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Bulk micro and nanostructuring of diamond by ultra-short laser pulses

Diamond is a unique material having high potential for applications in optical, electronic and acoustic devices. Many of them require precise processing of this ultra-hard material. It has been shown that pulsed lasers can be an effective tool for diamond cutting, drilling and surface structuring.

In this work a novel technique for bulk structuring of transparent poly and nanocrystalline diamond via its high intensity and ultrashort laser induced transformation into graphitic phase was proposed and realized. Optically clear diamond stones and CVD diamond plates were used in the experiments. It was found that in case of Ti:Al_2O_3 laser, fine structures could be produced only for pulse length shorter than few picoseconds.

The process can be triggered by small diamond volume graphitization on the rear surface or in the bulk of the diamond sample. Then for each sequential laser pulse graphitization wave develops in the direction of the coming beam. Direct correlation between graphitization wave velocity and laser pulse fluence $E \leq 50 J/cm^2$ was established. The velocity of such waves was in the range 2-600 nm/pulse depending on pulse duration as well as laser wavelength.

Formation of well defined long graphitic cylinders with minimal diameter smaller than micron (spot size 3μm) and aspect ratio up to 1000 was achieved by moving the focusing lenz in respect to the sample. It was also demonstrated that graphitic material can be selectively etched away and by this technique hollow channels could be produced inside the body of a diamond sample. Possibility of two and three dimensional bulk structuring of diamond will be also demonstrated.