

THE PULSED ELECTRON ACCELERATOR FOR RADIATION TECHNOLOGIES

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Abstract

The design of pulsed electron accelerator for radiation technologies is considered in the report. The pulsed electron source consists from pulsed Marx high voltage generator, vacuum electron source with explosive emission cathode. The measurements system for beam parameters on the basis of PXI system with high-performance National Instruments components and LabVIEW is described.

INTRODUCTION

The radiation technologies include different directions for treatment of materials by electron beams, photons and X-rays. At last time the main focus of radiation technologies was made in the next:

- the modification of materials;
- the food irradiation;
- the sterilization.

The progress of development for pulsed electron accelerators is shown new ideas in this technique. The main principles of design for low energy electron accelerators for applications were considered in papers [1,2]. The main advantage of pulsed electron accelerators is the high efficiency for dissipation of energy for short time in irradiated materials.

This paper is considered a compact pulsed electron accelerator for radiation technologies.

STRUCTURE OF PULSED ELECTRON ACCELERATOR

The pulsed electron accelerator consists from electron source with vacuum chamber and pumping vacuum system and high voltages pulsed Marx generator see Fig. 1. The explosive emission cathodes on the basis of carbon fiber materials [3] and carbon nanotubes [4] are used in this vacuum diode. The two Marx generators with pulse duration 20 and 100 nsec are used for supply of electron source. The high voltage generators have synchronization with real-time system for dose measurements. The variation of gas pressure for gas sparks allows to have regulation of value of accelerating voltage in wide range. Induction elements for charging and discharging circuits in one Marx generator allow to increase repetition of pulses with flow gas to till 100 Hz without special requirements..

The vacuum chamber manufactures from stainless steel. The pressure of residual gas in vacuum chamber is 10^{-5} Torr. The high voltage insulator designed on the basis of new technology of plastic materials from INTECH Corporation. The nylon insulator with central metal electrode has good vacuum and electrical characteristics.

Additional vacuum chamber is used for irradiation of samples. This accelerator has additional thin Ti foil window for output electron beam from vacuum chamber to air.

The diagnostic for electron beam is included the current transformer (Rogowski Coils) and Faraday Cups with low induction current shunts. High resistive dividers are used for measurements of acceleration and charging voltage. The block-diagram for measurement system on basis of PXI-1025 is given on Fig. 2,3. The switch, scope and LabVIEW 6.1. from National Instruments were used for design of this system. This system allows to have measurements of stability beam current and accelerating voltage (kinetic energy of electrons) in real-time with following printed protocol. Other variant of measurements of this measurement system permits the measurements the charge of ions from cathode plasma. Last more important for detail turning of plasma cathode with explosive electron emission.

X-rays target [5] presents the structure from Al substrate and deposited layer (target) of material with high atomic number (Ta, W, Au). The thickness of target is 10 – 75 microns. The magnetron method deposition of large thickness of target coating (more 20 microns) has place on the surface of substrate with roughness. This construction of X-rays target allows to have clear X-rays beam without electrons.

MAIN PARAMETERS AND CHARACTERISTICS OF ACCELERATOR

The main parameters of electron accelerator are next:

1. Kinetic energy.....100 – 400 keV.
2. Beam current.....10 – 1000 A.
3. Beam pulse duration20 and 100 nsec.
4. Repetition.....0.01 - 100 Hz.

The optimal thickness L_{opt} of an irradiated product is determined by this distribution. The thickness of irradiated product is 0.05 – 20 mm for many materials with density 0.1 – 2.0 g/cc and kinetic energy of electrons 120 – 400 keV. The level of absorbed doses for materials with same thickness is about 50 – 200 kGy/pulse.

The dose distribution for this electron source is presented on Fig. 4. This dose distribution shows the high homogeneous of absorbed doses and high homogeneous of current density for electron beam.

CONCLUSION

The pulsed electron accelerator with considered parameters can be used for broad directions of radiation technologies.

