Ultrashort pulse action onto thin film on substrate: Shock propagation in substrate

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Thin films located upon supporting substrates are important class of laser targets for surface nano-size modification, e.g. for plasmonic or sensoric applications. There are many papers devoted to this problem. But all of them are concentrated on dynamics of a film, paying small attention to substrate. In these papers the substrate is just an object absorbing the first shock. Here we present another point of view directed onto dynamics of a substrate. We consider (i) generation of a shock wave (SW) in a supporting substrate, generation by impact of a film–support contact on supporting condensed medium; (ii) transition from one to two-dimensional (2D) propagation of SW; (iii) we analyze lateral propagation of the SW along a film–support contact; and (iv) we calculate pressure in the compressed layer behind the decaying SW. This positive pressure acting from substrate to the film accelerates the film in direction to vacuum. Above some threshold, velocity of accelerated film is enough to separate the film from support. In the cases with large energy absorbed by a film, the circle of separation is significantly wider than the circle of high heating around the focal laser spot on film surface. Absorbed laser heat exponentially decays around an irradiated spot as $\exp(-r^2/R_L^2)$, where R_L is radius of Gaussian beam. While the law of decay for the 2D SW in substrate is the power law. Therefore in the mentioned cases of powerful laser action the edge of a separation circle is driven by SW in support.