Materials Letters 382 (2025) 137878

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/matlet

Preliminary study on laser texturing of glass: Techniques, process parameters, and initial findings

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ABSTRACT

This paper explores the preliminary study regarding the Laser Texturing on soda-lime glass to modify its functionality to achieve a superhydrophobic surface. Glass, a prominent material in various industries, is particularly crucial in the automotive sector for manufacturing windshields and in renewable energy applications like solar panels. Various laser parameters such as power, scanning speed, and repetition rate were studied for trial to understand their impact on surface morphology and functionality. Initial findings reveal that laser texturing can effectively improve glass surface properties, creating superhydrophobic surfaces while maintaining optimal transparency. However, challenges were encountered in achieving the desired textures without compromising glass integrity. Therefore, the study concludes that trials faced challenges due to the transparent and brittle nature of the glass, resulting in damage from higher temperatures and brittleness, this study provides valuable insights for optimizing laser parameters and exploring alternative substrate preparation methods to advance the development of functional glass surfaces for industrial applications.

1. Introduction

Glass is a substantial material utilized in various industries, incorporating electronics, automotive, and structural design. Among all the related fields automotive industry remains the most focused on manufacturing vehicle windshields [1]. However due high demand of adopting renewable energy resources, solar being a viable and abundant resource also needs glass for the PV Module [2]. The widespread use of Glass is primarily due to its transparency, making it ideal for applications requiring unobstructed visibility and light transmission. However solar PV modules in open environments accumulate dust, grime, and bird droppings on their surfaces [3]. Modifying the surface properties through texturing can significantly enhance functionality [4]. Laser texturing, a non-contact method, offers precise control over surface modification, enabling the creation of microscale features [5]. This study investigates the primary techniques for laser texturing, identifies crucial process parameters, and presents initial results from experimental trials.

Laser surface texturing has emerged as a superior alternative, offering precise control, environmental safety, and the ability to create intricate patterns without additional chemicals [6]. Traditional methods such as chemical etching and coating are complex, costly, and environmentally challenging [7]. Self-cleaning, inspired by the Cassie–Baxter state, was achieved through laser surface texturing. Femtosecond, picosecond, and nanosecond laser techniques have been widely studied for creating superhydrophobic surfaces with hierarchical micro-nano structures, which are advantageous for self-cleaning, anti-fogging, and anti-icing applications [7,8]. In this work, soda-lime glass texturing using a nanosecond fiber laser is investigated; the effects of scanning speed, fluence, and pulse duration on surface morphology and functioning are focused. Lin et al. [9] applied SEM and EDS to analyze these surfaces, addressing the difficulty of balancing surface roughness for hydrophobicity with maintaining high optical transparency, critical for applications like solar panels.

2. Technical approach

In this study, the experimental sample used was commercially available soda-lime glass with dimensions of 25 mm × 76 mm × 1 mm with chemical composition illustrated in Table 1. Since the Glass is a transparent solid through which the laser beam passes but does not interact directly as illustrated in the schematic in Fig. 1. Therefore, the sample was prepared with seven different techniques to let the laser beam focus on the glass substrate as depicted in Fig. 1. Glass treatment ranges from a) Spray coating, b) Adhesive Tape, d) pretreatment in ultrasonic cleaning with ethanol e) coated with paraffin wax f) Ultrasonically cleaned with acetone, g) glass attached with MS sheet, and h) glass attached with aluminum sheet.

In this study, the focus was to create laser marks on the glass. Therefore, circles were created with a diameter of 0.5 mm and a spacing

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https://doi.org/10.1016/j.matlet.2024.137878
Received 9 August 2024; Received in revised form 24 October 2024; Accepted 9 December 2024
Available online 10 December 2024