Photothermal superhydrophobic anti-icing interface design with multi-functional protection

Yihan Zhang[1], Xiaoqiang Fan[1, *]

[1]*Key Laboratory of Advanced Technologies of Materials (Ministry of Education), School of Materials Science and Engineering, Southwest Jiaotong University, Chengdu, Sichuan 610031, P R of China*

Presenter's e-mail address: zyhzbl77@outlook.com

Abstract The disaster of low temperature rain, snow and ice will cause great harm to rail transit, power transmission network, aerospace, ships and so on[1-3]. Superhydrophobic materials can increase the nucleation barrier of ice crystals to prevent surface wetting and become a new anti-icing material[4-6]. However, in the periodic anti-icing process, the micro-structure damage caused by uncontrollable external forces and low surface energy dissipation make the Cassie-Baxter state change to the Wenzel state, making the single superhydrophobic surface anti-icing function fail[7, 8]. Therefore, improving the mechanical and chemical stability of the superhydrophobic surface is the key to enhance the service life of the superhydrophobic coating. Hence, we put forward the photothermal superhydrophobic active and passive anti-icing technology. Through the interaction of solar photons with the coating surface, heat is generated to melt ice and deliquid, and the purpose of permanent anti-icing is achieved. Specific research is as follows:

1. The photothermal superhydrophobic coating of Graphene@SiO_2 hybrid was prepared. The mechanical stability of the coating was improved by the "pinning effect" on the surface of AZ31 treated with micro-arc oxidation (MAO). The coating contact angle is 162.2°. The excellent photothermal effect of multilayer graphene results in an average coating temperature of 49.56 ℃ (200 mW/cm^2). At the same time, the coating surface has "air valley", the barrier effect is enhanced, acid resistance, corrosion resistance.

2. Using plasma electrolytic oxidation (PEO) technology, porous black ceramics with narrow band gap semiconductor properties were formed in situ on the surface of AZ31 magnesium alloy. At the same time, polydimethylsiloxane micro-nano particles were loaded. The results show that the composite coating has a band gap of 3.62 eV, the photothermal temperature of 69.4 ℃ (200 mW/cm^2), the contact angle of 156° , and excellent anti-icing performance and long-term stability.

Keywords: Superhydrophobic, Photothermal, Anti-icing, Anti-corrosion

Reference:

[1] Z. Wang, Recent progress on ultrasonic de-icing technique used for wind power generation, high-voltage transmission line and aircraft, Energy and Buildings 140 (2017) 42-49.

[2] P.-O.A. Borrebæk, B.P. Jelle, Z. Zhang, Avoiding snow and ice accretion on building integrated photovoltaics-challenges, strategies, and opportunities, Solar Energy Materials and Solar Cells 206 (2020) 110306.

[3] W. Wei, L. Ni, W. Wang, Y. Yao, Experimental and theoretical investigation on defrosting characteristics of a multi-split air source heat pump with vapor injection, Energy and Buildings 217 (2020) 109938.

[4] K. Golovin, A. Dhyani, M.D. Thouless, A. Tuteja, Low-interfacial toughness materials for effective large-scale deicing, Science 364(6438) (2019) 371-375.

[5] W. Huang, J. Huang, Z. Guo, W. Liu, Icephobic/anti-icing properties of superhydrophobic surfaces, Advances in Colloid and Interface Science 304 (2022) 102658.

[6] A. Khadak, B. Subeshan, R. Asmatulu, Studies on de-icing and anti-icing of carbon fiber-reinforced composites for aircraft surfaces using commercial multifunctional permanent superhydrophobic coatings, Journal of Materials Science 56(4) (2021) 3078-3094.

[7] F. Wang, Y. Zhuo, Z. He, S. Xiao, J. He, Z. Zhang, Dynamic Anti-Icing Surfaces (DAIS), Advanced Science 8(21) (2021) 2101163.

[8] S. Farhadi, M. Farzaneh, S.A. Kulinich, Anti-icing performance of superhydrophobic surfaces, Applied Surface Science 257(14) (2011) 6264-6269.