Polymer ablation: From fundamentals of polymer design to laser plasma thruster

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This work reviews laser ablation of polymers with an emphasis on the design of polymers for UV laser ablation and IR irradiation. Laser ablation of polymers is an accepted process in industrial applications, but the mechanisms of ablation are still controversial. Different polymers, such as polymethylmethacrylate, polyimides and special designed polymers are used as examples to show that the mechanism is a mixture of photochemical and photothermal features which are closely related to the polymer structure and properties. The designed polymers reveal better ablation characteristics, i.e. ablation rate and quality, as compared to standard polymers. Photoactive groups have been introduced into the polymer structure to improve the quality of ablation and to elucidate the ablation mechanisms. The experimental techniques to probe the ablation mechanism range from time-resolved measurements, such as shadowgraphy, TOF-MS, and ns-surface interferometry to variations of the irradiation wavelengths and pulse lengths [1,2,3]. The necessity for critical evaluation of the experimental procedures and analysis is discussed exemplary for polyimides, where experimental procedures are possibly causing problems for the data evaluation. A very different application of polymers for laser irradiation can be found in a micro laser plasma thruster. The micro laser plasma thruster (µLPT) is a micropropulsion device, designed for the steering and propelling of small satellites (1 to 10 kg). A laser is focused on to a polymer layer on a substrate to form a plasma. The thrust produced by this plasma is used to control the satellite motion [4,5]. The lasers applied in this application are near-IR diode lasers and the goal for the polymers is a large thrust obtained from the plasma. Designed polymers for this application should absorb near IR radiation and decompose exothermically. The decomposition of these designed energetic polymers is probed by various techniques, ranging from shadowgraphy (example shown for an exothermic polymer in Figure 1) to emission and mass spectrometry. The designed polymers exhibit a higher thrust than standard polymers.


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