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HIGH-POWER TEST OF A 12-CELL ACCELERATING STRUCTURE BUILD IN HALVES

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Abstract

An X-band 12 cell travelling-wave accelerating structure has been developed and high-power tested at Tsinghua University in China. This structure works at $2/3\,\pi$ at the frequency of 11.424 GHz. It is a 12-cell constant-impedance structure build in halves and was silver-brazed as a vacuum tight structure. The high power test was conducted at Tsinghua X-band high power test facility [1] with a 50-MW X-band klystron at a repetition rate to 40 Hz. The final input power was 51.23 MW with a 200 ns pulse width, which means an accelerating gradient of 88.58 MV/m was reached. This paper presents the high power test results including the gradient and breakdown history.

INTRUDUCTION

The Tsinghua X-band high power test facility was built for the study of novel accelerating structures and breakdown theorem. Stainless steel RF loads from CERN and Tsinghua and T24 [2] accelerating structure has been tested for the system commissioning and the output power reached 50 MW, 1.5 μs pulse length. We have the auto-conditioning system and pulse compressor [3] installed before the Half structure high power test. The maximum output power of pulse compressor was predicted to be 200 MW with the pulse length of 50 ns. The auto conditioning system will record the time, vacuum, power and breakdown status of each pulse. More accelerating structures will be tested on the test facility.

RF TEST OF THE HALF STRUCTURE

We had the half structure [4] tested as Figure 1. The RF test were conducted in air without cooling system. The four waveguide ports were connected to the R&S ZVA 40 vector net analyser for S parameters measurement and bead-pulling.

The measured working frequency at $2/3\,\pi$ of structure is 11.4295 GHz, 5.5 MHz higher than designing. The S11 and S21 are -35.98 dB and -0.942 dB and Q is 6700 at working frequency.

HIGH POWER TEST

The high power tests were conducted at Tsinghua X-band high power test facility. We first tested the T24 for the second time(have been tested in KEK before) as comparision, and then have the half structure tested. The auto-conditionning system were installed before the half structure test. We have the pulse compressor installed to reach a higher pulse at the end of the test.

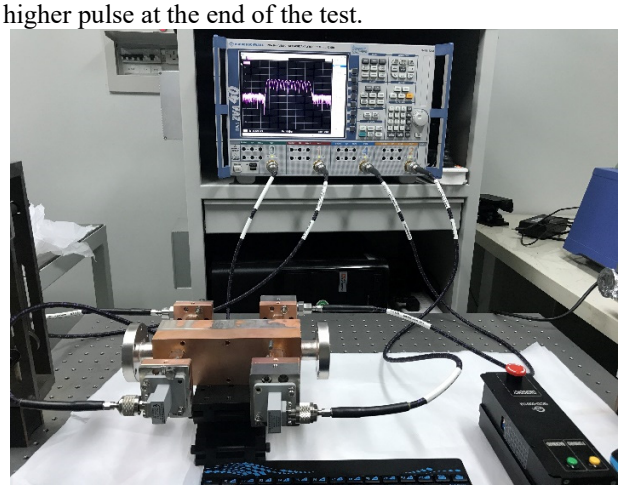

Figure 1: Half structure RF test.

The S curves and complex S11 of bead-pulling are shown in Figure 2 and Figure 3.

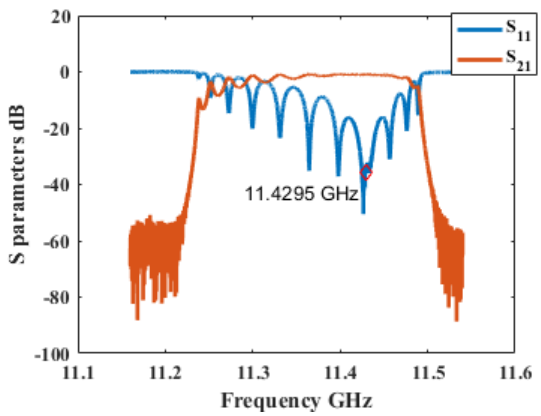

Figure 2: S11 and S21 from VNA.

