PERFORMANCES OF LAE 10 ACCELERATOR WITH A THREE ELECTRODE ELECTRON GUN

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Abstract

The electron accelerator type LAE 10 provides electron pulses suitable for pulse radiolysis experiments. The influence of electric electron gun parameters on the properties of the LAE 10 accelerator has been investigated. The relation between the pedestal charge to the total charge of the accelerator current pulse ratio and gun accelerating voltage amplitude has been evaluated. Nanosecond grid modulator of the accelerator gun generates 10 ns, 4 kV pulses. Pulse of electrons duration can be changed in range from 6 ns to 9 ns by adjustment of the grid bias voltage level.

1 INTRODUCTION

Electron accelerator LAE 10 has been constructed at Department of Radiation Chemistry and Technology, Institute of Nuclear Chemistry and Technology (INCT) in Warsaw [1-3]. This facility is dedicated to pulse radiolysis and related experiments in the field of radiation chemistry. The following accelerator parameters are the most interesting from point of view of experiments:

- the amplitude of the electron beam pulse;
- the duration of the accelerator electron beam pulse;
- the relation between the pedestal charge Q_p and the total charge Q_t of the accelerator pulse ratio.

The dose rate is defined by accelerator parameters. It is proportional to the duration and pulse current amplitude of accelerated electrons. Therefore, time shape and space shape of the pulse should be measured. The smaller value Q_p/Q_t parameter may cause a smaller error in radiolysis experiment results. The pulses which the pedestal charge is less than or equal to 0.1 of total charge can be accepted, but it might be better if pedestal charge Q_p was considerable smaller.

The measurements was performed for different parameters of the three electrodes electron gun. The control electrode (grid) of the gun consist of the main part with rotational symmetric and an additional element – "flat" mesh grid. The results has been compared with the results which has been obtained for the control electrode of the gun without mesh grid.

2 EXPERIMENTAL ARRANGEMENT

The measuring circuit consist of TDS 620 Tektronix digital oscilloscope (400 MHz band) and special designed Faradays cup [4]. The measurements of the pulse shapes between cathode and anode of the gun was realized at the same time (for selected accidents) with the assistance of the second channel of the TDS 620 oscilloscope. The high voltage pulse divider own construction (by ratio of transformation 1:1000) was applied. The divider was made with ceramic non-inductive disk resistors M001 HVR International LTD. The measurements of the pulse shapes between cathode and grid of the gun have been performed using the Tektronix probe P5100 and TDS620 oscilloscope. It could be realized only when anode modulator was switch off because the cathode and grid was on high potential (tens kilovolts) in relation to the ground if the modulator is in operation. The time–integrated distribution of the beam current density was determined using a transparent foil made of 0.25 mm thick PVC (polyvinyl chloride) placed at various planes perpendicular to the direction of the electron beam, especially in the target (cell) plane.

3 RESULTS

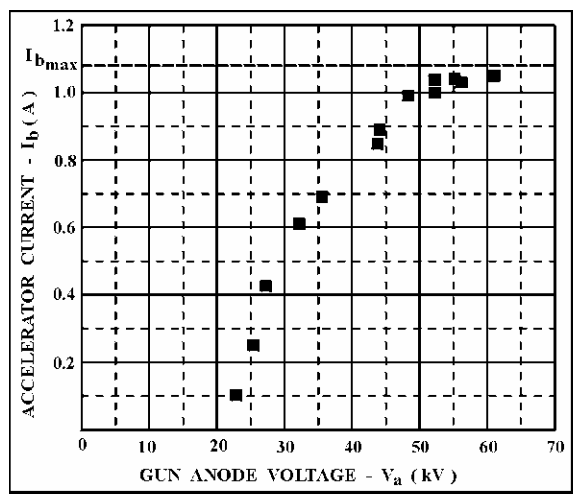

Figure 1: The relation between accelerator electron beam current amplitude and gun anode voltage.

Figure 1 shows the relation between the accelerator electron beam current amplitude and the gun accelerating voltage (gun anode voltage) amplitude V_a. The current amplitude increases with voltage amplitude and the curve is saturated when the voltage is about 52kV.

Accelerating structure (section) with nominal electron output energy 10 MeV can work with different efficiency. The efficiency depends on electron energy at the structure input. Electron energy at the input of the accelerating structure depends on the gun accelerating voltage V_a.

