L.1 Diode-end-pumped $Nd:YVO_4$ laser marker system

Laser marking is a non-contact, permanent and indelible marking process. It is highly flexible compared to any other marking process. It can mark alphanumeric, 2D matrix codes, bar codes, logos, serial numbers and any pictures and images. Solid State Laser Division of RRCAT has developed a compact laser marker system using a Q-switched $Nd:YVO_4$ laser, in collaboration with the Laser Electronics Support Section of RRCAT. The maximum average and peak power is 5 W and 40 kW respectively. The scanning of the laser beam has been done by galvanometric x-y scan mirror assembly with a flat field objective of 163 mm focal length having marking field of 110x110 mm^2. The focussed spot size is around 50 μm and the marking speed close to 2.5 m/s can be achieved. The pulse parameter of this laser is ideal for ablation marking, and precipitation marking such as surface etching and surface annealing.

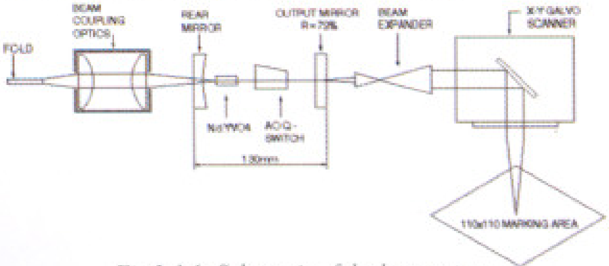

Fig.L.1.1: Schematic of the laser set up.

The system consists of an acousto-optically Q-switched laser and control electronics. The laser gain medium is a rectangular $Nd:YVO_4$ crystal doped with 0.5% Nd (atomic). The pump source is an 808 nm, 30 W fiber coupled laser operating at 25^0C. The pump beam is collimated and focussed by two plano-convex lenses on the crystal to a spot size ~ 400 μm. The resonator is formed by high reflecting rear mirror and 80% plane output coupler. The cavity length is 130 mm. Fig.L.1.1 shows the schematic of the laser set-up. The active Q-switching is accomplished by a high efficiency acousto-optic Q-switch operating at a carrier frequency of 41 MHz. The maximum diffraction efficiency produced by the Q-switch is > 70% for the RF power of 5 W. Such high performance Q-switches are essential for laser system with high gain crystal like $Nd:YVO_4$. For the extraction of maximum power in TEM_{00} mode, the ratio of the cavity spot size to pump spot size is set to be 0.8. An 8x beam expander was used to reduce the divergence of the beam before the scanner. The typical repetition range for marking application varies from 15 kHz to 40 kHz depending upon the material to be marked.

The control electronics consists of a micro-controller based control module interfaced to PC through RS-232 serial port. The control module has an 'Application Specific Integrated Circuit' (ASIC) based interface to XY scanning head. It also controls the laser On/Off while marking through the acousto-optic Q-switch. A Labview based drawing editor is developed to create a combination of text, bitmap images, geometrical shapes etc. for marking. The editor is specially designed to map the screen drawing pad area to the marker co-ordinate system. It visually indicates the graphic cursor position directly in the marker co-ordinates for editing. The editor provides an intuitive user friendly GUI with horizontal and vertical scales along the drawing pad. All the graphic editing features such as object selection, moving within the drawing area, scaling and MS-Windows™ supported text, fonts, styles, sizes, etc, are available for the user. The editor accepts all the standard image file formats e.g. BMP, TIFF, JPG, etc and internally converts them to bi-level images after suitable image processing. The user can save the drawing for later use in proprietary marker file format.

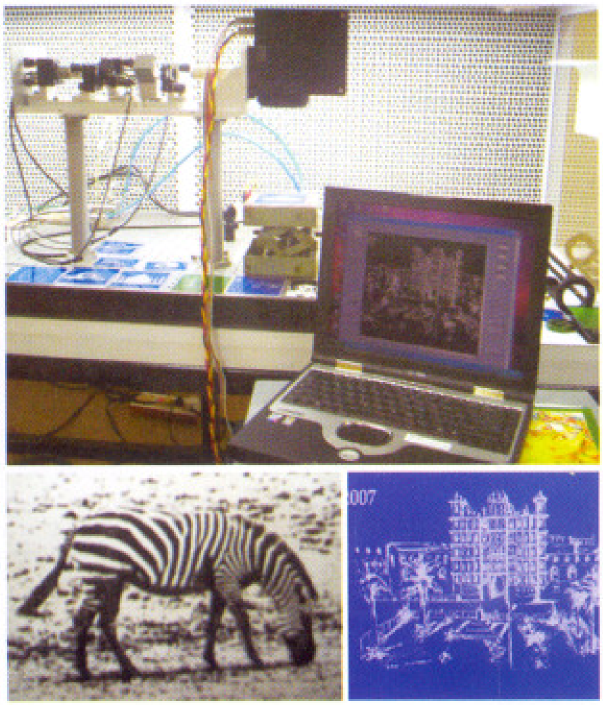

Fig.L.1.2: Photograph of the system and some of the marked samples.

High quality pictures were marked on anodized Al-plates using raster scanning technique. Fig.L.1.2 shows some of the marked samples. In order to make this a compact and portable system, several improvements are being carried out. The overall size and power consumption of the system is around 230 mm x 260 mm x 485 mm and 300 W respectively.

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