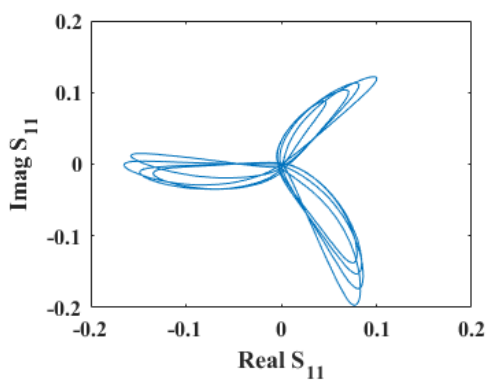

Figure 3: Complex S11 of bead-pulling.

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Tsinghua X-band High Power Test Facility

The layout of Tsinghua X-band high power test facility is in Figure 4. A CPI klystron amplifies the RF pulse up to 50 MW, 1.5μs and transfer them to shielding room by a 5 meters waveguide. The ScandiNova K400 modulator supplies the klystron with high voltage DC pulse lower than 420 kV.

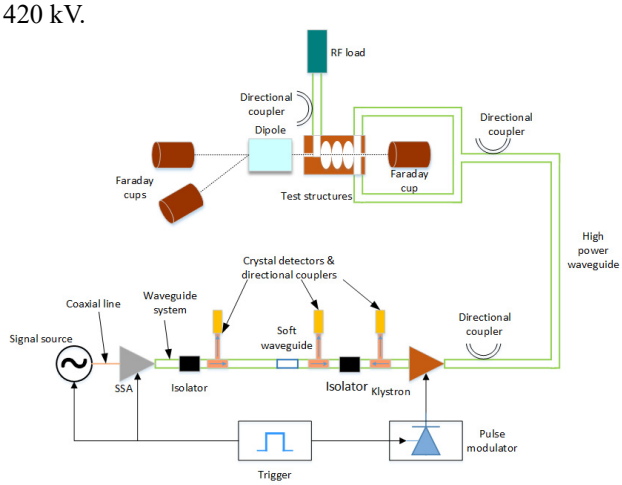

Figure 4: Tsinghua X-band high power test facility layout.

Two directional couplers at output port of klystron and input port of test structure measure the input, output and reflection power and waveform. The reflect power and signals of the two faraday cups worked as the criterion of breakdown. The pulse compressor installed recently in the shielding room just before the directional coupler close to test structure as shown in Fig. 5.

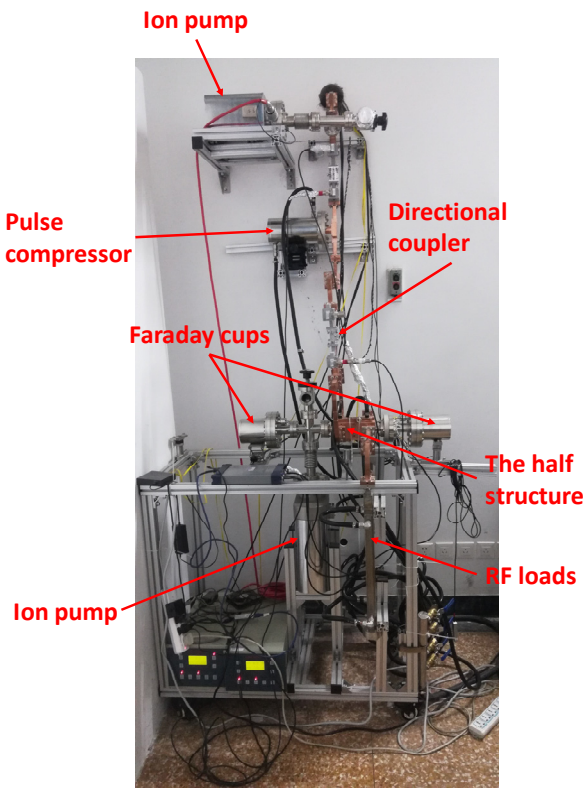

Figure 5: The half structure under test.

