Smart laser engraving system for wide-band gap materials for the luxury industry

ALEX CAPELLE[1, 2], K. DEVA ARUN KUMAR[1], OLGA SHAVDINA[2]
BABACAR DIALLO[3], NADIA PELLERIN[3], BARTHÉLEMY ASPE[1], LÉO THOMAS[1],
MARTIN DEPARDIEU[2], ANNE-LISE THOMANN[1], NADJIB SEMMAR[1*]

[1]GREMI - CNRS UMR 7344, Orléans, France
[2] Décor World Services (DWS), Orléans, France
[3] CEMHTI - CNRS UPR 3079, Orléans, France, as collaborator from ARD MATEX
corresponding author: nadjib.semmar@univ-orleans.fr

ABSTRACT

The decoration of glass has become a major issue for manufacturers of packaging for cosmetics, perfumes or wines and spirits, particularly represented in the CVL Region. These manufacturers use many processes aimed at coloring and texturing the glass on the surface or in volume. Laser stripping process makes it a promising way to obtain a certain surface texturing offering a particular decorative aspect, while laser engraving makes it possible to print very fine patterns on both the surface and volume of the glass.

1. INTRODUCTION

This project aims to master light-matter interaction between common lasers and products from the luxury industry which represent scientific interests. A novative approach using machine learning algorithm and computer vision will be developed and implemented.

Obtaining a specific and reproductible visual texture is very important in the luxury sector and finding the right set of parameters (laser beam and stage moving) to obtain the desired rendering is often a time-consuming process. It requires a good knowledge of the laser engraving system (engineer work), experience in searching for a desired rendering (artisanal work) which will satisfy customers expectations (artistic work).

In this scope, machine learning algorithm seems to be a convenient tool to link a set of visual characteristics with the agreement of a customer. The visual characteristics are obtained by a set of measurement techniques (characterisation system). The study of light-matter interaction mechanisms will be the link between laser beam characteristics and surface texture characteristics.

This final goal will be achieved by first replacing the customer by a characterization system composed of physical measurements combined with optimisation criteria. Moreover, the training of the algorithm requires a certain quantity of data for learning and testing. The characterization system will then be developed to generate the required quantity of data in a reasonable time.

Fig. 1 Decorated glass (DWS)

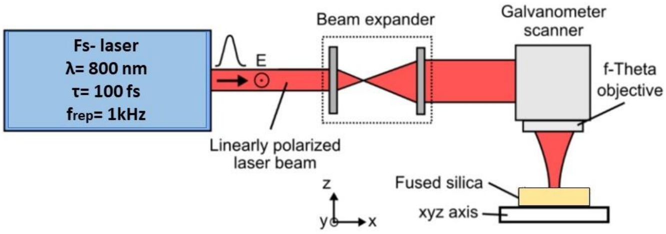

Fig. 2 Scheme of the experimental setup used for the generation of laser-induced periodic surface structures (LIPSS) on fused silica

The first step of this work will be to selected one material and study the mechanisms with three industrial lasers. The material of study will be industrial soda-lime container bottles and the selected lasers are microsecond NIR CO_2 laser, Picosecond UV Ti:sapphire, Femtosecond IR Ti:sapphire.
The second step will be to list the mechanisms, for example direct scribing, LIPSS, defragmentation, melting, suitable for creating interesting visual textures. Here, Laser-induced periodic surface structures (LIPSS) are a universal phenomenon that can allow tailoring nano-electronics and nano-photonics devices. The generation of LIPSS in a single-process step provides a simple way of surface nanostructuring toward a control of optical, mechanical, or chemical surface properties, which can be used for various applications [1]. Several experimental parameters have been identified to be important for the generation and control of LIPSS. Apart from the laser wavelength and the laser beam polarization, two important key parameters are the laser fluence ϕ (energy density in J/cm^2) and the number of laser pulses N applied to the same spot. Moreover, the angle of incidence θ affects the LIPSS periods as well as the local environment. While the periods of LIPSS generated in air and vacuum are quite similar, the irradiation in liquids usually leads to a significant reduction of the LIPSS periods to values as small as ~100 nm [2].

