THE MEASUREMENT SYSTEM OF THE ELECTRON GUN WITH DOUBLE-ANODE STRUCTURE*

F.L. Shang, L. Shang†, J. Li#,
NSRL, USTC, Hefei 230029, China

Abstract

The double-anode structure with an intermediate electrode has been proposed to overcome the strong space-charge force on the cathode and improve the transverse focusing, which makes the goal of high perveance and high compression ratio achieved. This gun plays a key role as the external injecting electron source of the independently-tunable-cells (ITC) RF gun. In order to understand the quality of the beam, a measurement system has been designed. The paper presents the measurement system and the result of the test.

INTRODUCTION

Terahertz wave, whose wavelength is between 1mm to 100um in the electromagnetic spectrum, has a wide range of potential applications. Compared to other terahertz sources, FEL is the best way to obtain maximum power output [1]. In order to meet the requirement of FEL for high-quality electron beam, a thermionic RF gun with two independently-tunable-cells (ICT) has been developed at the National Synchrotron Radiation laboratory for several years, of which the cells are power fed independently [2]. The ICT RF gun uses an external DC gun as the injector, and the performance of the ICT RF gun largely depend on the DC gun. In order to obtain beam with high perveance and high compression ratio, a double-anode structure is designed in the external DC gun [3]. It is shown in Fig. 1.

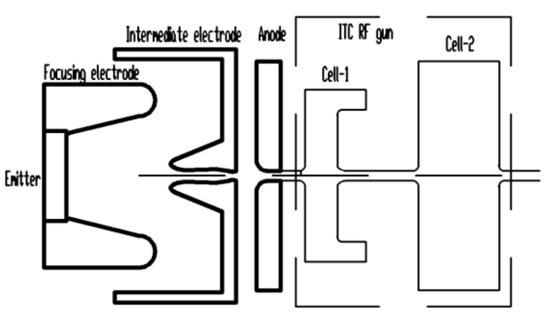

Figure 1: The double-anode structure.

Compared with the normal DC gun, the double structure gridded DC gun has added an intermediate electrode, which improves the transverse focusing and overcomes the strong space-charge force on the cathode, but makes the electrode structure compact and complex. The beam, which has the characteristics of low-energy and high-current, gets through the anode and then diverges rapidly. In order to exactly know the quality of the beam and the values of the current from the cathode and beam current lost at the electrodes, the improved beam current measurement system has been built.

THE BEAM CURRENT MEASUREMENT SYSTEM

The measurement system includes these parts: mechanical support, ceramic chamber, vacuum chamber, reflector, stepping motor and vacuum system. The YAG screen is placed in the vacuum chamber, with the stepping motor, the YAG screen can be moved close to the anode. The stepping motor is connected to the screen holder in the vacuum chamber by the bellow. By using the guide bar, the screen holder will always move at the axial line when it is driven close to the anode. The ceramic chamber was used to connect the gridded gun and the anode is fixed on the flange of the ceramic chamber. The measurement is shown in Fig. 2.

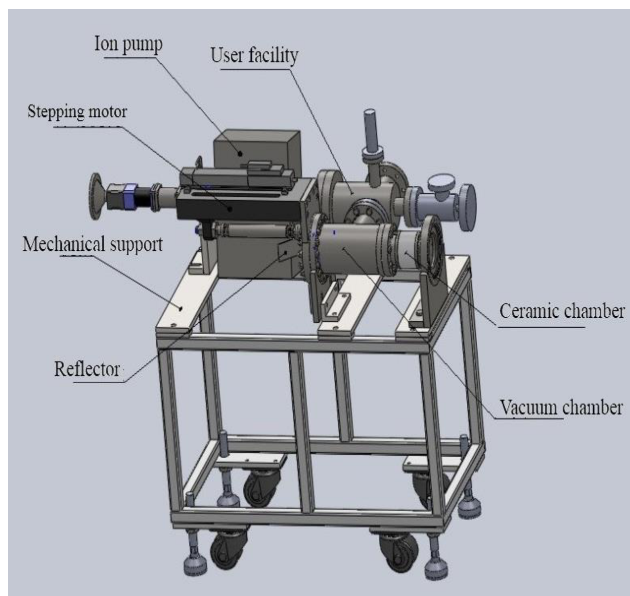

Figure 2: The facility of the measurement.

The Beam Spot Measurement

The fast beam current transformer (FCT) without shield has been covered outside of the ceramic chamber, and the wire has been used to connect the beam current chamber which has been separated by ceramic chamber. The YAG screen can be driven from the downstream vacuum chamber to the position close to the anode. Since the YAG screen is very thin, just 0.5mm thick, the screen is nearly transparent, the beam spot is collected by the reflector which is put after the inspection window. The schematic diagram is shown in Fig. 3.

