Morphological changes on semiconductor surfaces after irradiation with ultrashort-pulsed lasers

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Femtosecond laser pulses provide unique possibilities for high-precision material processing. Understanding of the underlying physics and fundamental mechanisms that take place in materials irradiated by ultrashort laser pulses can facilitate optimization of experimental parameters in current applications and development of contemporary pulsed laser technologies.

The fundamentals of the physical mechanisms are employed to conduct a thorough investigation of ultrashort pulsed laser induced surface modification due to conditions that result in a superheated melted liquid layer and material evaporation are considered. The proposed theoretical model aims to address the laser-material interaction in sub-ablation conditions and thus minimal mass removal in combination with a hydrodynamics-based scenario of the crater creation and ripple formation following surface irradiation with single and multiple pulses, respectively. The development of the periodic structures is based on a synergy of electron excitation and capillary wave solidification and the interference of the incident wave with a surface plasmon wave.

A hybrid theoretical model is also presented to describe thermoplastic deformation effects on silicon surfaces induced by single and multiple ultrashort pulsed laser irradiation in submelting conditions.

Some early results of a similar mechanism is presented to describe thermal response of other types of materials (i.e. bimetallic layers) upon irradiation with ultrashort pulsed lasers.

Some references

1. Tsibidis G.D. 'A theoretical investigation of the influence of nonthermal electron dynamics on the relaxation process after ultrashort pulsed laser irradiation of double-layered metal films' (*submitted*)

2. Tsibidis G.D., Stratakis E., Loukakos P.A., and Fotakis C. (2013), 'Controlled ultrashort pulse laser induced ripple formation on semiconductors' (to appear in *Applied Physics A*)

3. Barberoglou M., Tsibidis G.D., Grey D., Magoulakis M., Fotakis C., Stratakis E., and Loukakos P.A. (2013), 'The influence of ultrafast temporal energy regulation on the morphology of Si surfaces through femtosecond double pulse laser irradiation', *Applied Physics A-Rapid Communications*, **113**, 273-283.

4. Tsibidis G.D, Barberoglou M., Loukakos P.A., Stratakis E., and Fotakis C. (2012), Dynamics of ripple formation on silicon surfaces by ultrashort laser pulses in subablation conditions, *Physical Review B*, **86**, 115316.

5. Tsibidis G.D., Stratakis E., Aifantis K.E.. (2012), 'Thermoplastic deformation of silicon surfaces induced by ultrashort pulsed lasers in submelting conditions', *Journal of Applied Physics*, **111,** 053502.