14Mev ELECTRON RADIATION PROCESSING ACCELERATOR AND ITS APPLICATIONS

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Abstract

14Mev electron linear accelerator at Institute of Atomic Energy(IAE) has been reformed to a radiation processing accelerator with a scanner and a 90° bending magnet. This paper describes chracteristics and applications of the accelerator. The average beam power is greater than 0.4Kw, dose rate is about 1MR/min, available radiation area is 600mm times 400mm, ununiformity of scanning is less than 10%. At present, we try to irridiate gemstone to change their colour but it is in beginning stage.

Introduction

14Mev linear electron accelerator was designed and manufactured for the purpose of building a 100Mev high-beam current and narrow-pulse length electron linear accelerator. This small accelerator was put into operation by the end of 1980 and its main parameters are listed in table 1. Because of financial problems, The program of 100 Mev accelerator was postponed. So we decided to reform this small accelerator to a radiation processing one(Fig. 1). Because dose rate of electron is proportional to the average beam power, so if we want to get higher average beam power, we must increase the repetition rate of pulses and pulse length. In order to do so, we increase pulse length from 10ns to 2μs, increase the repetition rate from 50pps to 300pps.

Main modifications

In order to increase the average beam power and conduct radiation processing, main modifications were taken:

1, Improving the electron gun trigger modulator so as to let the gun work in two modes, long pulse length(2μs) and short pulse length(10ns).

2, Original modulator for the high power klystron is no use, because the pulse length is too short, so we redesigned new modulator with the pulse length of 4.2μs(FWHM). The parameters of the modulator are listed in table 2.

3, In order to increase the beam current and stability of the accelerator, we designrd new electron gun with the scandate dispenser cathode. The testing results of the gun are given in table 3.

4, For the sake of puting the samples conveniently during radiation, 90° bending magnet was designed which changes beam line from horizontal direction to perpendicular direction.

5, In order to scan the beam, we designed and manufactured a magnetic scanner which scan the beam about 600mm wide.

6, During radiation processing, puting the samples on a moving car which can move forth and back automaticly at the speed from 10mm/s to 100mm/s.

7, For the sake of measuring absorption dose rate, dosimeter of calorimeter was designed according to the formula:

$$D = \frac{\Delta E}{m} = \frac{\Delta T.C.m}{m} \qquad (1)$$

Where D- dose rate; E-energy absorbded by material to be irridiated; m- mass of the material; C-specific heat; T- temperature increase after irridiation. If several material are irridiated, formula (1) becomes

$$D = \frac{\Delta T.\sum(C_i.m_i)}{\sum m_i} \qquad (2)$$

Dosimeters made of aluminum and graphite was designed and tested on the accelerator. Results are very satisfactory.

8, For the purpose of beam diagnosis, beam current transformer(BCT) and Farad cup were designed and pulse beam current was measured using these instruments.

performance of the accelerator

Energy of electron is greater than	13Mev
pulse length	2μs
Repetition rate of pulses	300pps
Average beam power(after bending and scaning) is greater than	0.4Kw
Available radiation area	600mm x 400mm
Ununiformity of scaning is less than	± 10%
Dose rate is about	1MR/min

Applications

In order to reduce the minority carrier lifetime, turn-off time of the silicon controlled rectifiers (SCR), usually gold or platnium diffusion method was used. But this technology is very complicated and costly. Recently radiation method is developing rapidly, so we try to irridiate SCR using high energy electron beam. Because

$$1/\tau = 1/\tau_0 + K\Phi \qquad (3)$$

Where τ_0, τ are the minority carrier lifetime before and after irridiation respectively. Φ is electron flux(e^-/cm^2), K is damage coefficient[1].

Based on our experience, we found that using 12 Mev electrons to irridiate SCR has the best results. If energy of electron is too low(below 2Mev), K is too small. If energy of electron is greater than 12 Mev, K does not increase too much, but may induce radioactivity[2] due to (γ,n) reaction.

From 1987, more than ten thousand pieces of SCR are irridiated using electron flux from 3 x10^{12} e^-/cm^2 to 6 x10^{13} e^-/cm^2 for institutions and factories. After irridiation, the minority carrier lifetime and turn-off time can be sharply reduced, for example, from 50μs to 2μs(Fig. 3). And performance of SCR is very stable, rate of end product is increasing. Now many chinese factories and institutions producing SCR accepted this new technology and discarded traditional diffusion gold and platnium technology.

At present, we try to irridiate gemstone to change their colour. Topaz was irridiated and light blue colour have been achieved. But this research is in the beginning stage and it is a long way to go.

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References

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Table 1,Main parameters of 14Mev linac

Energy of electron	14 Mev
Pulse length	10-50ns
Operating frequency	2856Mhz
Repetition rate	50 pps
Pulse current(in peak)	3 A

Table 2, Parameters of Modulator

Parameters	design	Achieve
output pulse voltage(in peak)	220Kv	220Kv
Perveance(μp)	1.6	
Leading edge	0.7μs	0.8μs
Trailing edge	1.3μs	1.6μs
Pulse length(FWHM)	4μs	4.2μs
Repetition rate	300 pps	306 pps

Table 3, Parameters of the electron gun with scandate dispenser cathode

Trigger pulse(V)	800	900	1000
Beam current (A)	2	4	6
Bias(V)	-1000		
High voltage(KV)	80		

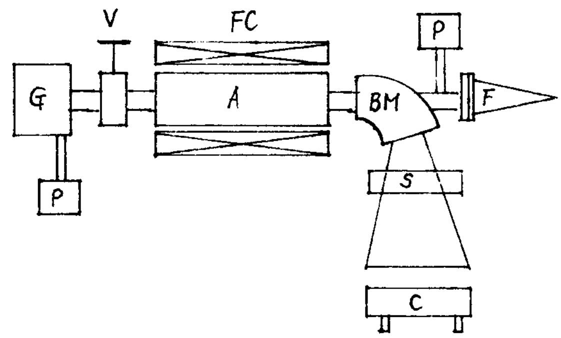

Fig.1 Schematic diagram of radiation processing linac

G-electron gun; P -ion pump; V -vacuum valve; FC -focusing coils; A -prebunchers,buncher,and accelerationg section;BM -bending magnet; S -scanner; C -moving car; F -Farad cup.

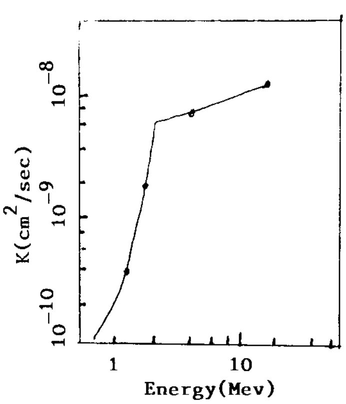

Fig.2 Dependence of K and energy

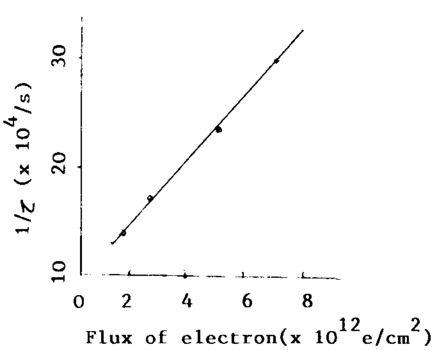

Fig. 3 Dependence of τ and flux ϕ