* Work supported by NSFC No. 10875116 and 11175181
† lshang@ustc.edu.cn
# currently at HZB, Germany

ISBN 978-3-95450-147-2

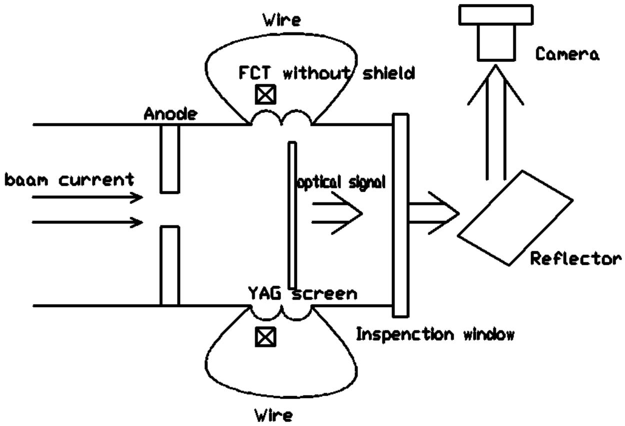

Figure 3: Schematic diagram of the electron-gun beam current and beam size measurement.

Measurement of the Lost Beam Current

Since the electrode structure is compact and complex, the high-voltage dc power supply may cause the breakdown in vacuum and creepage on the ceramic surface. In order to avoid these disadvantages, two pulsed power supplies are employed for the cathode and intermediate electrode. And the grid-controlled signal is superposed on the high-voltage pulsed signals. The pulsed power supplies not only can reduce the risk of breakdown and creepage, but also provides a convenience for the measure. The power supplies are shown in fig. 4.

In order to measure the lost beam current, two FCT and one current transformer (CT) were used in the power circuits, they were placed as the fig. 4 shown. The CT was used to detect the current of the cathode-gridded circuit, which was regarded as the beam lost at the grid. The FCT1 was placed at the negative high voltage power circuit, which was used to measure the output beam current of the cathode-grid assembly. The FCT3 was placed at the positive high voltage power circuit, which was used to detect the beam lost at the intermediate electrode. The FCT4 was used to detect the output beam current of anode. With these beam current monitors, the values of the current emitted from the cathode and beam current lost at the each electrodes are clearly collected, which gives a reference for gun tuning.

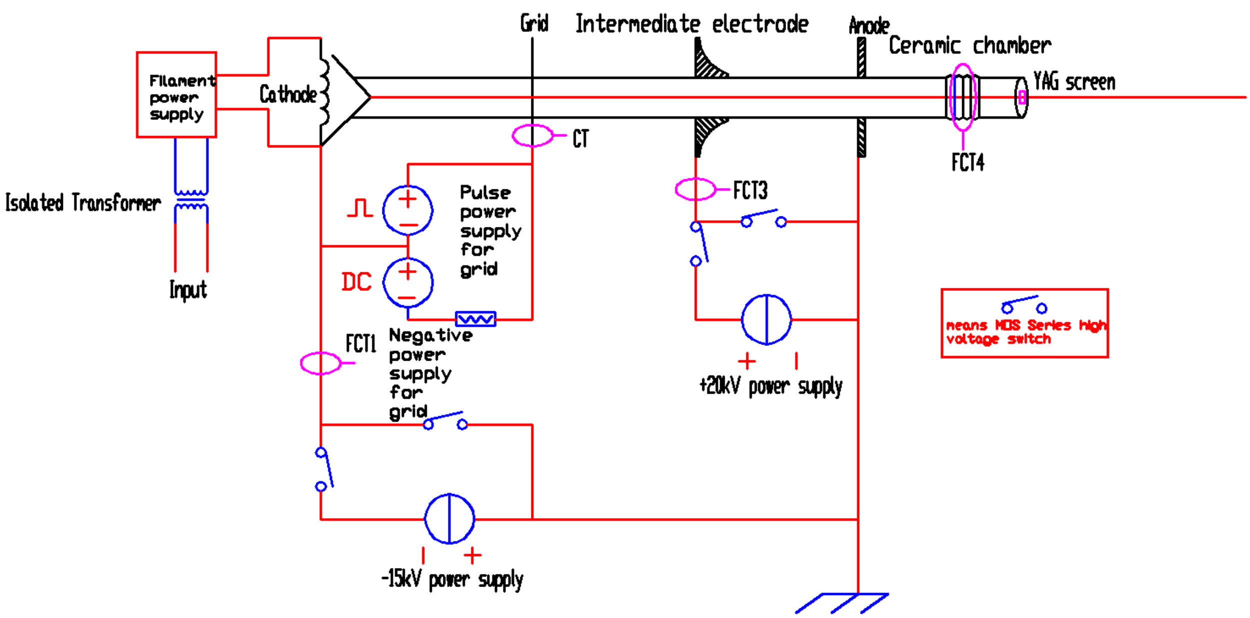

Figure 4: Schematic diagram of beam current measurement and pulse-power supply.

