Topical Symposia
Room Grand Hall - Session TSP-ThP
Topical Symposia (TS) Poster Session

TSP-ThP-1 Surface Modification of Multiwalled Carbon Nanotubes for Electro-Thermal Heating in Ice Protection*, **Francesco Zangrossi**, F Xu, N Warrior, X Hou,* University of Nottingham, UK

Icing inevitably occurring on the surfaces of aircraft causes a serious concern of flight safety. Various de-icing strategies have been developed to overcome the icing problems on aircraft. Electro-thermal technique is categorized as heat generated by internal electrical component and transferred to the outer surface for ice protection. Given the increased use of composites on aircrafts structure, self-heating fibre reinforced polymer composite have been studied as de-icing system for the new generation aircraft. In the present work, electrical resistance of multi-walled carbon nanotubes (MWCNTs) was modified by two approaches: functionalisation by acid treatment and silver decoration techniques. The aim was to reduce the electrical resistance of the carbon nanotube networks. To evaluate the electrical resistance of carbon nanotubes, MWCNTs coated glass fibres samples prepared by filtration method. The results showed that MWCNTs treated by silver decoration via Tollen reaction had increased the electrical resistance. On contrast, the functionalisation by acid treatment of the carbon nanotubes reduced the resistance by approximate50%. Treated MWCNTs with improved electrical conductivity were used to produce multiwall carbon nanotube paper (MWCNP) and a composite structure with glass fibres and epoxy matrix. De-icing tests will be carried out to verify the electro-thermal performance in a climate chamber.

TSP-ThP-2 Nanostructured a-C:H:SiOx Coatings with Superhydrophobic Properties*, **Damian Batory**,* Lodz University of Technology, Poland*; J Lengaigne,* Ecole Polytechnique de Montreal, Canada*; A Jedrzejczak,* Lodz University of Technology, Poland*; S Brown, J Klemberg-Sapieha,* Ecole Polytechnique de Montreal, Canada

The main aim of the work was to obtain carbon and silicon based amorphous layers with different surface morphology allowing to obtain superhydrophobic properties. SiOx incorporated diamond-like carbon coatings with different thicknesses were synthesized onto reactive ion etched silicon wafers with previously deposited thin layer of gold. An island shape of the thin golden layer made it possible to obtain selectively etched pillar-like structure of silicon surface with morphology depending on the time of etching. A combination of different structures of the silicon substrates with three thicknesses of subsequently deposited a-C:H:SiOx layers enabled to obtain six sets of samples with respect to the thickness of the coatings and morphology of the substrate. The obtained coatings were characterized using scanning electron microscopy, Raman spectroscopy and atomic force microscopy. Finally the contact angle was measured using sessile drop technique. Additionally the contact angle hysteresis and roll-off angle were determined. As the result of the investigation it was noticed that the structure and morphology of the silicon substrates change with the time of etching. The deposition of a-C:H:SiOx coatings onto the reactive ion etched silicon substrates decreases the roughness parameters and surface area, which progress with increasing thickness. However, an optimal surface morphology correlated with a proper thickness of the coating resulted in contact angle exceeding 150 deg.

TSP-ThP-4 Structural Investigation of the Stability in Temperature of Some High Entropy Alloys*, **Monique Calvo-Dahlborg**,* University of Rouen Normandie-CNRS, France, Swansea University, UK*; U Dahlborg, J Cornide,* University of Rouen Normandie-CNRS, France*; S Mehraban,* College of Engineering, Swansea University, UK*; R Wunderlich,* University of Ulm, Germany*; N Lavery,* College of Engineering, Swansea University, UK*; S Brown,* Swansea University, UK

It has been shown in a previous study [1] that High Entropy Alloys (HEA) can be classified in three domains according to their e/a and r values, e/a being the number of itinerant valence electrons as calculated by Massalski [2] and r being the average radius for a 12 local neighborhood [3]. $CoCr_zFeNi$-XY (with X and Y = Al, Cu, Pd, Ru, Ti and z=0 or 1) HEAs from the three domains identified by e/a have been investigated in as cast conditions (T0), after 3 hours homogenization at 1100°C (T1) and after 3 hours annealing at 700°C (T3). The comparison is based mainly on diffraction and calorimetry results.

It is observed that for the alloys from domain I which contains fcc structures, the microstructure transforms from multi- to almost single-phase under homogenization. In Domain III which contains cubic (Bcc+B2) structures very small multi-structural changes are observed. The alloys in domain II have mixed structure which is changing under heat treatments. Morover, an additional heat treatment at T3 after homogenization leads in all domains to the appearance of other phases. All results are confirmed by the calorimetric results. The effect of heat treatments on hardness is discussed for some compositions.

