Incubation behaviour in triazene polymer thin films upon near-infrared femtosecond laser pulse irradiation

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For more than two decades now, the laser processing of polymers has been intensively studied [1]. Most of this research has been focused on the nature of the laser-matter interaction mechanisms and on possible applications of laser ablation, especially in the UV regime where many polymers of interest are highly absorbing. One polymer group of particular interest is that of the triazene polymers which are photochemically very active upon UV irradiation and feature superior ablation properties for irradiation at a wavelength of 308 nm. These polymers have a great potential for a number of applications e.g. as photoresist materials in laser lithography or for laser plasma thrusters in micro-/nano-satellites [2]. In two previous works, we have studied the irradiation of triazene polymer thin films by single near-infrared femtosecond laser pulses for fluences below [3] and above [4] the damage threshold. Here, we extend these studies with a detailed investigation of the multi-pulse irradiation behaviour. The effects induced by a sequence of ultrashort (130 fs), near-infrared (800 nm) Ti:sapphire laser pulses in a ~1 μm thick triazene polymer film on a glass substrate have been investigated by means of in-situ real-time reflectivity measurements performed simultaneously with a ps-resolution streak camera and a ns-resolution photodiode set-up. The polymer film shows significant incubation effects upon the multiple-pulse irradiation at fluences below the single-pulse damage threshold. In this case, during a few incubation pulses, the reflectivity of the film shows a rapid decrease down to 70% of its initial value within a time of 1 ns. Afterwards, the reflectivity recovers its initial value on the millisecond timescale. The application of several pulses to the same spot leads to a permanent film damage when a critical number of pulses is exceeded. Additional laser pulses then cause a partial removal of the film material from the glass substrate. The critical number of laser pulses needed to generate a permanent damage of the film has been studied as a function of the laser fluence. Scanning force microscopy (SFM) and micro Raman spectroscopy (μ-RS) have been used to characterise ex-situ the irradiated surface areas. Based on these complementary measurements the possible incubation mechanisms are discussed.


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