UNIVERSITY OF LEICESTER

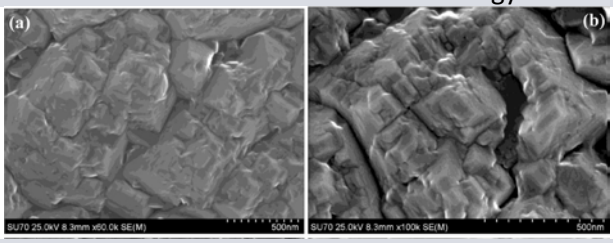
CSE-ENG11-YE

Self-lubrication carbon coatings for aerospace dry drilling application

Highlights

- Research on novel type of carbon coatings formed by PVD and CVD
- Training on functional thin film growth and characterisation using the state-of-the-art research facilities at Advanced Spectroscopic Centre
- Unique opportunity to explore the potential application in aerospace industry

Level	PhD
First Supervisor	Prof Haitao Ye
Second Supervisor	Prof Richard Ambrosi
Application Closing Date	21st January 2019
Subject Areas	Astrophysics Materials Science Mechanical Engineering Nanotechnology



High-resolution SEM images of the nanocrystalline diamond coatings grown by chemical vapour deposition.

Overview

For the Aerospace Industry, precision drilling is a very important topic for the production, especially for drilling of Aluminium components, e.g. the combined hard and soft Aluminium alloy skin. The coatings for drills are needed not only for having a satisfied drilling life, but also for overcoming the stickiness from drilling materials, which could potentially damage the precision of drilling holes. Many drilling manufactories have started to modify drill's geometry and use coatings to improve the drilling properties under the current water/solvent based lubricated condition. Unfortunately, the choices are limited with a current hard coating dominated market.

Furthermore, due to the liquid coolant, there are many complex production processes introduced e.g. seals of the component. It also causes many quality issues during the process. The implementation of a lubricant-free drilling solution for in-situ, semi-automated drilling of aero-structures will avoid the high costs of lost time during industrial process.

Aerospace industries have for some years looked into the possibilities of removing lubricants from the majority of its operations. Numerous attempts by multiple tooling companies have tried but failed to find a solution. The idea of using physical vapour deposition system (PVD) and chemical vapour deposition system (CVD) for the growth of i-graphite /nanodiamond is novel and critical as it is the first attempt to grow multilayers for self-lubrication purpose, which will make adaptation of cutting tools to perform operations without the requirement of lubrication.

The properties of high quality carbon based coatings, such as PVD coatings (i-graphite, industrial patented material) and CVD coatings (nanodiamond, grown at Leicester) have been widely recognized as the basis for a wide range of tribological applications. Such materials possess the best properties for hardness and thermal conductivity of any known material and also have an extremely low friction co-efficient, which could be improved and potentially used for dry drilling applications, especially in aerospace industries. In addition, these carbon-based materials offer high

surface smoothness, high chemical inertness, radiation hardness, which are all desired for tribological applications in harsh environment.

The aim of this project is to synthesis, engineer and functionalize carbon based PVD and CVD coatings for a wide range of high value added dry drilling applications, including aircraft alloy skin, bearing, seals, cutting tools.

Methodology

- Undertake systematic studies of the process parameters of both PVD and CVD synthesis using numerical modelling to optimize the growth conditions required for carbon-based materials (i-graphite, nanodiamonds). This will improve parametric control and quality assessment.
- Carry out novel i-graphite coating growth using TCL's patented PVD system, and nanodiamond coating growth using Leicester's CVD system, respectively; to evaluate the distribution, morphology, structure and mechanical properties of the i-graphite and nanodiamond coatings on alloys.
- Based on ii) we will develop a novel multilayer coating process system based on the best attributes of both the PVD and the CVD process. We will evaluate new multilayer coatings and their self-lubricating properties with enhanced thermal stability and low affinity for aluminium alloys.
- Optimized multilayer coatings will be tested under simulated Space environment to evaluate their lifetime and durability via Space Research Centre at Leicester.

Further Reading

1. M. Zolgharnia, B. J. Jonesb, R. Bulpettb, A.W.Ansona, J. Franksc, Energy Efficiency improvements in drying drilling with optimised diamond-like carbon coatings, Diamond and Related Materials, 17 1733 (2008). doi: 10.1016/j.diamond.2007.11.012
2. V. Kundrát, X. Zhang, K. Cooke, H. Sun, J. Sullivan, H. Ye, A novel Mo-W interlayer approach for CVD diamond deposition on steel, AIP Advances 5, 047130 (2015). https://doi.org/10.1063/1.4918969
3. H. Xu, H. Ye, D. Coathup, I.Z. Mitrovic, A.D. Weerakkody, X. Hu, An insight of p-type to n-type conductivity conversion in oxygen ion-implanted ultrananocrystalline diamond films by impedance spectroscopy, Applied Physics Letters 110 (3), 033102 (2017). https://doi.org/10.1063/1.4974077

Funding

This research project is one of a number of projects in the Department. It is in competition for funding with one or more of these projects. Usually the project which receives the best applicant will be awarded the funding.

Home/EU Applicants

This project is eligible for a fully funded College of Science and Engineering studentship which includes :

- A full UK/EU fee waiver for 3.5 years
- An annual tax free stipend of £14,777 (2018/19)
- Research Training Support Grant (RTSG)

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International Applicants

This project is eligible for a fully funded College of Science and Engineering studentship which includes :

- A full international fee waiver for 3.5 years
- Research Training Support Grant (RTSG)

Application Instructions

The online application and supporting documents are due by **Monday 21st January 2019**.

Any applications submitted after the deadline will not be accepted for the studentship scheme.

References should arrive no later than **Monday 28th January 2019.**

Applicants are advised to apply well in advance of the deadline, so that we can let you know if anything is missing from your application.

Required Materials

1. Online application form
2. Two academic references
3. Transcripts
4. Degree certificate/s (if awarded)
5. Curriculum Vitae
6. CSE Studentship Form
7. English language qualification

Applications which are not complete by the deadline will not be considered for the studentship scheme. It is the responsibility of the applicant to ensure the application form and documents are received by the relevant deadlines.

All applications must be submitted online, along with the supporting documents as per the instructions on the website.

Please ensure that all email addresses, for yourself and your referees, are correct on the application form.

For more information, please visit our website at :
https://www2.le.ac.uk/colleges/scieng/research/postgraduate-opportunities/cse-2019/instructions