STUDY OF RADIATING PLASMA GENERATED IN A GAS DISCHARGE TUBE OF COPPER VAPOR LASER

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ABSTRACT

A high power copper vapor laser (CVL) utilizes strong electric field with short rise time and duration to provide sufficiently high electron energy to excite copper atoms and breakdown to occur. The discharge in the laser tube after breakdown generates high density plasma in the copper vapor. The resulting plasma current produces laser beam. The discharge phenomenon of a CVL was briefly discussed in the paper. The plasma driven at a certain frequency by an electrical pulse has stochastic noise that depends upon the collision rate in the plasma. This noise can affect the electromagnetic environment. The plasma noise can sometimes produce significant amount of electromagnetic emissions and damage the sensitive equipment in the vicinity. In this paper the noise radiating plasma is considered to be as a dipole radiator. The radiated power from the plasma noise was derived using continuity of charge equation and plasma momentum equation for electron motion. The net radiated power from the plasma was found as a function of plasma frequency, plasma collision frequency and plasma dimensions. The results in this paper show that the peak frequency radiated from the plasma noise can induce electromagnetic interference (EMI) in the nearby sensitive equipment. The impedance of the dipole radiator was derived from the relation of magnetic and electric fields. In cylindrical coordinates, the fields are computed by solving the magnetic vector potential satisfying the Helmholtz equation in the plasma. The solutions are in terms of Bessel functions, where the argument depends upon the plasma frequency, which in turn depends upon the density of ionized electrons. This means that the plasma impedance can be varied to reduce electromagnetic emissions. The radiation resistance of the plasma is calculated from the net radiated power of the plasma noise which in turn is a function of plasma density, plasma frequency, plasma collision rate, and plasma dimensions. Hence the radiation efficiency of the plasma can be varied by varying the plasma parameters. Plasma EMI noise from the discharge tube of copper vapor laser is of direct significance for the EMC community since it can damage the nearby sensitive electronic equipment. The paper concludes with suggestions to reduce the EMI from plasma. The maximum EMI occurs when the interfering frequency matches the plasma frequency. Hence by altering the plasma frequency by adjusting the amount of ionization in the plasma, EMI radiation from the plasma can be reduce significantly. In addition, the laser discharge is a load whose impedance changes rapidly as the discharge develops. This cause impedance mismatching between the plasma and the connecting feed lines. This mismatching will reduce the efficiency of the radiating plasma, which in result reduce the EMI in the surrounding equipment.