The RF power can be increased up to about 250 MW after power compressor. One or two RF loads are installed depends on the test structure.

We installed an electron window on the downstream pipe of the half structure to measure the dark current energy spectrum. The auto-conditioning system increases and decreases the power automatically and record the power level and breakdown events.

During the conditioning [5], the auto-condition system first increases the RF power until the target level and increase the pulse length by one step and decrease the output power. It will stop the conditioning for 10 seconds if a breakdown happened and then decrease the power level. The breakdown rete will be kept below $10^{-4}/pulse$ autamaticlly.

Half Structure High Power Test

The high power test of the half structure was conducted with the assistance of auto-conditioning system. The pulse compressor was not install in the first part of the test. Figure 6 shows the input and output waveform of the pulse compressor. We marked the maximum output power as the input power of half structure.

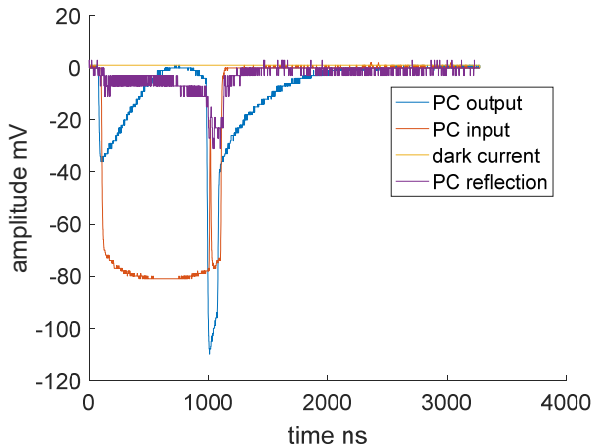

Figure 6: Pulse Compressor(PC) waveforms.

The conditioning history is shown in Figure 7. The maximum gradient power we reached during the conditioning is 88.58 MV/m at 70 ns pulse length. We can find from Fig. 6 that breakdown number first increased at the beginning of the condition. The second increasing started from 1.3×10^6 pulse because of the increasing of input power and pulse length. The installation of pulse compressor happened from pulse 1.65×10^6, which caused the drop of pulse length. The maximum power after pulse compressor cannot went higher than 51 MW as the high breakdown rate in the half structure. The average breakdown rate of the whole conditioning is $1.9 \times 10^{-5}/pulse$.

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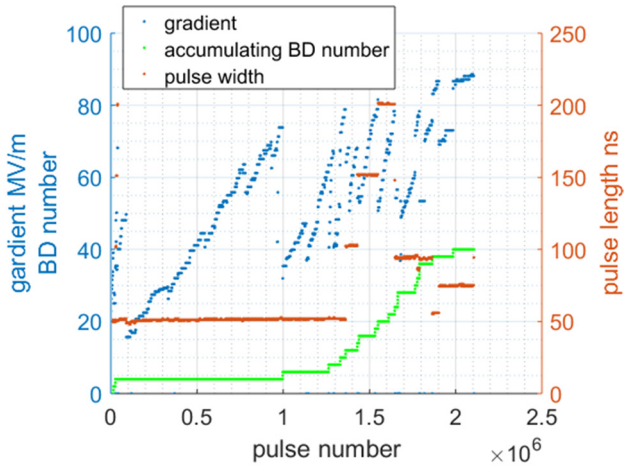

Figure 7: Half structure conditioning history.

The pulse length was kept to be 70 ns at the end of this test for breakdown rate measurement. There were totally 2.02×10^5 pulses measured with only 2 breakdowns. Further test is undergoing.

CONCLUSION

The gradient of the Half structure reached 80 MV/m at the pulse length of 200 ns and the maximum gradient is 88.58 MV/m at 70 ns pulse length. More pulses are needed for the lower error of breakdown rate measurement. The modulation of pulse compressor output waveform and installation of dipole is continuing.

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