DEVELOMENT OF S-BAND HIGH POWER LOAD

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Abstract

Several types of S-band high power loads have been designed, manufactured and tested successfully in Tsinghua University. The high power loads, which work at 2856MHz for 10MW~100MW range, are made of all stainless steel. This paper presents the design, fabrication and the high power test results.

INTRODUCTION

RF load is one of the most important components in microwave circuit. High power load has been widely applied to absorb the surplus power in the accelerator system. High power load can be divided into two types according to the absorption material: water load and dry load. Dry load is commonly made of Silicon Carbide (SiC), ceramic doped with conducting material or ferrite. Compared to water load, dry load is more firm and reliable. In addition, Silicon Carbide is also an ideal absorption material. Nevertheless, it has some technologic problems in baking and brazing.

Therefore, we propose several types of S-band high power loads in Tsinghua University to apply in our accelerator system. The type of microwave load is fabricated from stainless steel, and has an indirect water cooling structure. It was successfully operated with up to 20MW of RF power at a 2-µs pulse width and 10-pps repetition rate in the S-band frequency (2856MHz) in high-power test. This paper will present the design, fabrication and the outcomes of the load.

THE LOAD DESIGN

The load based on waveguide is made of all magnetic stainless steel (SS430) with a length of about 1m. Commonly the load concept is based on the waveguide absorption when operated close to its cut-off frequency [1]. We have introduced a new load waveguide cross-section to guarantee the enough and full waveguide absorption, see Fig.1. There will be regular grooves with gradual depth along the longitudinal direction inside this load [1].

For S-band load, the size of cross-section will be based on the BJ32 waveguide. Besides, to be convenient for the processing of the grooves, we divide the load into two parts at the middle of the long edge along the longitudinal direction. After manufactured, the two parts were welded together to a complete load [2].

Along the longitudinal direction, the load consists of four sections: taper section, match-absorption section, regular-absorption section and end-box section, see Fig.2.

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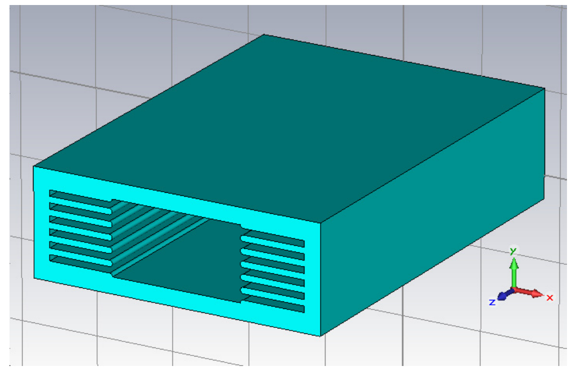

Figure 1: Cross-section of load in CST.

The taper section is used to connect the flange and the load. Moreover, the absorption section has two parts: the match section with parallel stainless steel slices in gradual height and the regular section with slices in constant height, which are both used for full absorption. The end-box section is reserved for tool backlash movement.

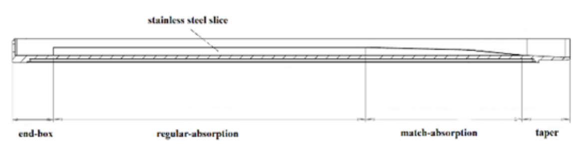

Figure 2: Sections of the load.

There is also water-cooling structure to maintain the temperature constant relatively for load. Circulation water channel is designed at both part of the load. In addition, a vacuum port is attached at the end of the load to connect the vacuum pump.

To get the optimized parameter of the load, we model the vacuum area in CST and calculate for optimization. At last, an S-band stainless steel load with grooved cross-section is designed and optimized successfully, see Fig.3.

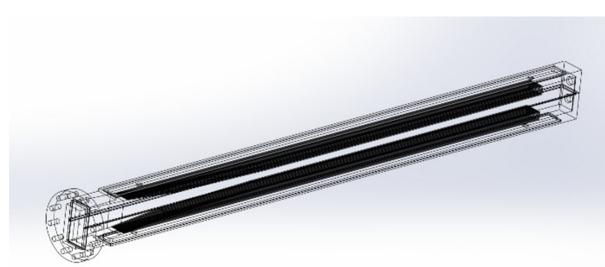

Figure 3: The whole model of load.

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FABRICATION AND OUTCOMES

The load was fabricated in the workshop in Department of Engineering Physics of Tsinghua, see Fig.4. Then they were cleaned and assembled for bench test. The resonant frequency and the S-parameter was tested by vector network analyser. The two parts were then welded by argon arc weld, see Fig.5. Then we tested it with vector network analyser again before the high power test again.

