. 2.Diffusion bonded circuit assembly ready for cold testing

BWO circuit will be manufactured employing diamond saw technology to create the micro pillars; conventional high precision CNC milling technology will be employed to machine the waveguide and beam structures around the circuit; diffusion bonding will be employed to create the proper bond and alignment between the circuit halves (Fig.2); finally, outside machining operation will be used to turn the assembly into the cylindrical part ready for alignment with the vacuum envelope and the magnetic confinement structure of the BWO. Diamond saw technology is well suited for fabrication of this circuit considerably reduced manufacturing time as well as simplifying the overall assembly of this high frequency VED.

IV. Electron Gun and Magnetic Focussing Field

An electron gun to generate an electron beam with 22kV beam voltage and 30 mA beam current and a diameter of 160 micron has been built and tested at BVERI. A magnetic permanent periodic magnetic (PPM) focusing system of about 0.48Tassures a high beam transmission and low weight.

V. RF Windows and Assembly

The RF window was a diamond-disc pill-box window (Fig.3) and will be assembled to the DCW body by brazing (Fig.4) The test results show that the window can operate from 330GHz-350GHz, and the transmission loss is 1.5-3dB (Fig.5).

VI. Conclusions

The fabricated parts for the first 0.346 THz BWO for plasma diagnostic have been presented. The assembly and measurements of the BWO will be a breakthrough in the field of THz vacuum electron devices.

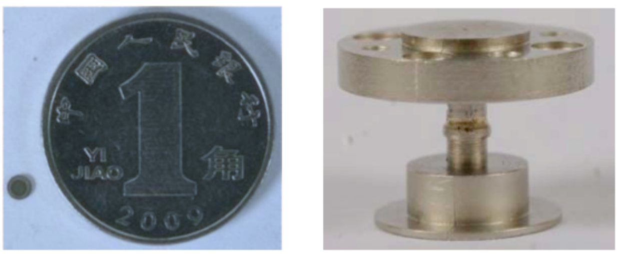

Fig.3 Window/assembly

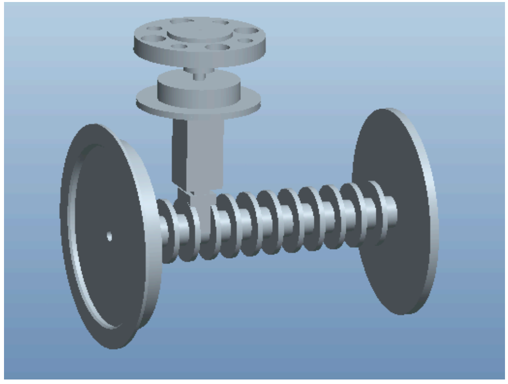

Fig. 4 3D solid model of the window and the SWS

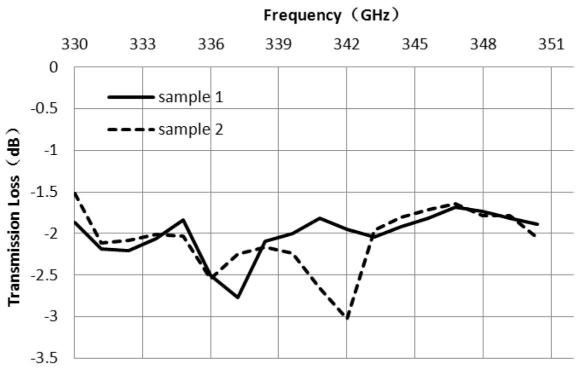

Fig 5 The tested loss of the window for two samples

VII. References

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