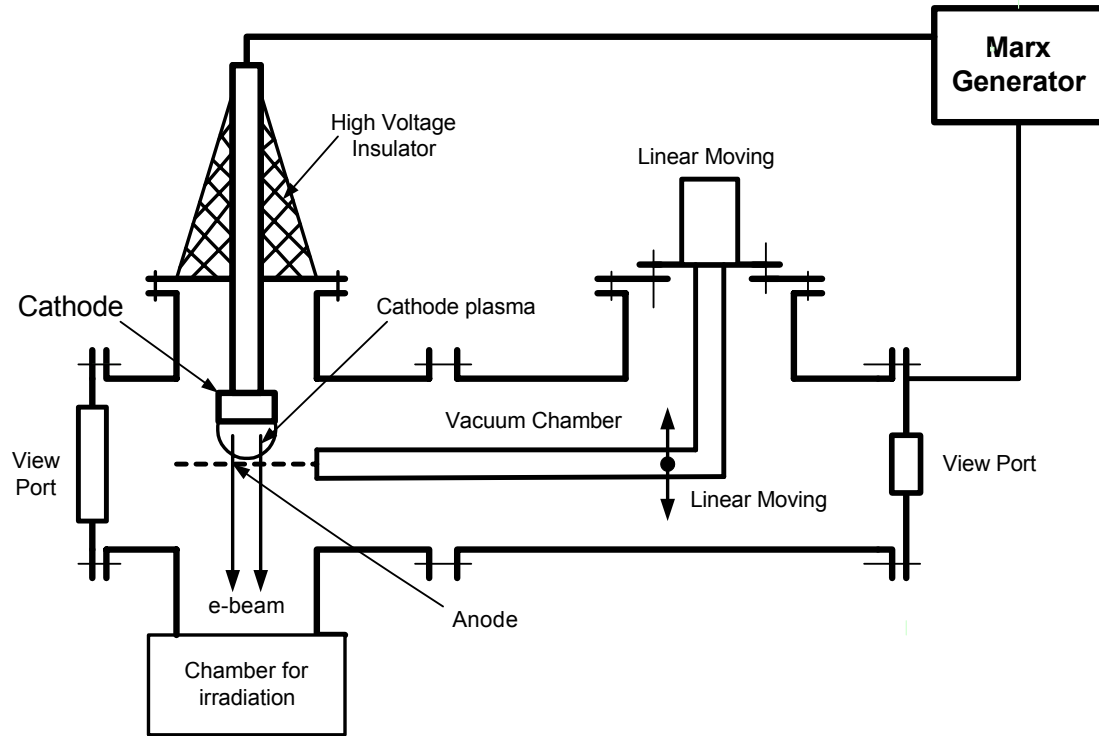


Figure 1: The structure of electron accelerator

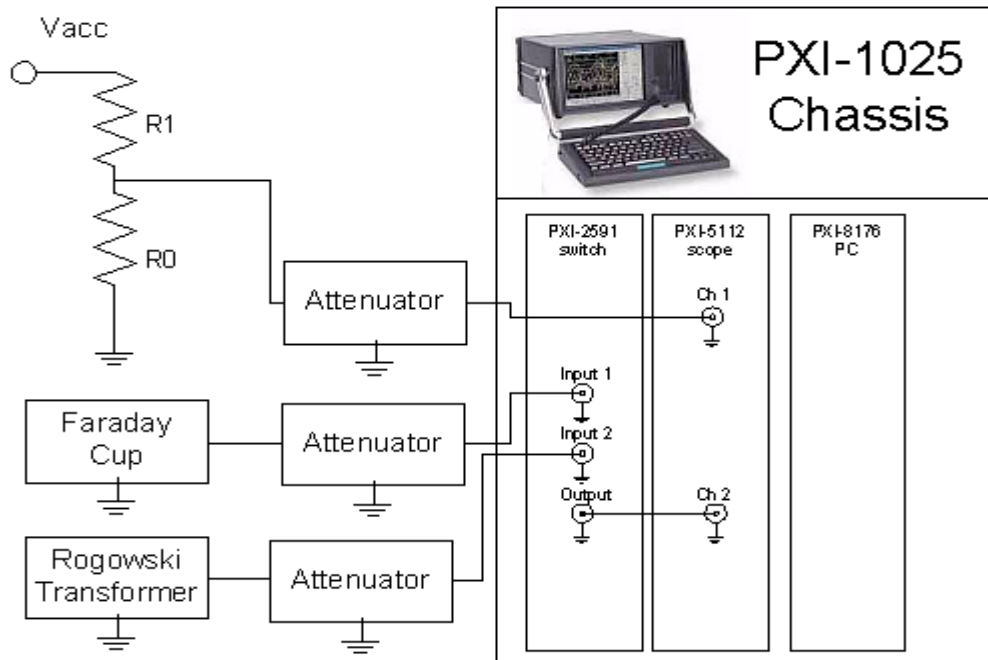


Figure 2: The block diagram for system of beam measurement.

