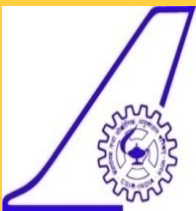
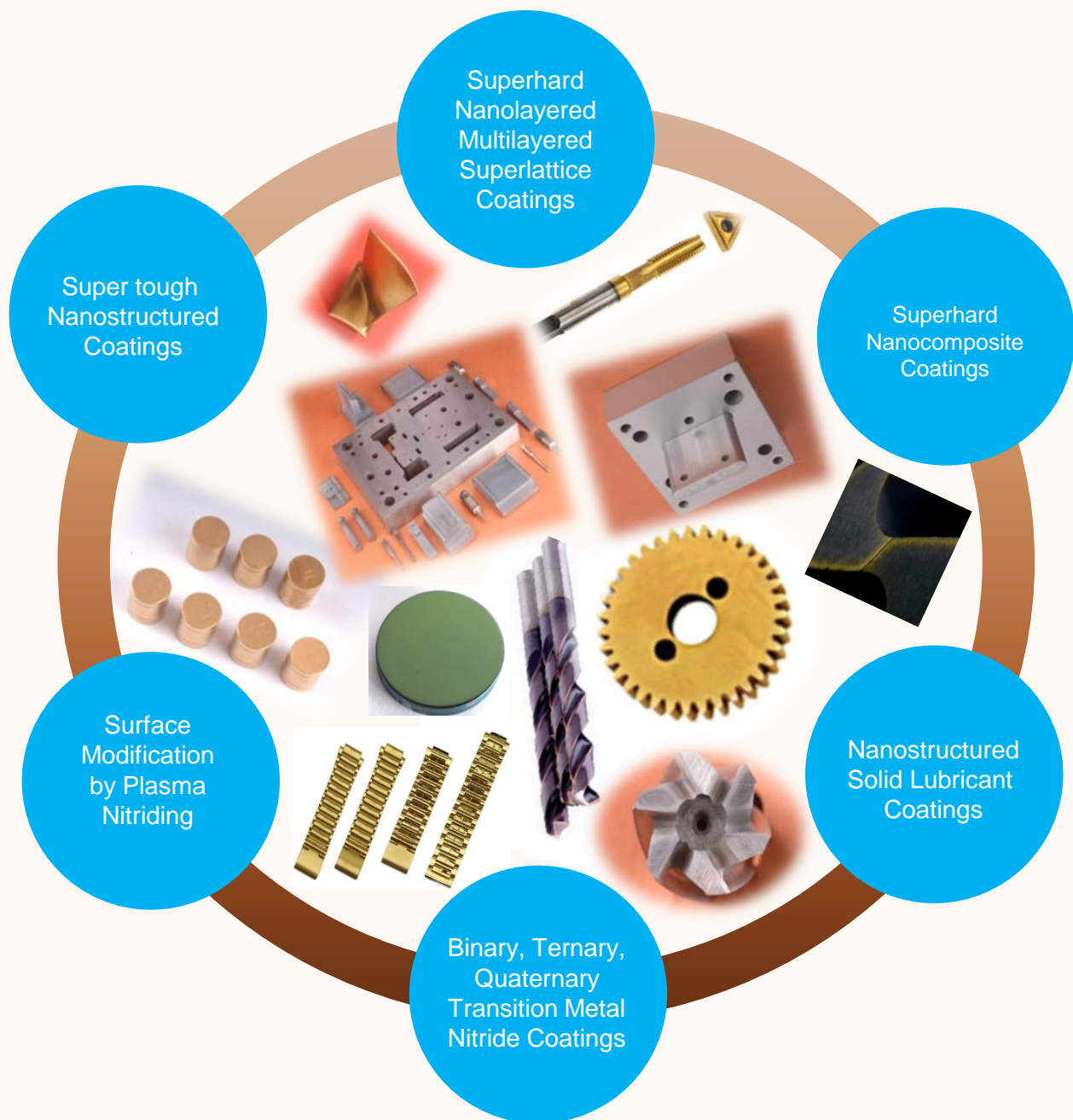
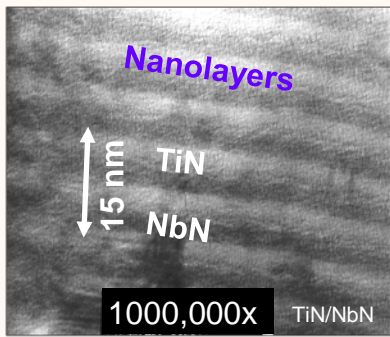


High Performance Nanostructured Tribological Coatings for Advanced Engineering Applications

