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STUDY OF AN ELECTRON BEAM PUMPED AR-XE LASER

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Abstract

The study of electron pumped Ar-Xe laser was started. The scattering simulation of a laser medium and an electron within the laser tube which impressed the magnetic field of 0.4T using the Monte Carlo method was carried out to optimization of laser efficiency. The design and manufacture of lambda type laser tube equipment was performed using the simulation result.

1.INTRODUCTION

Since, as for Ar–Xe laser, high intensity and an efficient laser oscillation are expected in a 1.73 to 3.65 μ m the near infrared wavelengths. So by the present age, many study has been done with the various pumping systems, electric discharge, electron beam, electron beam sustained discharge, UV-preionized discharge, X-ray preionized discharge, and nuclear pumping. In this study, in order to aim at optimization of the laser efficiency by electronic beam pumping, the Monte Carlo technique was used to carry out the simulation of the multiple scattering with electron beam and laser medium in laser tube. Now, design and manufacture of the Lambda type laser tube equipment was carried out using the simulation result, and the experiment was started.

2. ENERGY LOSS OF THE ELECTRON BEAM IN A LASER MEDIUM

The high energy electron beam in laser medium loses energy gradually, deposit energy to a composition atom and ionization or excitation by repeating an inelastic collision. When considering this energy deposit process, stopping power is important. In this study, the electron beam maximum kinetic energy is 200keV, so the energy loss by bremsstrahlung can be disregarded, and include relaticistic effect, it can be presented by the Bethe formula.[1)]

$$\frac{dE}{dx} = -\frac{2\pi e^4 N_a \rho Z}{m_0 c^2 \beta^2 A}\left[\ln\left\{\frac{T^2(T+2)}{2\left(\frac{I}{m_0 c^2}\right)^2}\right\} + 1 - \beta^2 + \frac{\frac{T^2}{8} - (2T+1)\ln 2}{(T+1)^2}\right]$$

where N_a is the Avogadro number, ρ is the density, Z is the atomic number, T is the kinetic energy of electron beam, A is the atomic weight, and I is the ionization potential,and given by the following formula

$$I = Z\left(9.76 + 58.8Z^{-1.19}\right) \qquad Z \geq 13$$

3. ELECTRON ORBIT IN THE MAGNETIC FIELD

The electron beam in a laser medium is spreaded by multiple scattering, and excitation of a laser medium become uneven spatially. Since the quality of a laser beam deteriorates as a result, it is necessary to control a spread by using an external magnetic field. It drifts along with a line of magnetic force, an electron receiving Lorentz force by impressing an external magnetic field, and carrying out circular motion in a Larmor radius. If an external magnetic field is strengthened, since a Larmor radius becomes small, it can control a spread more by scattering. In this study, the magnetic field of 0.4T was used with the solenoid coil so that an electron beam might be drifted along with axis of a laser tube. Moreover, the magnetic field of 0.1T was used to deflect.(Fig.1)

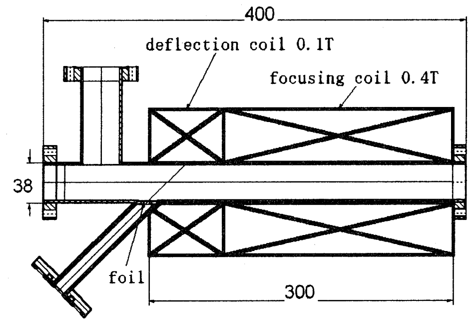

Fig.1 Layout of laser tube and solenoid coils

4.THE MONTE CARLO TECHNIQE

The Monte Carlo technique is the general term of a numerical computation method which used the random number. The details of the Monte Carlo simulation, carrying out incidence of the electron beam into a material is writen out reference 2) and reference 3).In this study, we used reference 3) continuous energy loss type program :type (A).

5.RESULTS

Simulation results of an electron beam 200keV pentrate the kapton foil with thickness of 25 μm, and inject into laser tube containg Ar 1atm, changing length of deflection coil to 1cm, 6cm, and 12cm and magnetic field intensity on the main axis is shown in Fig.2, Fig3, and Fig4. Consequently, the length of a deflection coil is set to 6cm, it turns out that an electron beam spreads most uniformly within a laser tube.

