Fabrication of Superhydrophobic Surface on Aluminium Alloy using Laser Texturing

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Abstract- *Many studies have shown that super hydrophobic surfaces have been applied to micro–nano structures and low surface energy materials. In the present study, an ultraviolet laser process for fabricating micro-groove structures on an aluminium alloy surface and subsequent chemical treatment are carried out to increase the surface hydrophobicity. Groove patterns of various angles with respect to vertical with crossed lines were textured on the substrate by using Femto second laser pulses. The laser parameters, such as hatching distance (HD) and scanning speed (SS),can be varied by keeping the laser power as constant for the various tilted angle of the groove pattern. Changing the wetting properties of surfaces is attracting great interest in aerospace for less fuel consumption and to the anti-icing in the aircraft and to avoid the corrosion of the materials.[3]*

Keywords- Aluminum, Laser texturing, Femtosecond laser, Super hydrophobicity

I. INTRODUCTION

Aluminum resources are abundant in nature. Aluminum alloy is low density, high strength, high plasticity, good electrical and thermal conductivity, and is widely used inaviation, aerospace, automobile, machinery manufacturing, shipbuilding and chemical industries. Especially in cold environment, water droplets will freeze on the surface. The occurrence of these conditions has greatly affected the performance and service life of aluminum alloy and even can cause huge economic losses and disaster accidents.[2]

A superhydrophobic coating is a thin surface layer that repels water. It is made from superhydrophobic materials. Droplets hitting this kind of coating can fully rebound. Generally speaking, superhydrophobic coatings are made from composite materials where one component provides the roughness and the other provides low surface energy. Surfaces with very high-water contact angles, particularly larger than 150°, are usually called super hydrophobic (SH) surfaces [3]. These surfaces are of special interest in the field of biomedical, aerospace, aviation, wind turbine, electric transmission lines, because properties such as, anti-icing, and self-cleaning.

In this paper, Superhydrophobic aluminium surface will be prepared by Fem to laser texturing. Laser texturing technique is used to construct rough micro patterned structure to attain super hydrophobicity by changing the laser parameter such as scanning speed (less than 50 mm/sec) and hatching distance (30 – 90 microns). The pattern on the substrate will influence the surface roughness to attain super hydrophobicity.

II. LITERATURE REVIEW

Annalisa Volpe etal (2021) Changing the wetting properties of surfaces is attracting great interest in many fields, in particular to achieve a surface with a superhydrophobic behaviour. Laser machining is an emerging technique to functionalize materials with high precision and flexibility without any chemical treatment.

SamuelSanjayRajaetal. (2020)simplistic and highly effective ultra-fast laser technology was used to fabricate Superhydrophobic surface on aluminium substrate. Compared to other laser systems, picosecond laser systems have smaller thermal affected area on the aluminium substrate

Zang etal. (2019) The superhydrophobic surface was successfully prepared on aluminum alloy 6061 by anodization and lauric acid modification. The reaction was carried out for 1 h in a 0.3 MH3PO4 electrolyte at a voltage of 60 V to construct a honeycomb pore-needle microstructure with a water contact angle (WCA) up to around 160° and a sliding angle (SA) less than 2.

Yang Liu etal (2019) An experimental study was conducted to characterize the laser-textured surfaces fabricated by using a novel nanosecond Laser-based High-throughput Surface Nano structuring (nHSN) method. While the two-step Nhsn approach (i.e., water-confined nanosecond laser texturing and chemical immersion treatment) in producing super hydrophobicity over metal surfaces is described in great details, a throughput analysis of different laser-based surface texturing methods is also performed in the term of Specific Laser Scanning Time (SLST).

Chao Huang etal (2017) An ultraviolet laser process for fabricating micro-groove structures on an aluminium alloy surface and subsequent chemical treatment are carried out to improve surface hydrophobicity. The finding reveals that surface morphology and surface energy are assessed in correlation with wettability. The laser textured surface with chemical modification decreases the polar component of the surface energy and enhances the superhydrophobicity.