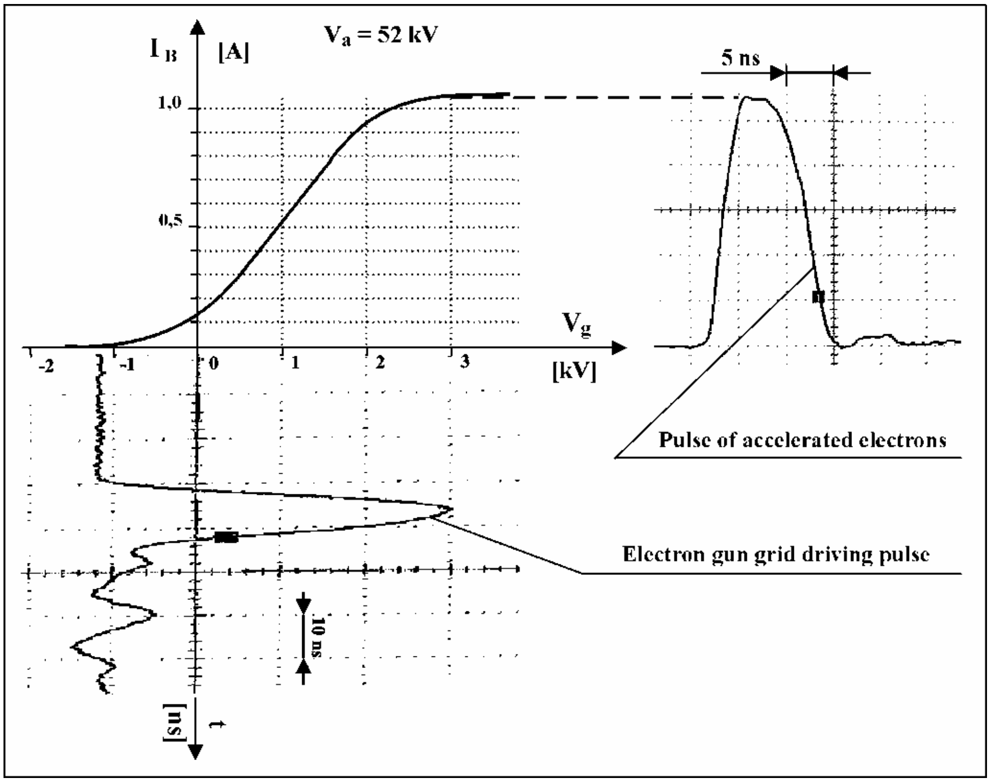

Figure 2: Characteristic features of the triode system of the accelerator electron gun.

Figure 2 illustrates characteristic features of the triode system of the accelerator electron gun. The pulse, between the cathode and grid, is rather triangle than rectangle. The pulse has inadvisable oscillations because of the not very perfectly gun matching to the nanosecond grid modulator. Pulse shape is little distorted by probe 5100. The probe transmit only 250 MHz frequency band [-3dB Bandwidth (System)]. The accelerator pulses can be obtained with different pedestal, amplitude and duration, depending on grid bias level. Figure 2 shows as well selected oscillogram of the pulse for grid bias – 1.25 kV.

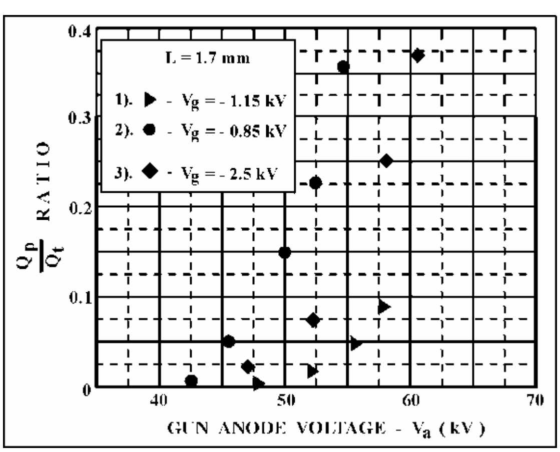

Figure 3: The relation between the pedestal charge to the total charge of the accelerator current pulse ratio and gun accelerating voltage amplitude.

Figure 3 shows the relation between the pedestal charge to the total charge of the accelerator current pulse ratio and gun accelerating voltage amplitude. The ratio of the charges increases with the voltage amplitude and reach 0.05 value for 56 kV (first curve for V_g = - 1.15 kV) and 46 kV (second curve for V_g = - 0.85 kV). Such a relation for the gun without mesh grid is shown as well (third experimental points for V_g = - 2.5 kV).

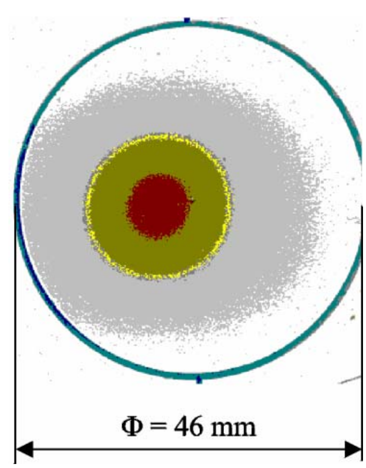

Figure 4: The trace of the accelerator electron beam in the target plane for 7000 pulses

Figure 4 shows the trace of the accelerator electron beam in the target plane. It can be noticed, that the distribution of the electron beam current density be able uniformity in the target plane, because target dimension is less than 3 mm.

4 CONCLUSION

In conclusion we can state that electron pulses with current amplitude congenial to the maximal possible value and with very small pedestal charge (for example $Q_p \leq 0.01\ Q_t$) can be obtained only for the gun with mesh grid.

The electron accelerator type LAE 10 provides electron pulses suitable for pulse radiolysis experiments. The nanosecond grid modulator of the accelerator gun generates 10 ns, 4 kV pulses but the electron pulse duration can be changed in range from 6 ns to 9 ns by adjustment grid bias voltage level.

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