L.4: Development of 110 W Copper HyBrID laser

A Copper HyBrID (Hydrogen Bromide In Discharge) laser delivering an average output power of 110 W at 16 kHz pulse repetition rate has been developed in Laser System Engineering Division of RRCAT. Copper HyBrID laser is a low temperature (500-550 ^{0}C), high pulse repetition rate (15-20 kHz), short start up time (10-15 minutes) and high efficiency (1.5-3%) copper vapour laser (CVL) variant. Due to lower working temperature, a Copper HyBrID laser is compact, light weight and air cooled device even at high average power in contrast to higher temperature (1500-1600 ^{0}C), water cooled CVL versions with larger mass and larger start up times (45-60 minutes).

Fig.L.4.1 shows the photograph of developed 110 W Copper HyBrID laser. The laser was based on an air cooled fused silica discharge tube of bore diameter 6 cm and length 200 cm. It contained copper metal pieces at regular interval of ~10 cm. The active medium was vacuum sealed by pair of fused silica windows suitably mounted on water cooled metal electrodes. Indigenously developed Neon and HBr gas mixing/monitoring system was used to inject a controlled quantity of gas mixture directly into the discharge tube. In-situ reaction of flowing HBr gas and copper pellets produced CuBr molecules which subsequently dissociate by electron impact to produce copper atoms as the lasing species.

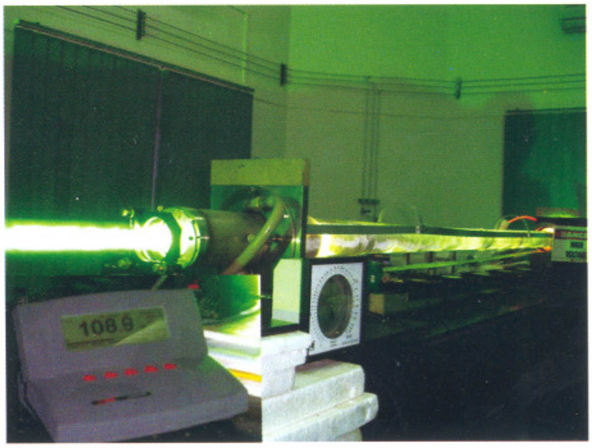

Fig.L.4.1 A 110 W Copper HyBrID laser in operation

The active medium was excited by IGBT switch based high voltage pulsed power supply operating at 16 kHz repetition rate. It contained three stages of magnetic pulse compression (MPC) circuits in cascade. The storage and peaking capacitors were 1.98 μF and 1.3 nF respectively. Three aluminium strips placed coaxially all along the discharge tube served as low inductance current return. The optical resonator contained a high reflecting plane mirror (R >99%) and an uncoated fused silica blank (R~7%).

Fig. L.4.2 shows the variation of laser average output power and laser tube efficiency vs. electrical input power deposited at the laser head. The deposited electrical power was estimated from the recorded discharge voltage and current waveforms. The laser power increased monotonically to 110 W as the deposited electrical input power is increased to a maximum value of ~5 kW (Fig. L.4.2). No saturation in laser output power with respect to deposited electrical input power is observed. This shows that still higher laser power can be obtained from the same tube. The laser tube efficiency dropped from 2.9% to 2.2% as laser power increased from 70 W to 110 W. At maximum laser power level, the green (510 nm) and yellow (578 nm) components were 70 W and 40 W respectively. The laser pulse width (FWHM) was ~50 ns. At 110 W power level, HBr concentration was ~6% of total gas pressure of 35 mbar. The neon gas flow rate was ~6 lit.atm./hr. The peak laser head voltage and current were ~23 kV and ~360 A. The current pulse rise time was ~75 ns.

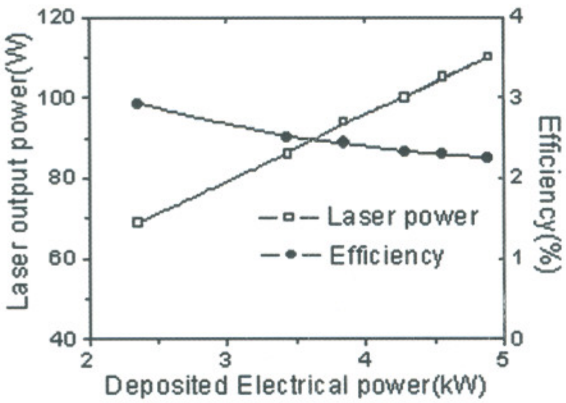

Fig. L.4.2 Laser average power and tube efficiency vs deposited electrical power

In conclusion, a Copper HyBrID laser of 110W power with 2.2% tube efficiency is developed. Higher efficiency of 2.9% is observed at 70 W power level. This is the highest performance achieved so far in RRCAT from a single CVL. Further scaling of laser power is expected by improving coupling of electrical power to the laser tube.

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