III. PROBLEM IDENTIFICATION

Pattern used in laser texturing are micro groves, dimples, pillar shaped, trapezoidal and honey comb to attain non wetting properties. Micro groove also called riblets which are mostly used in air foil for reducing drag hence less fuel consumption. In micro groove surface moved the vortex away from the surface. This leads to high shear stress on the peak of micro groves and lower drag in the valley.

In this paper, our scope to develop laser texturing techniques for super-hydrophobic surface fabrication on Al6061 substrate drag reduction and Anti-icing on the substrate.

IV. MATERIALS SELECTION

4.1 Aluminium:

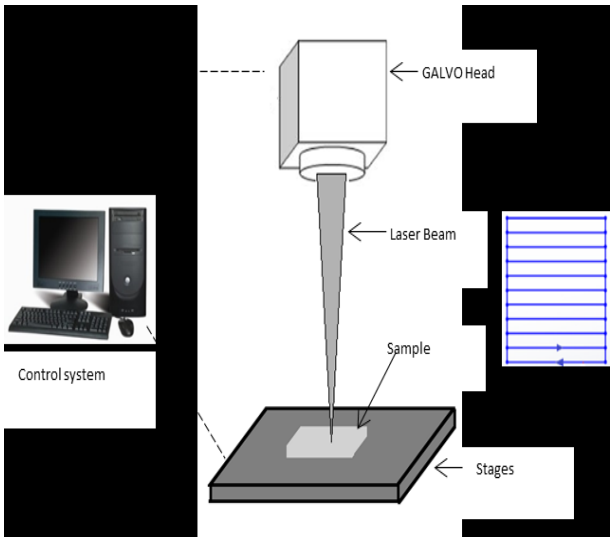
It has good mechanical properties, exhibits good weldability, and is very commonly Extruded. It is one of the most common alloys of aluminum for general-purpose use. T6 temper has been treated to provide the maximum precipitation hardening (and therefore maximum yield strength) for a 6061-aluminum alloy. It has an ultimate tensile strength of at least 290 MPa (42 ksi) and yield strength of at least 240 MPa (35 ksi). More typical values are 310 MPa (45 ksi) and 270 MPa (39 ksi), respectively.6061 (Unified Numbering System (UNS) designation A96061) is a precipitation-hardened aluminium alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935[1]

Al is commonly used for the following:

- Construction of Aircraft structures, such as wings and fuselages more commonly in home-built aircraft than commercial or military aircraft, which is usually used for corrosion resistance.
- Yacht construction, including small utility boats.
- Automotive parts, such as the chassis of the Audi A8 and the Plymouth prowler.

4.2 Laser Texturing:

- A femtosecond laser is a laser which emits optical pulses with a duration well below 1 PS (→ ultrashort pulses), i.e., in the domain of femtoseconds (1 fs = 10^{-15} s)
- Laser texturing is an emerging technology for generating surface functionalities on basis of optical, mechanical, or chemical properties. Taking benefit of laser sources with ultrashort (fs) pulse durations feature outstanding precision of machining and negligible rims or burrs surrounding the laser-irradiation zone. Consequently, additional mechanical or chemical post-processing steps are usually not required for fs-laser surface texturing (fs-LST).[4]



4.3 Contact Angle:

- Contact angle, θ (theta), is a quantitative measure of wetting of a solid by a liquid. The contact angle is geometrically defined as the angle formed by a liquid at the three-phase boundary where a liquid, gas, and solid intersect.[5]
- Superhydrophobic surfaces are hydrophobic surfaces with micron or nanometer sized surface roughness. These surfaces have very large static advancing contact angles and little static contact anglehysteresis.[5]

V. FUTURE WORK

Texturing:

Laser Parameter:

1. The hatch distance of the laser is 30μm-90μm and the depth is 30μm.
2. The Scanning Speed is less than 60-70mm/s.
3. The parameter is Straight line with the crossed line.

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