

自然界に学ぶ機能表面設計とレーザー加工による応用戦略 Biomimetic Functional Surface and Application Strategies via Laser Processing

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Abstract

This paper reviews strategies for fabricating and applying biomimetic functional textures through ultrashort-pulsed laser processing. Inspired by natural surfaces, these textures provide hydrophobicity, antifouling, and other advanced properties. To enable industrial application, we fabricated a fully automated system that integrates femtosecond-pulsed laser processing, 3-dimensional surface measurement, and robotic handling. This system allows continuous operation and the collection of large-scale surface datasets. Based on these datasets, we constructed machine learning models capable of predicting geometric parameters such as groove width and depth with high accuracy. The predictive performance exceeded 95% for groove width, thereby demonstrating the feasibility of data-driven process design. Furthermore, ultrashort-pulsed lasers offer distinct advantages over conventional chemical treatments, including low environmental impact, applicability to diverse materials, and compatibility with curved or re-entrant geometries. These features not only improve manufacturability and competitiveness in industry but also align with the sustainable development goals by contributing to clean energy, healthcare, and environmental conservation. In summary, the combination of ultrashort-pulsed laser microfabrication and data-driven modeling provides a promising pathway toward sustainable, high-functionality surface engineering for next-generation manufacturing.

キーワード：レーザー、バイオミメティクス、撥水、機械学習、SDGs

Keywords : Laser, Biomimetics, Hydrophobicity, Machine learning, SDGs

1. はじめに

生物が地球環境に適応するために進化の過程で獲得してきた多様な機能を人工的に模倣するバイオミメティクスが、製造業から注目を浴び

ている¹⁾。固体表面に付与された親液／撥液／滑落性、防汚性、無反射、光透過性、発色、低摩擦／流動抵抗、低騒音といった新しい物理的機能を発現するナノ・マイクロメートル領域の微細構造は、機能的テクスチャと呼ばれる。例えば、撥水性や滑落性は水の惑星地球で生きる生物にとって極めて重要な機能であり、ハス(=lotus, ロータス)の葉が持つ表面の凹凸構造が高い撥水性と滑落性を示すことは、ロータス効果として知られている²⁾。この撥液テクス

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