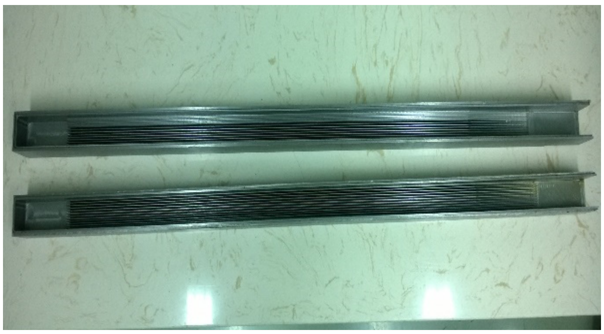

Figure 4: Two parts of the load.

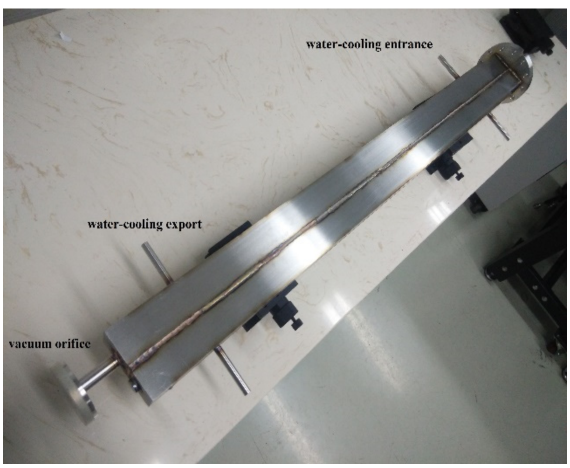

Figure 5: Load after welding.

We can get the S-parameter (S11) describing the power reflection in the load. Figure 6 shows the measured S11 of the load before and after weld. The load has been adjusted to get the biggest attenuation at the frequency of 2856MHz before weld. The reflection can be -37.51dB at 2856MHz and the bandwidth below -30dB can be 18.5MHz. However, the load has a little deformation after weld so that it get a frequency offset. The reflection can be -27.5dB at 2856MHz. Overall, the load performs well while cold test.

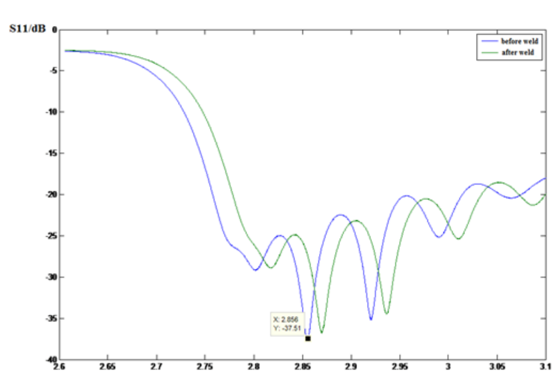

Figure 6: S-parameter before and after weld.

HIGH POWER TEST

Test of frequency characteristic for load showed that the reflection could be low around the resonant frequency. Next, we would supply microwave power to the load from high power resource system to test if the load could operate stably.

Test System

The test system is a high power microwave system with power combination and pulse compression based on two high power klystrons. The schematic diagram for all component of the test system is showed in Fig.7. The output power of the two klystrons is combined by the hybrid and then compressed, and at last divided to the tested stainless steel load. The two klystrons have up to 50MW peak RF power output and 4μs pulse width. This system can have an output of 500MW peak power and 480ns pulse width after compression.

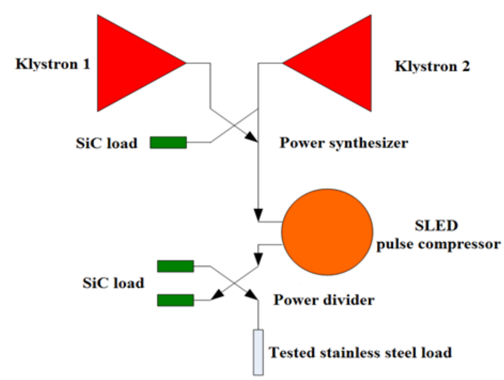

Figure 7: Constitutional diagram of test system.

The layout of the system is showed in Fig.8. The input power and the reflected power can be tested by directional coupler located in the front of the load and showed in a multi-channel oscilloscope.

