Nanomechanics and Tribology of Thin Films and Coatings

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Course objectives
- To understand the rationale for measuring coating mechanical properties independent of substrate and how coating microstructure affects such properties
- To learn measuring the elastic, plastic and fracture properties of thin films and coatings.
- To understand the use of appropriate measurement techniques to monitor effects of stress generation and relaxation in coated systems
- To gain an appreciation of Coatings Tribology and coating/treatment selection for particular applications
- To understand how coating property data can be used to design better Surface Engineering solutions

Course Description
This course aims to give an understanding of the factors which control the mechanical properties of thin films and coatings and how these properties may be reliably measured. The differences between coating properties and those of the coating/substrate system (and the influence of micro-/nano-structure on wear and friction behavior) will be highlighted. The differences between mechanical property data used for design and that which can be measured by a simple test will be emphasised. Extraction of mechanical property data for thick coatings using conventional mechanical tests will be discussed – as will difficulties in measuring submicron coatings by conventional test methods. A discussion on the use of indentation and scratch tests is followed by a review of instrumented indentation – and how to extract reliable property data. The importance of the scale of the deformed volume with respect to the microstructural dimensions (and how size effects modify the data for small indenter penetrations) will be explained. The importance of mechanical properties and residual stress on coating adhesion will also be illustrated. Robust thin-film property data (such as Hardness and Elastic modulus, correctly extracted from instrumented indentation) can be used as design tools to optimize the coating/substrate system for different applications. A comprehensive overview of key tribological design criteria will be provided, including (for example) use of the H/E ratio as a mechanical design consideration for selecting appropriate coating and substrate pairings (including substrate pre-treatments, where needed). Practical examples and case studies will be used to exemplify Surface Engineering solutions to wear/friction issues.

Course Content
- The importance of mechanical properties of coatings, interfacial regions and coating/substrate systems
- Designed vs. measured properties in thin films and microstructure/mechanical property relationships
- Assessment of thick coatings using conventional mechanical tests
- Factors affecting indentation testing for thin film property assessment
- Measurement and assessment of factors affecting coating/substrate adhesion
- Coatings tribology considerations for wear and friction control
- Design criteria for substrate and coating/treatment selection

Who Should Attend?
Engineers, scientists and students interested in mechanical property evaluation of coatings and the design of coatings and treatments to address issues of wear, friction and other functional property requirements

Course Materials
Course notes (PowerPoint files) and reference lists will be provided.