Advanced Manufacturing by Short Pulse Lasers for Precision Processing on Challenging Surfaces at the Microscale

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This study aims to explore and then identify the optimised laser processing parameters for advanced manufacturing on challenging microscale surfaces under extreme processing conditions. It focuses explicitly on transparent conductive coatings on transparent substrates. It employs different laser systems to achieve precision processing on two substrates: ITO (indium tin oxide) coated on glass and PET (polyethylene terephthalate). The following optimal laser processing conditions were identified through parametric experiments and advanced image processing techniques.

For ITO/Glass substrates processed with a 355 nm, 10-picosecond laser at 600 kHz, a fluence of around 1.4 J/cm^2, a scanning speed between 1000 mm/s and 2000 mm/s, and two overscans yield the best ablation results. For ITO/PET substrates processed with a 1050 nm, 150-picosecond laser at 600 kHz, a lower fluence range of 0.382 J/cm^2 to 0.637 J/cm^2 combined with higher scanning speeds between 2000 mm/s and 3500 mm/s is found to produce ablations, where 0.637 J/cm^2 fluence reached near ITO-thickness ablation and stable ablation width around the focal spot diameter of 50 µm. It concludes that for both substrates, scanning speed significantly affects both ablation depth and width under the condition of high pulse overlap. Ablation depths demonstrate a threshold relationship with scanning speed and fluence, reaching a peak beyond a certain point. In contrast, for both types of substrates, the ablation width increases more linearly with fluence until saturation.