L.5: Laser micromachining milling process

Laser micromachining (LMM) finds several applications in making very fine holes and slits of few 10's of microns, masks for photo lithography, micro channels for cooling applications, and other precision jobs like micro tooling via laser milling etc. Laser milling is new method of machining process to achieve high performance and longer life components especially in the field of micro tool manufacturing. There are several advantages over conventional machining. One of the major advantage is that this process is non-contact hence no stress is applied on the job. This virtually eliminates delicate job fixturing and any deformation issues. A Diode side pumped Nd:YAG laser of 18 W average power @15 kHz with M2 value 3 was designed and developed at SSLD for micro-machining application. Laser can be operated from 5 kHz to 35 kHz repetition rate. Temporal pulse width varies from 140 ns at 5 kHz to 500 ns at 35 KHz. Pump housing was described elsewhere in our newsletter article [1]. 30 W pump diodes were used to pump the active medium, there were 3 diode stacks with each stack of 5 diodes each. Resonator is of convex concave type with 2.5 m radius of curvature (ROC) mirror as rear mirror and output coupler mirror of 5m ROC and 90% reflectivity, with overall length of the resonator being ~85 cm. 2D and 3D spatial profile of the laser beam at 18W &15 kHz are shown in Fig.L.5.1

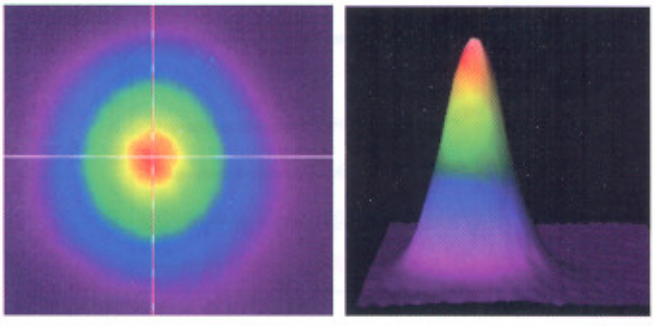

Fig. L.5.1: Spatial profile of the laser beam at 18 W and 15 kHz

In order to achieve tight focal spot, the laser beam was expanded using 8x telescope. The expanded beam is then fed to flat field focusing lens of focal length 80cm through a computer controlled xy scanner. The scanner is run by commercially available software. Focal spot diameter was measured using a CCD camera based laser beam analyzer and it was found to be ~40 microns. Various materials like Copper, Aluminium, Stainless steel end ceramics were used to study the laser micromachining.

Material removal rate for Aluminium, SS, copper and ceramic at 18 W, 15 kHz is shown in table[1]

Material	Removal rate (mm^3/sec)
Aluminium	0.043
Copper	0.022
Stainless steel	0.009
Ceramic	0.0056

With this laser, experiments on metal foils of different thickness and different metals were done.(figs L.5.2 to L.5.5) Masks were fabricated for semiconductor laser section for photolithography for developing photodiodes. Micro channels were made in copper blocks. Photographs of Some of the micro machined samples are shown below.

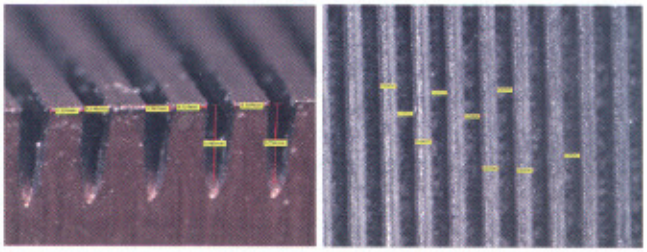

Fig. L.5.2:Micro channels in copper & Al block respectively

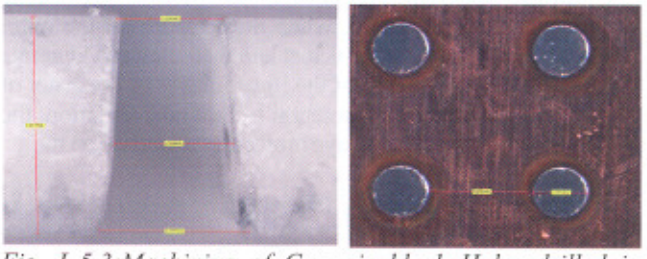

Fig. L.5.3:Machining of Ceramic block Holes drilled in copper foil

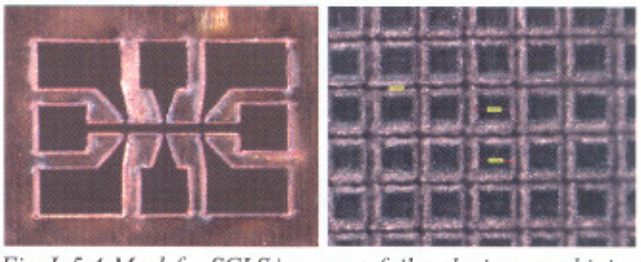

Fig. L.5.4:Mask for SCLS in copper foil and micro machining of copper block respectively.

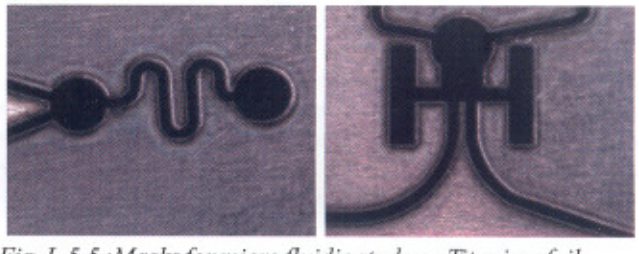

Fig. L.5.5 :Masks for micro fluidic study on Titanium foil

Reported by:
R.Sundar (sundhu@rrcat.gov.in),
K.Ranganathan, K.S.Bindra, S.M.Oak