University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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"Fabrication of Robust Superhydrophobic Aluminium Alloys and Their Application in Corrosion Protection"

Department of Mechanical Engineering

Thursday, September 7, 2017
2:00 P.M.
Engineering and Computer Science Building
Room 468

Supervisory Committee:
Dr. Martin B.G. Jun, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Frank C.J.M van Veggel, Department of Chemistry, University of Victoria (Co-Supervisor)
Dr. Rustom Bhiladvala, Department of Mechanical Engineering, UVic (Member)
Dr. Harry H.L. Kwok, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Seonghwan (Sam) Kim, Department of Mechanical and Manufacturing Engineering, University of Calgary

Chair of Oral Examination:
Dr. Chris Darimont, Department of Geography, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Superhydrophobic coatings attract significant attention regarding a variety of applications, such as in friction drag reduction, anti-contamination surfaces, and recently metals corrosion protection. Superhydrophobic surfaces are known to protect metals and their alloys from natural degradation by limiting water access and its surface interaction. Non-wetting properties of superhydrophobic surfaces are attributed to their low-surface energy, in combination with their surface microtexture. Several approaches based on tailoring a microtextured surface followed by surface modification with a low-surface-energy material have been employed for developing non-wetting metallic surfaces. However, developing a durable superhydrophobic coating, in terms of mechanical abrasion, thermal and chemical stability, which could server in harsh environments, is still an outstanding challenge.

In this research work two different approaches have been employed to create durable superhydrophobic aluminium alloy surfaces. In the first approach a practical and cost-effective method, which is based on direct surface acid/base etching is used to promote desired rough microstructure on aluminium alloy. Then, a facile surface modification with chlorosilanes as a low-surface-energy compound is utilized to generate surface superhydrophobicity. The superhydrophobic aluminium alloy has a water contact angle of about 165 ± 2˚ and rolling angle of less than 3 ± 0.2˚. The developed superhydrophobic aluminium alloy surfaces shows remarkable thermal stability up to 375 ˚C for 20 min.

In the second approach, a controlled hydrothermal deposition process is utilized to develop cerium oxide based coatings with well-defined microtextured surface on aluminium alloy substrates. The superhydrophobicity of the cerium oxide coatings is acquired by further treatment with trichloro(octyl)silane surface. The impacts of various hydrothermal processing conditions on surface microstructure of coatings, wettability, and ultimate corrosion protection have been also investigated. The fabricated cerium oxide based coating exhibit high level of water repellency with a water contact angle of about 170 ± 2˚ and rolling angle of about 2.4 ± 0.2˚. The superhydrophobic coatings show outstanding wear-resistance by maintaining their non-wetting properties after abrasion by #800 abrasive paper for 1.0 m under applied pressures up to 4 kPa pressure. The coatings also show remarkable chemical stability under acidic and alkaline condition and during immersion in corrosive 3.5 wt % NaCl solution for more than 2 days. They also provide excellent corrosion protection for T6-6061 aluminium alloy substrate by decreasing its corrosion rate for about three orders of magnitude.