Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **4437** Type: **Poster Competition (Graduate Student) / Compétition affiches (Étudiant(e) 2e ou 3e cycle)**

(G*) (POS-56) An Integrated Machine Learning Strategy for Estimating the Optimal Process Conditions in Femtosecond Laser-induced Microporous Structures

Tuesday 28 May 2024 17:59 (2 minutes)

Formation of microporous structures on a polymer surface leads to improved surface properties such as self-cleaning, anti-fogging, antibacterial characteristics, and strengthened adhesion with metals. Femtosecond laser-induced microporous structures (fs-LIMS) are microscale features created using laser technology for subsequent metal deposition. However, their quality is heavily influenced by complex interactions between various laser processing parameters and material properties. Presently, the selection of appropriate laser parameters relies largely on the operator's experience and requires laborious experimentations. To achieve a more efficient, rapid, and cognitively automated process, an integrated machine learning methodology is introduced for determining the optimal process conditions for fs-LIMS. This methodology commences with feature extraction from images captured by scanning electron microscopy (SEM) using a convolutional neural network (CNN). Subsequently, various dimensionality reduction techniques such as principal component analysis (PCA), multidimensional scaling (MDS), and t-distributed stochastic neighbor embedding (t-SNE) are employed to explore various analytical approaches. The k-means clustering method is then utilized to automatically classify the main characteristics (extracted from various dimensionality reduction methods) of fs-LIMS into categories representing high, moderate and low quality. Among the diverse dimensionality reduction methods, PCA proves most effective, achieving a peak accuracy of 95.97% in a three-dimensional PCA model. Finally, based on the labeled images by PCA and k-means clustering, support vector machine (SVM), artificial neural network (ANN), and random forest (RF) algorithms are applied to predict the laser processed outcomes. The results reveal that SVM attains the highest accuracy, performing at a level of 92%. This study introduces a novel approach for identifying the optimal laser process conditions to create laser-induced microscale porous structures.

Keyword-1

Laser machining

Keyword-2

Machine learning

Keyword-3

Optimal process conditions

Authors: REN, Jun (School of Mechanical Engineering. Jiangnan University; Surface Science Western, Western University); LIU, Yu (School of Mechanical Engineering. Jiangnan University); ZHANG, Yang (Department of Civil and Mechanical Engineering. Technical University of Denmark); NIE, Heng-Yong (Surface Science Western, Western University)

Presenter: REN, Jun (School of Mechanical Engineering. Jiangnan University; Surface Science Western, Western University)

Session Classification: DAMOPC Poster Session & Student Poster Competition (10) | Session d'affiches DPAMPC et concours d'affiches étudiantes (10)

Track Classification: Technical Sessions / Sessions techniques: Atomic, Molecular and Optical Physics, Canada / Physique atomique, moléculaire et photonique, Canada (DAMOPC-DPAMPC)