[1] M. Calvo-Dahlborg, S.G.R. Brown. *J. Alloys and Compds* **724** (2017) 353-364. http://dx.doi.org/10.1016/j.jallcom.2017.07.074

[2] T.B. Massalski, *Materials Transactions* **51** (2010) 583-596. https://doi.org/10.2320/materia.49.192

[3] E.T. Teatum, K.A. Gschneidner Jr., J.T. Waber, 1968. Report LA-4003. UC-25. Metals, Ceramics and Materials. TID-4500, Los Alamos Scientific Laboratory.

TSP-ThP-6 Cu-nanoparticles /Polyfluoroacrylate Emulsion Nanocomposite Coating for Icephobic Applications*, T Barman, H Chen, J Liu, **Xianghui Hou**,* The University of Nottingham, UK

Atmospheric ice accumulation and adhesion on component surfaces often causes great concerns in various industries, especially for aerospace in which catastrophic accidents may occur under inflight or ground icing conditions. Applying icephobic coatings on the components surface has been considered as a promising solution for minimising the accumulation of ice and prompting the removal of the ice from the surface. In the present work, a nanocomposite coating has been developed by mixing Cu-nanoparticles with synthesized polyfluoroacrylate (PFA) emulsion and depositing the mixture on the substrates by spin coating method. Surface hydrophobicity of 140 ° was achieved on the surface of the nanocomposite coating, which has the average surface roughness (R_a) in the range of 0.2 to 0.3 µm. Ice adhesion of the coating was measured by centrifugal approach and it was found that the ice adhesion strength has been effectively reduced as compared to reference surface. De-icing performance of the coating was also evaluated using electro-thermal heating method and 35 % decrease in energy consumption was observed as compared to uncoated aluminium surface.

TSP-ThP-7 Surface Characteristics and Diffusion Phenomenon of $Ni_2FeCoCrAl_x$ Alloys Treated by Atmospheric Pressure Plasma*, **Chi-Ruei Huang**,* National United University, Taiwan*; J Duh,* National Tsing Hua University, Taiwan*; F Wu,* National United University, Taiwan

High entropy alloys, HEAs, recently attracted intense attention due to its outstanding performance in mechanical properties, thermal stability, sluggishness in diffusion, anti-sticking, corrosion resistance, etc… However the knowledge of the evolution of microstructure and surface characteristic of HEAs under treatments through atmospheric pressure plasma jet, APPJ, was limited. In present study, Al incorporated $Ni_2FeCoCr$ high entropy alloys were treated by APPJ to investigate the surface property evolution and diffusion characteristics on HEAs surface. The treatment parameters included gas source, input power, flow rate, and torch-surface distance, ranged from dry air to N_2, 850 to 1100 W, 35 to 50 sccm, and 15 to 50 mm, respectively. The slow and stable Ni showed limited diffusion and reaction even against highest power input under air. The surface microstructure and property evolution were attributed to the elemental redistribution of the active Al in the designed HEAs. The detailed concentration profiles, phase, and surface characteristics were analysed and discussed in consideration of concentration gradient, microstructure evolution, and chemical potential.

TSP-ThP-8 Development of Microwave Remote Plasma Source for New Surface Functionalization*, Y Isomura, Y Ikari, **Tadao Okimoto**, Y Tauchi, K Nishiyama,* Kobe Steel, Ltd., Japan*; H Toyoda, H Suzuki,* Nagoya University, Japan

We developed the so-called Twin-Roll Plasma Enhanced CVD (PECVD) integrated into an industrial roll to roll process for surface functionalization of a flexible substrate. In Twin-Roll PECVD process the winding rolls themselves function as the electrode for plasma discharge and hence provide a stable deposition process for a long time even for deposition of non-conductive films as compared to typical pulse PECVD process. In this technique, however, the direct plasma discharge occurs between the electrode winding rolls and hence the substrate material needs to be electrically non-conductive. The application of the direct plasma method to a conductive substrate is therefore practically limited.

We have been developing a microwave remote plasma source and its integration into roll to roll process as for demonstration of a new surface functionalization technique. In direct plasma discharge process such as in the case of Twin-Roll PECVD, for instance, ion bombardment/irradiation is expected during the film growth by application of a negative bias potential to the electrode. The ion bombardment effect is known to be quite effective for microstructural control of the growing film and hence the film properties. Application of bias voltage to the electrode is however not feasible when a conductive substrate is employed. In the remote plasma source developed, a positive bias potential is applied at a point of plasma source, and the plasma potential is increased with respect to a grounding substrate, accordingly. This source is a linear type exhibiting a possible plasma treatment on a large area with high uniformity. In this work we present the basic principle and function of this remote plasma source. We also demonstrate some applications thereof for film deposition, contributing towards a new technique for surface functionalization.

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