Materials Ablation: EUV versus Femtosecond Lasers

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Laser ablation and/or desorption is an effective method for material microanalysis, structuring and synthesis of thin films. A major challenge is the effect caused by thermal by-processing which leads to non-stoichiometric sampling, cracking, etc. To overcome this challenge, workers have proposed to enhance the absorption, reduce laser-plasma effects, and mitigate incongruent melting with either shorter pulse durations or shorter wavelengths, e.g. evolving from infrared (e.g., Nd:YAG, CO2) to deep ultraviolet (e.g., harmonic generation, excimer). However, nanosecond pulses, even in the deep UV, can still induce melting effects. In fact, photophysical processes such as thermal diffusion, fusion, and explosion, are of the order of tens of picoseconds [1][2]. Ultrafast laser with a time scale in the 10-100 fs have been preferred for stoichiometric sampling and clean micro-structuring.

The basic idea is that a short pulse can stack multiple pulses (a multiphoton process), which can promote ionization, photoemission, bond breaking and ablation with insignificant collisional electron thermalization. Therefore, the term "cool ablation" is to be understood as an effect of a time scale for ablation much shorter than the thermodynamic process. Recent evidence suggests that not only ultrafast pulses [1] but also EUV pulses [3][4] can result in non-thermal ablation on various materials.

Table-top extreme ultraviolet (EUV) sources and lasers are available for "single photon" ablation. Contrary to a multiphoton process, a single photon of several tens of an eV is able to directly excite the bound states to break the bond photochemically. However, discharge based EUV sources mainly have pulse durations in the 1-100 ns time scale (save when pumped by a drive laser). Therefore, it is questionable if the single photon effect for a "cool ablation" is fully exploited. Therefore, there is an urgent need to address the thermodynamic processes problem of laser ablation.