The Results of the Test

Given the cathode current 2.3A, the gridded pulse voltage 100V, the anode voltage -15kV, change the intermediate electrode's voltage, the values of the current emitted from the cathode and beam current lost at the electrodes were measured as the Fig. 5 shown.

At the same time, the beam spot is obtained by the camera, by reading the photo of the beam spot, the grey distribution could be drew, as the Fig. 6 shown. The width of the YAG screen corresponds to the distance between the crest in the grey distribution, so the beam spot is less than 2.1mm.

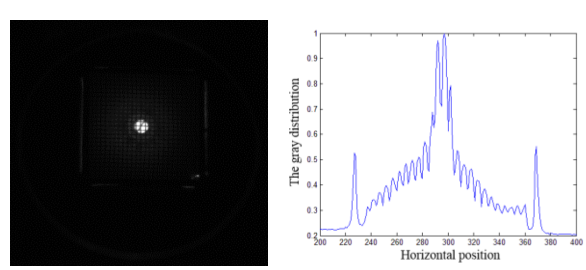

Figure 6: Diagram of beam spot and grey distribution.

ISBN 978-3-95450-147-2

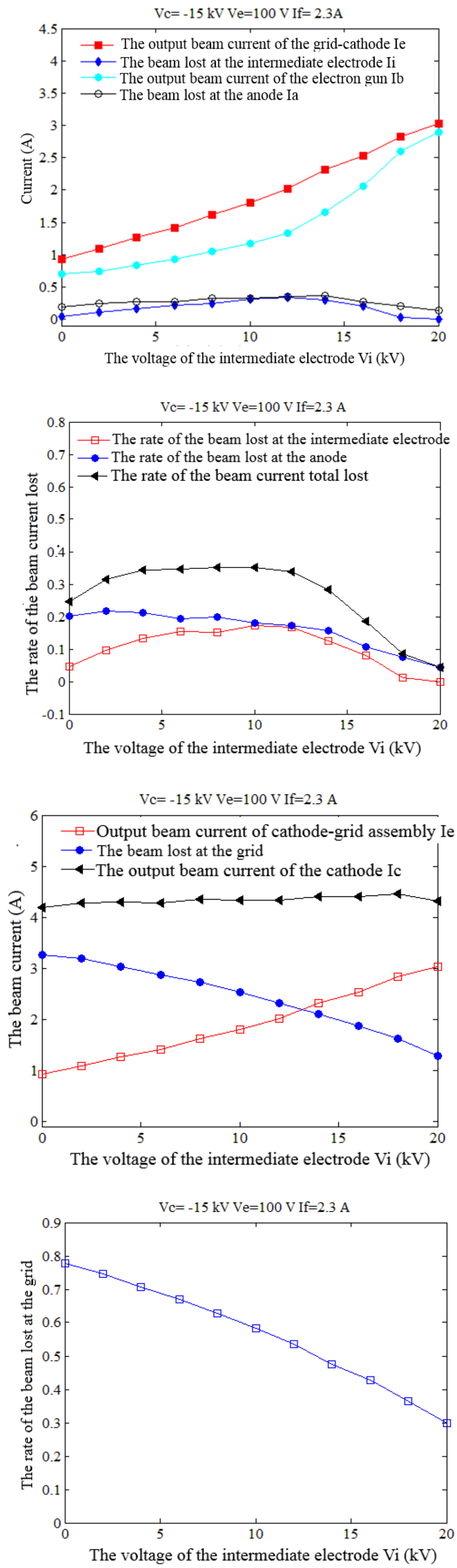

Figure 5: The results of the test.

CONCLUSION

The measurement system can measure the beam current at the each electrode. By analysing the measured data, the quality of the beam is clear. The data of the test indicates that adding the intermediate anode can reduce the beam current lost at the grid, increase the output beam current of the electron gun, and improve the transverse focusing. The simulated calculation agreed with the experimental results, so the requirements of the design objective were met. The electron gun with the double-anode scheme has been successfully used in the ICT-RF gun.

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