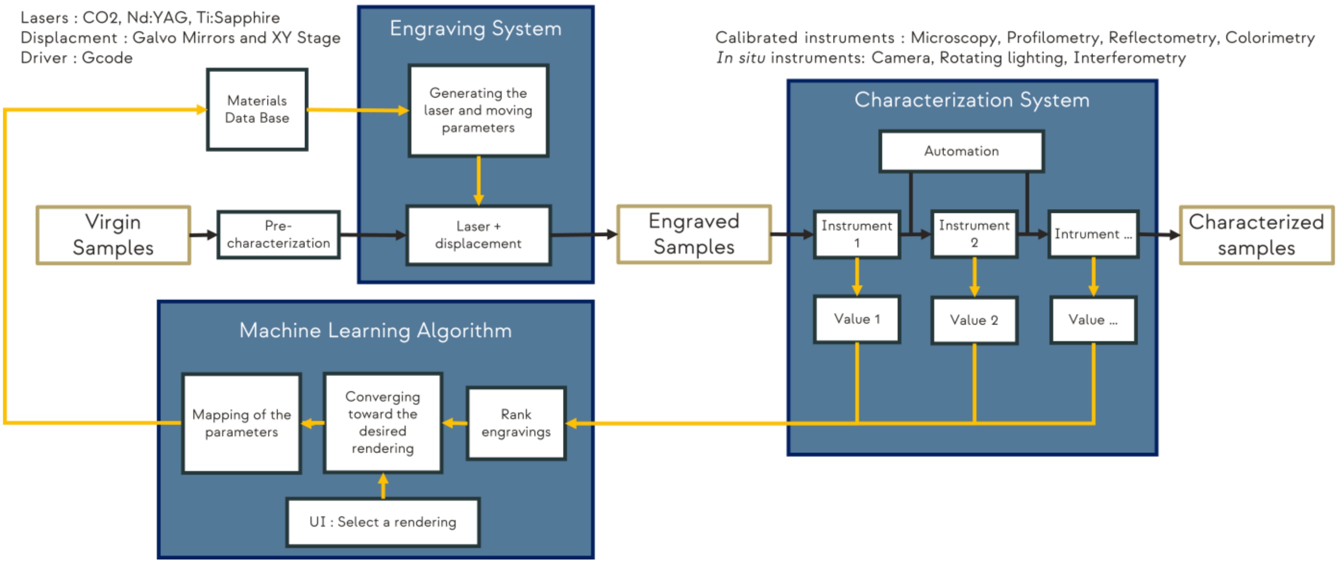

Fig. 3 Smart system diagram

However, for commercial applications, processing in air is strongly desirable in order to avoid expensive equipment with vacuum and reducing the working time and the production costs. In this aid, the current research state in this field of LIPSS generated by fs-laser pulses in air.
In order to study the impact of transient changes of the optical properties of LIPSS formation, we have to choose the dielectric material since a large difference between the optical properties of nonexcited (dielectric) and the strongly fs-laser pulse excited (metal like) material can be expected. Therefore, the main work will be to study the mechanisms of femtosecond lasers with glass surfaces (soda-lime container bottles). Followed by the generation of LIPSS on glass surfaces will be studied using a femtosecond laser. The laser-irradiated surface regions will be characterized by optical microscope (OM) and scanning electron microscopy (SEM).
The third step will be to use the characterization system to maximize the visibility criteria, which will be detailed in the presentation and process characteristics like average depth of modification, process time, residual stress…
Finally, all of these criteria will be input in the machine-learning algorithm, which will attempt to match them with human feeling rating.

REFERENCES

[1] J. Bonse, J. Krüger, S. Höhm, et al. J. Laser Appl. 24, 042006 (2012)
[2] C. Wang, H. Huo, M. Johnson, M. Shen, and E. Mazur, et al. Nanotechnology 21, 075304-1–5 (2010)