L.3: Development of 2 W average power, 18 kHz repetition rate UV source at 255.3 nm by second harmonic generation of Copper-HBr laser

High pulse repetition rate (PRR~ kHz), watt-level average power, coherent ultraviolet (UV) source at wavelength of 255.3 nm is useful for fast and efficient writing of fiber Bragg gratings, UV-photo-lithography, micro-machining of semiconductors, polymers, glass & ceramics and photo-excitation studies of many elements. This UV source, normally obtained by second harmonic generation (SHG) of conventional copper vapour laser, has PRR of around 5-6 kHz. It is expected that still higher PRR UV radiation, with same pulse energy, would lead to a faster processing speed. Low temperature, high PRR (15-20 kHz) copper laser i.e., Copper-HBr laser (Cu-HBrL), with diffraction limited (DL) beam quality, provides an attractive means to develop such higher PRR UV source. With this view, in LSES, an UV (255.3 nm) source of ~2 W average power and 18 kHz PRR has been developed. It is based on SHG of green (510.6 nm) radiation of indigenously developed Cu-HBrL operating at 18 kHz PRR, where a β-BBO crystal is used as a second harmonic generator.

Figs. L.3.1 and L.3.2 show the schematic of the experimental set up and the developed UV source respectively. The Cu-HBrL was fitted with a positive branch confocal unstable resonator of magnification 50 (F_1=250 cm & F_2=-5 cm), with an intra-cavity cube polarizer. The polarized output beam of dia. ~2.7 cm, taken out as the reflection off a scraper mirror, was separated for green & yellow (present in the original beam) using a dichroic mirror. The green beam was then compressed to ~2.7 mm and ASE was filtered, using a telescopic lens pair (f_1,f_2 = 100,10 cm) and an aperture of dia. 0.5 mm placed at the common focal plane. The ASE filtered, collimated beam was focused, by a cylindrical lens (f_3) of focal length 3 cm, on a β-BBO crystal (6 x 4 x 10 mm^3, cut angle = 47^o) which was tilted suitably for type-I phase matching angle (~51^o) of the green beam. The depleted green beam and generated UV beam were then collimated using a fused silica cylindrical lens (f_4=10 cm), which were separated using a fused silica prism. Average UV power was monitored using a power meter while the temporal profiles as well as the wavelength of the radiations (fundamental green, depleted green & generated UV) were monitored using a setup of bi-planner photo tubes of sub-ns rise time & 500 MHz oscilloscope and a spectro-photometer respectively (Fig. L.3.3).

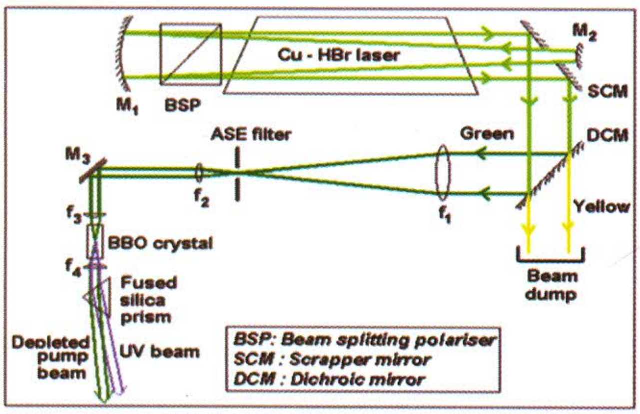

Fig. L.3.1 Schematic of the experimental set up

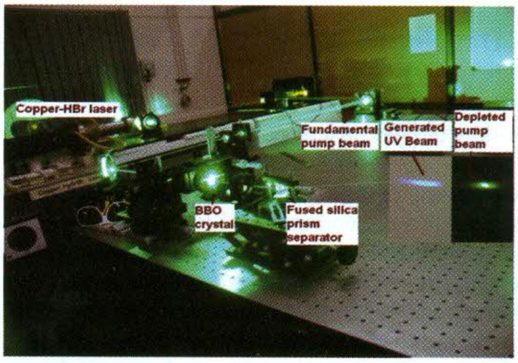

Fig. L.3.2 Photograph of the developed 18 kHz PRR, 2 W UV source at 255.3 nm by SHG of Cu-HBrL

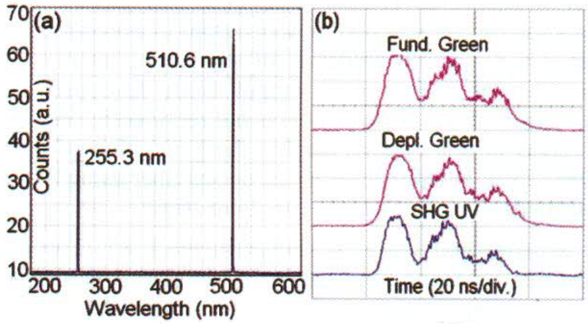

Fig. L.3.3: Spectrum (a) and temporal intensity profiles (b) of the radiations involved

Prior to the SHG experiment, the pulse averaged beam divergence, far-field pointing stability as well as spectral width of the fundamental green laser beam were measured to be ~120 μrad (~2 x DL), ± 15 μrad and ~4 GHz respectively as reported earlier (R. Biswal et. al., IEEE J. Q. E. 50(2), 112-119,2014). At maximum safe (to prevent thermal dephasing) average incident power of ~8 W (8.2 W), an average UV power of 2.05 W (taking into account 20% reflection loss in the collimating lens (f_4) & the prism) was obtained, which corresponds to an average optical conversion efficiency of ~25%. Estimations based on the temporal intensity profiles (Fig.L.3.3) reveals the corresponding peak instantaneous conversion efficiency of ~27%.

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