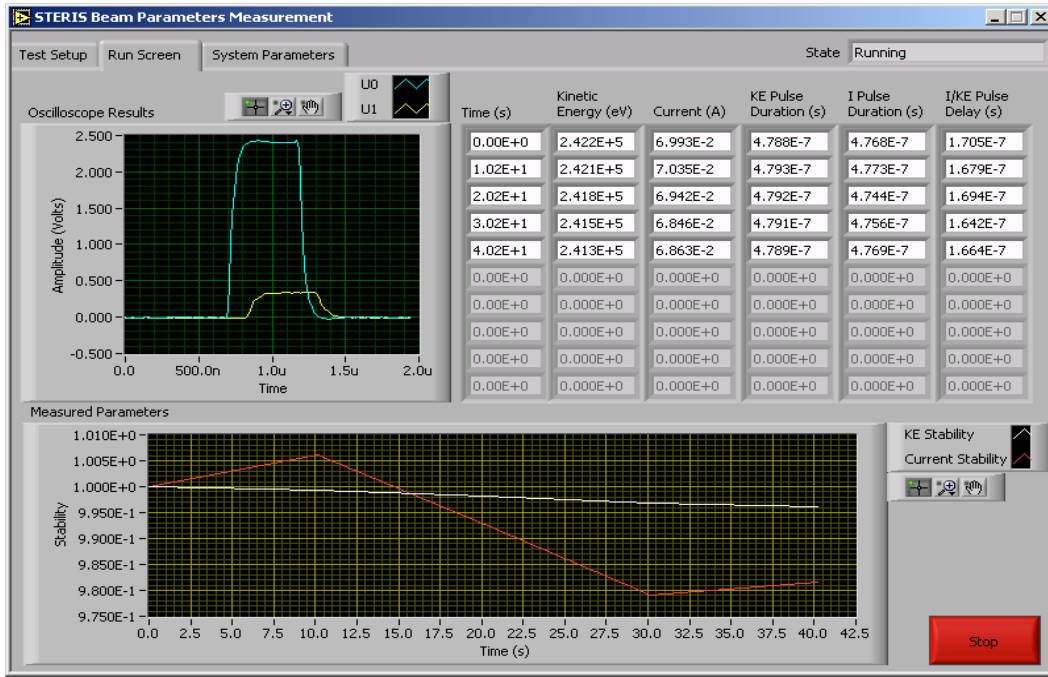
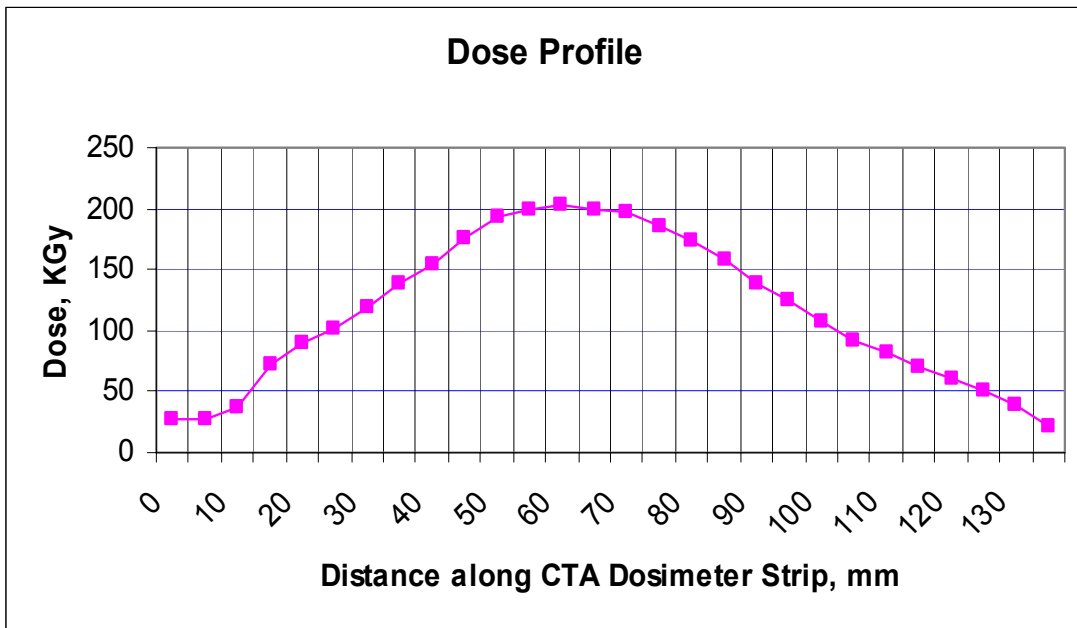


Figure 3: Monitoring Screen for measurements of current and voltage.



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