# Modelling ultrafast laser structuring/texturing of free form surfaces

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Laser structuring/texturing of free form surfaces is attracting the attention of researchers and industry because it can enable many applications and also the benefits that the technology can offer compared to alternative/conventional processes, e.g. in regards to achievable accuracy, flexibility and processing time. So far laser structuring/texturing has been applied mostly on planar surfaces, however, while employing it for 3D processing requires additional factors to be considered such as disturbances because of their effects on processing conditions. In particular, beam incident angle (BIA) and focal offset distance (FOD) are two important processing disturbances that impact the resulting structures/textures and also their functional responses. So, they should be considered as constraints in planning the laser processing operations, i.e. in pre-processing 3D models by partitioning the surfaces, and also in designing the processing strategies. In the case of Laser Induced Periodic Surface Structures (LIPSS), it has been reported that BIA mostly affects their periodicity while FOD – the height of the ripples. Homogenous and uniform LIPSS can be produced only when the accumulated laser fluence is maintained within pre-defined ranges for a given material. In this research, a model for calculating and maintaining the accumulated fluence throughout the processed 3D surfaces is proposed. It takes into account the beam quality factor $M^2$ and the actual beam intensity distribution on processed surfaces both at the focus plane and also when FOD is present. The ultimate objective is to determine theoretically the 3D structuring/texturing limitations associated with these two processing disturbances by predicting ripples' profiles and thus to judge indirectly about LIPSS functional response on free form surface. An experimental validation is performed on samples produced with known values of BIA and FOD and resulting LIPSS, characterised with SEM and AFM, are compared with the reference ones. The model can be also used in designing 3D laser processing strategies for achieving optimum throughput and quality.