The University Of Sheffield.

The Leonardo Tribology Centre

Al-based PVD Nanocomposite Coatings for Wear and Corrosion Protection

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Introduction

The motive for most new multifunctional coatings has been the enhancement of the tribological properties of engineering components. However, there are applications in which there is simultaneously a corrosive environment and an abrasive load. Hence, it is important to improve (by appropriate Surface Engineering methods) both wear and corrosion properties of engineering components.

Project Description

Though ceramic coatings produced by physical vapour deposition demonstrate attractive functional properties of high hardness and chemical inertness, they are not easy to deposit at a thickness adequate to provide satisfactory corrosion protection of a metal substrate. PVD metallic coatings in general do not suffer such thickness restrictions. Thick (in excess of 10 µm), lightly-stressed coatings, with insignificant porosity can, in principle, be produced at a rate of 10µm/hr or higher. Exploring the possibilities of pairing certain low-miscibility transition metals, - e.g. titanium/chromium/zirconium with copper/nickel - and the ability, with the selection of appropriate deposition parameters, to preferentially supersaturate the 'early' transition metal (i.e. Ti, Cr, Zr) with nitrogen (or other interstitially-located elements), thick metallic nanocomposite coatings can be produced. These coatings exhibit excellent wear resistance owing to their high hardness/elastic modulus ratio (H/E) and, may also possess many other potentially desirable properties (e.g. toughness and corrosion protection – sacrificial as well as 'barrier') inherent to metallic coatings - especially with the addition of aluminium as a base. These nanocomposite coatings which comprise a hard nanocrystalline phase embedded in an amorphous matrix exhibit improved properties over a range of varying conditions. A clear understanding of how deposition parameters affect the composition, structure and properties of such 'as-deposited' coatings is required. Other studies planned for this research work will include, for example, coating heat-treatment conducted at different temperatures (above the deposition temperature), to (i) assess coatings thermal stability and (ii) investigate possible improvements in physical and mechanical properties. All these will provide valuable information which may be linked to wear and corrosion behaviour

Methodology

Coating Deposition: Coatings will be deposited on austenitic stainless steel (304), low alloy steel (4145) and silicon wafers using closed-field unbalanced magnetron sputter equipment (fig 1) in reactive (N_2) atmosphere.

Fig.1Sputter Deposition Equipment

Characterisation

- *Scanning electron microscopy*
- *Energy-dispersive x-ray spectrometry*
- *X-ray diffractometry*

Testing

- *Nanoindentation Test*
- *Reciprocating-sliding Wear Test*
- *Micro-abrasion Wear Test*
- *Impact Test*
- *Potentiodynamic Polarization Scans*
- *Thermal Analysis using TGA and DSC*

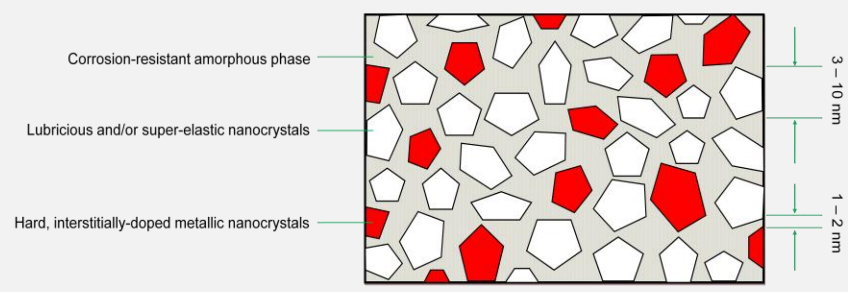
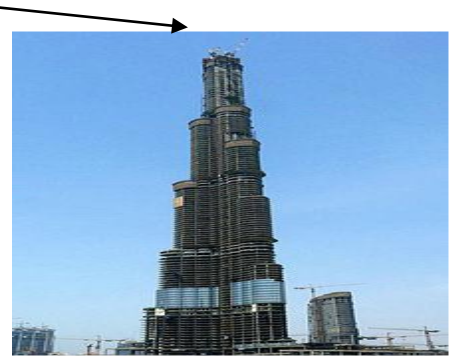


Fig.2 Schematic example of possible Aluminium-rich nanocomposite structure

Benefiting Industries



The coatings produced will provide alternatives to electroplated cadmium, IVD-aluminium, electroplated hard chromium, electroless nickel and other 'traditional' coatings used in aerospace, automotive and other engineering applications – where environmental legislation is restricting the use of toxic processes and materials. These metallic coatings with multifunctional and adaptive properties, will suit a range of technically challenging environments.

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