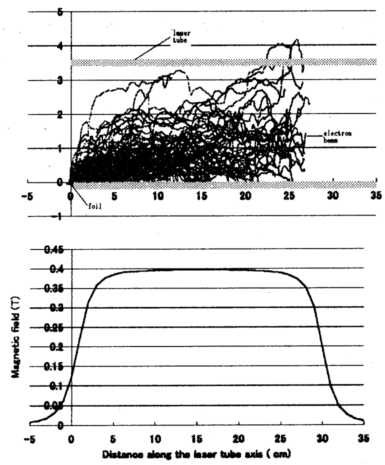

Fig2 Deflection coil 1cm

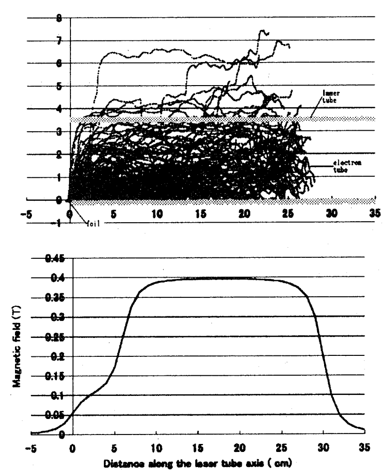

Fig3 Deflection coil 6cm

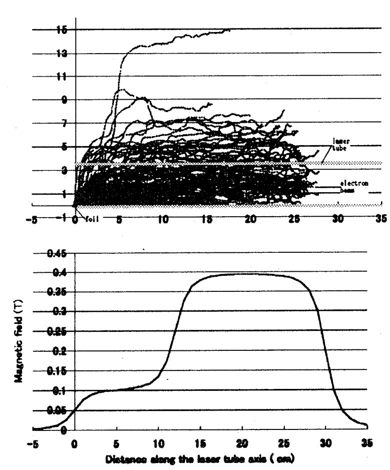

Fig4 Deflection coil 12cm

5.EXPERIMENTAL SETUP

The whole equipment setup is shown in Fig5. An electron gun and a turbo pump are on the mount insulated with four insulated insulators, and the high voltage are applied by the high voltage power supply to 200kV. The electron gun is grided electron gun and the material of cathode is BeO. The electron beam is accelerated with a 200kV acceleration tube, and penetrate a circular kapton foil with a diameter of 5mm thickness of 25 μ m. Then the electron beam is deflected 45 degrees with a deflection coil, and is injected into a laser medium. The length and the diameter of inner of a laser tube is 40cm and 34mm, and the vacuum is measured with a Baratron. A laser resonator consists of all the reflective mirrors of a golden coating plane mirror, and the plane mirror of 99.5% of the reflectance. Laser is measured by germanium photo-diode.

6. CONCLUSION AND FUTURE PLAN

As a result of changing the length of a diflection coil and calculating, the length of a deflection coil is 6cm, it turns out that an electron beam spreads uniformly within a laser tube most. Design and manufacture of equipment was carried out based on this simulation result. After conducting a test experiment with the electron beam of 50keV first as a future schedule using the manufactured equipment, the energy of an electron beam is raised to 200keV.

7.REFERENCES

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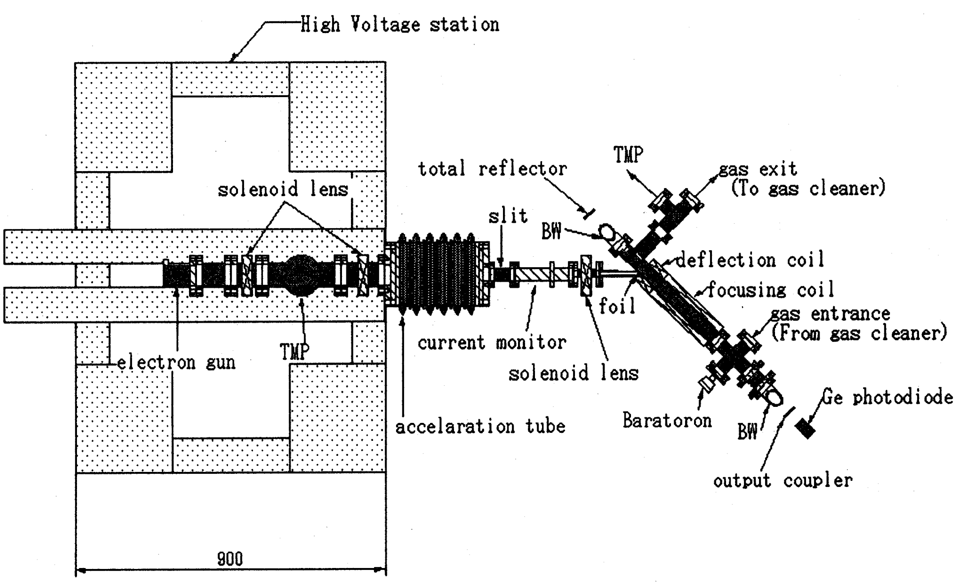

Fig5 Schematic of the experimental setup