FORMATION DYNAMICS OF PERIODIC SURFACE PATTERNS IN GE INDUCED BY UV NANOSECOND LASER PULSES

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ABSTRACT

Direct Laser Interference Patterning (DLIP) is a versatile technique that enables the single pulse fabrication of periodic surface structures over relatively large areas in a variety of materials [1],[2]. The sinusoidal shape of the intensity profile cross sections at the sample surface created by two or more interfering laser pulses triggers the formation of periodic surface patterns, whose periodicity can be tuned by modifying the irradiation configuration. In that sense, DLIP can be considered to belong to the larger category of laser induced periodic surface structures (LIPSS) fabrication strategies, with the added benefit of single pulse operation, tunable period, highly homogeneous feature shapes and orientations for a wider range of materials.

In this work, we have employed DLIP to process crystalline Ge using interfering unpolarised UV excimer laser pulses (ArF, $\lambda = 193$ nm, $\tau = 23$ ns). Using single pulse irradiation, homogenous diffraction gratings as large as 0.5 x 0.5 mm can be fabricated. The imprinted fringes are highly periodic and parallel, with a steep height modulation profile across the fringes. In order to unravel the formation dynamics of these periodic structures, we have performed time-resolved optical reflectivity and diffraction measurements with ns temporal resolution, which enable us to follow in real-time the dynamics not only of the melting and solidification process but of the evolution of the surface topography. Combined with a simple model of the diffraction efficiency of these structures, 3D maps of the transient surface elevation as a function of fluence and time can be obtained. The results reveal that the formation process of the 3D structures can be understood when taking into account both, Marangoni effect and the presence of thermocapillary waves with an oscillation period in the range of a few tens of nanoseconds.

REFERENCES

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