

Nanodiamond synthesis by fs laser filamentation in ethanol

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Laser filamentation occurs when intense laser pulse self-focuses nonlinearly and in-turn defocuses by the self-induced plasma in transparent medium ^[1]. The process occurs when the laser peak power is higher than a critical power, P_c in the order of GW in air. In liquid, P_c is in the order of MW and the scale is smaller than those in air. For both mediums, the existence of the process is evidenced by the unique characteristics namely supercontinuum generation, asymmetrical spectral broadening, intensity clamping and also multiple filamentation generation at elevated laser power.

In the current work, laser filamentation is set to occur in transparent liquid (ethanol, methanol) induced by a 1025 nm laser (500 fs, 1 kHz, up to 600 μ J) ^[2]. Focused laser pulses are incident onto the liquid surface of 3 ml of ethanol or methanol in a 1 cm x 1 cm x 4.5 cm cuvette. The critical power for self-focusing in ethanol is calculated to be ~ 1.51 MW (~ 0.8 μ J) while our results show that filamentation occurred at above 100 μ J ^[3] because of the presence of thermal-induced defocusing effect from ethanol which has a negative thermo-optic coefficient ^[4].

Above the threshold power, the transmitting laser beam vanishes and conical emission and super-continuum are detected. The transmitting laser energy reduces to only 10% as the laser energy increases. Fig. 1a shows the filamentation when the laser energy is 500 μ J. Bright conical emission with red, green, and blue concentric rings are visible.

In-situ measurement of the absorbance of the liquid indicate an increase at 230 nm to 240 nm with the number of pulses. At high laser power, molecular and atomic C species were detected in the optical emission spectra (Fig. 1b) After irradiation of 1 hour, the sample fluoresces at ~ 490 nm, when excited by UV light source. Nanodiamonds were detected in the sample by using Raman spectroscopy, XPS and TEM measurement.

References

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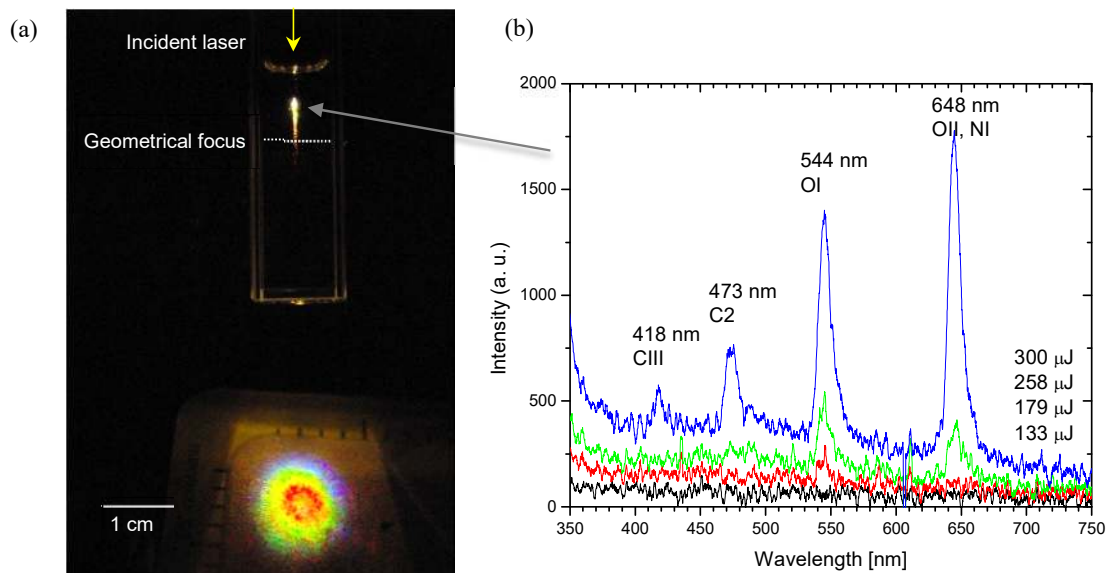


Figure 1 (a) Emission generated by fs laser filamentation along the laser axis at 500 μ J (b) Optical emission spectra obtained from the filaments.