Ultrafast laser-induced processes and processing on semiconductor surfaces at the micro/nano-scale by temporally shaped fs laser pulses

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The application of temporally shaped femtosecond laser pulses in the micro/nano-structuring of semiconductor surfaces is studied experimentally and theoretically. As an initial step towards full pulse shaping, sequences of double pulses with variable temporal spacing in the ps time domain with equal intensity have been used. Craters decorated with nm-sized ripples are formed following the laser-surface interaction depending on the irradiation conditions. The area, depth and strikingly the ripple periodicity show a dependence on the temporal delay between the individual components of the double pulses for the examined semiconductor surfaces, namely Si (Fig. 1) and ZnO.

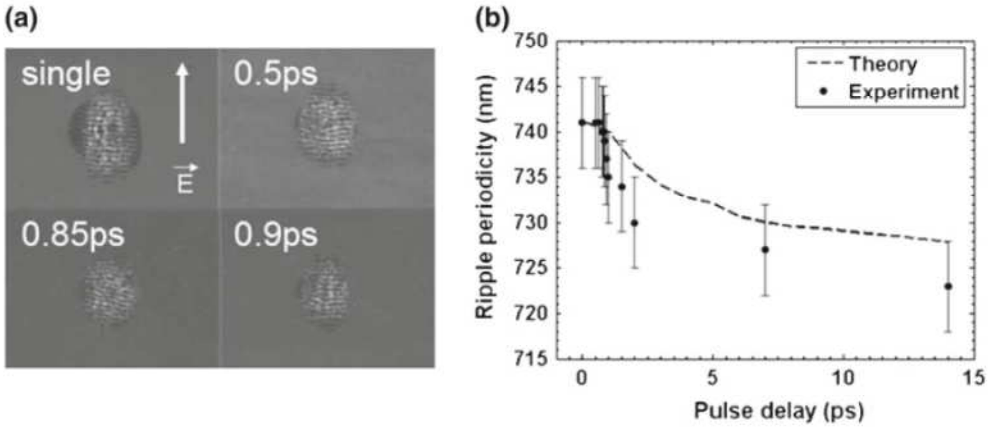

Figure 1: (a) Ripples generated on Si surfaces resulting from Laser-Plasmon interference, shown for different inter-pulse delay times. (b) The ripple periodicity exhibits a dependence (decrease) on the (increasing) temporal distance between the two components of the double femtosecond laser pulse sequences.

Our analysis and explanation for the dependence of the micro and nano-morphological features on the pulse delay is based on our recently developed theoretical model that combines the laser-triggered ultrafast excitation and relaxation mechanisms on a semiconductor surface such as carrier excitation, ultrafast carrier-lattice energy exchanges and energy transport along with the slower phenomena of melting, the corresponding hydrodynamics and re-solidification that follow until the final surface morphology is established. The details of our model and our recent experimental investigations on laser-irradiated Si and ZnO surfaces will be discussed [1-4].

References

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