AI-based prediction of surface roughness to enhance anti-reflective space components fabricated by Direct Laser Interference Patterning

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Abstract

Direct Laser Interference Patterning (DLIP) is a reliable tool to generate surface patterns in the sub-micrometer-scale and mimicry natural inspired properties. Such are anti-reflective, hydrophobic or cosmetic properties on different materials. [1] Hereby, the performance is highly depended on topography parameters, such as average surface roughness and homogeneity. Consequently, the prediction of the resulting surface topography from the process parameter becomes more and more important in order to reduce the development time of specific surface functionalities.

This study introduces different models to predict the surface topography fabricated by direct laser interference patterning, employing machine learning and statistical methodologies. In particular, the work compares the performance of machine learning algorithms, such as Random Forest and Artificial Neural Networks, with classical Design of Experiments (DoE) techniques like ANOVA. The modelling took into consideration the used laser parameters and other process-relevant information for the prediction of the surface topography. Statistical results indicate that both approaches can predict the desired surface topography with high accuracy, despite the use of a small dataset for the learning process. For machine learning algorithms, the average surface roughness can be predicted with an accuracy of 94%. Furthermore, the functional properties of the generated textures were evaluated by measuring gloss values to assess anti-reflective properties.

Valuable insights for optimizing DLIP processes in terms of efficiency, throughput, and other key performance indicators were found. Moreover, these predictive models can be employed to estimate the functional efficiency of a surface before initiating the laser texturing process, thus enabling more informed decision-making in materials engineering. Thereby light absorption surfaces for space industry can be designed in a shorter time frame.

Literature

[1] Andrés F. Lasagni et al. “Direct laser interference patterning, 20 years of development: from the basics to industrial applications”. In: Laser-based Micro- and Nanoprocessing XI 1009211 (2017)