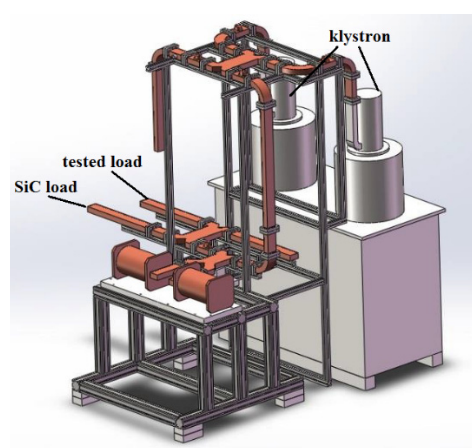

Figure 8: Layout of the system.

High Power Test

The load is connected to the test system, see Fig.9. We can control the input power, pulse width and repetition frequency of microwave to practise this load gradually. First, we will increase the input power with the invariable pulse width (1µs) and repetition frequency (1Hz) until the power reaches 34MW. Then, turn off the power supply, increase the pulse width by 0.2µs and repeat steps above until the power reaches 20MW. By such analogy, we can increase the pulse width to 2.4µs. Repeat these steps again; and we can increase the repetition to 10Hz.

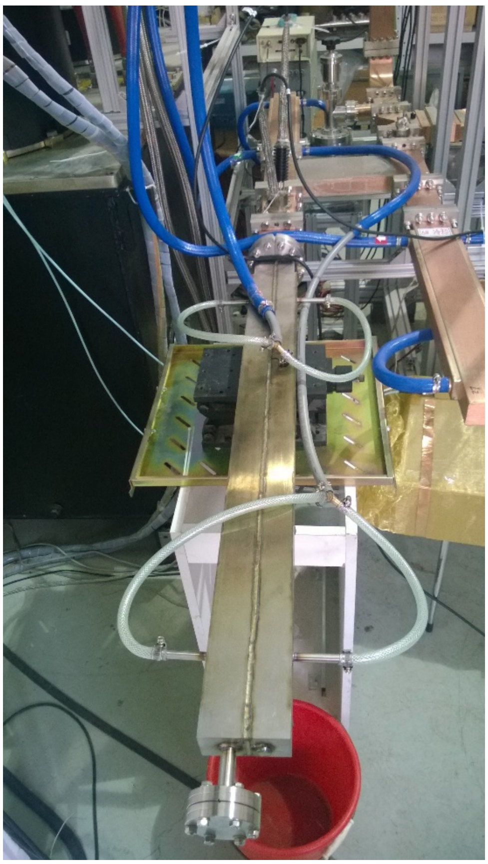

Figure 9: Load connected to the system.

Slight breakdown happened during this conditioning process. The oscillography is showed in Fig.10 at 2.0µs pulse width, 10Hz repetition frequency and 21.2MW input power. Channel 1 and channel 2 show the input power of the two klystrons. Channel 3 shows the input power and channel 4 shows the reflected power of the load. The reflected power from the load is 0.215MW, means -19.9dB. We can also see obvious shakes at the tail of the reflected waveform which maybe induced by secondary-electron multiplication in the load.

The power reaches up to 36MW at 1Hz during the conditioning process, and only two obvious breakdown happened. The reflectance of the power is between 1% and 1.6%. The load can operate at 36.1MW, 2µs, 1Hz and 21.2 MW, 2µs, 10Hz. For our accelerator system, the load will receive the microwave at 20MW, 2µs, 10Hz. Therefore, this load can operate well in our accelerator system.

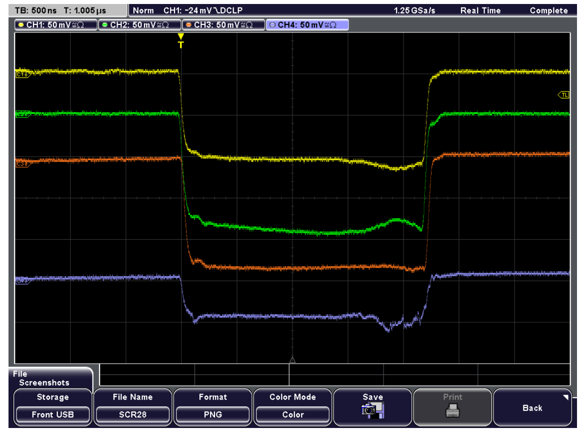

Figure 10: Waveform of the power.

CONCLUSION

We have designed a type of S-band all stainless steel load with gradually varied grooved cross-section. This load will be assembled by two parts, each with vacuum port and water-cooling tank. A pattern of load has been manufactured in the workshop in Department of Engineering Physics of Tsinghua and shows well frequency characteristic. On our high power test system, this load can operate stably at 20WM, 2µs, 10Hz.More patterns of S-band all-stainless-steel load with various number of slice or different size are being designed for different power levels and will be tested in Tsinghua University.

REFERENCE

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