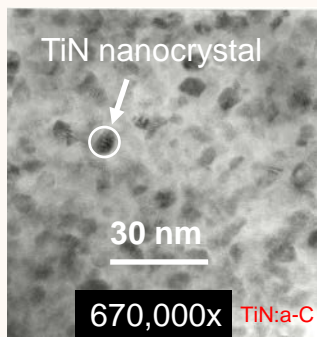


CSIR–National Aerospace Laboratories
Bangalore
India

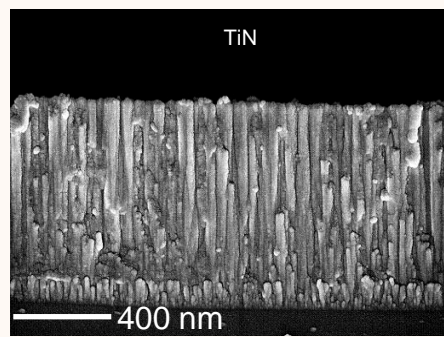




Multilayer coating



Nanocomposite coating

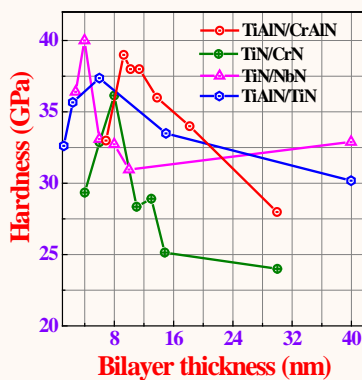


Typical PVD coating

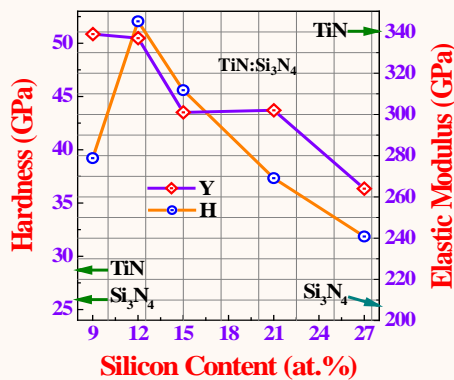
Preamble. In order to meet the ever changing technological demands, surface modification of advanced engineering materials is essential to improve their performance under complex service conditions. Application of protective coatings at affordable cost is one of the ways to improve the performance of the engineering materials. At CSIR-NAL, over the years, a variety of transition metal nitride/oxide/carbide based superhard coatings (hardness > 40 GPa) with superior wear, oxidation and corrosion properties have been developed on various engineering components (size up to 150 mm) using the concept of nano-scale architecture. To address the needs of the aerospace sector, solid lubricant coatings with extremely low friction coefficients and superior mechanical properties have been developed. These coatings are capable of operating under harsh conditions in ambient and vacuum. CSIR-NAL also has the know-how for plasma nitriding for the surface modification of a variety of ferrous and superalloys.

Current Level of Technology. In order to develop high speed machining capabilities of difficult-to-machine engineering materials, and wear protection of critical engineering components, CSIR-NAL has developed several high performance nanostructured tribological coatings on components such as: drill bits, inserts, dies, tapping tools, end mills, micro-cutting tools, gears, piston rings for automobiles, IDCA pistons, stamping tools, watch straps, etc. These coated components exhibit improvement in their performance by many folds. The know-how for development of technology for commercial production of the PVD coatings is available with CSIR-NAL.

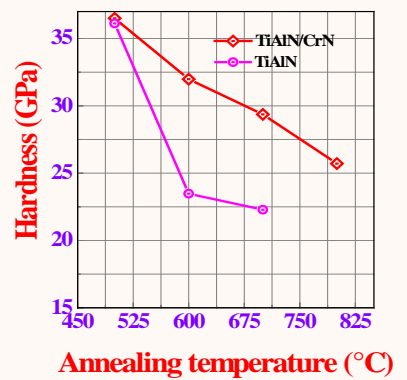
Mechanical properties of nanolayered multilayer coatings & nanocomposite coatings



Hardness of multilayers

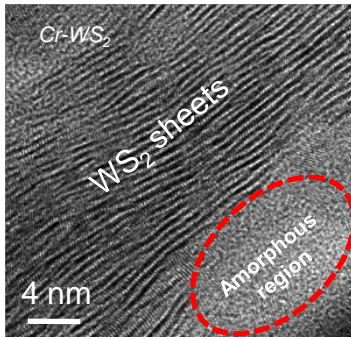


Hardness of nanocomposites

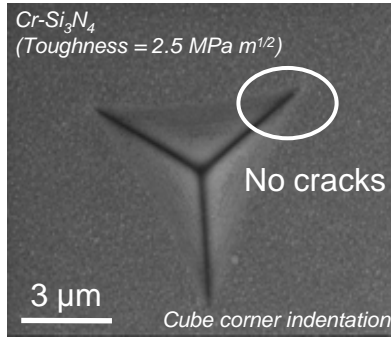


Hardness at elevated temp.

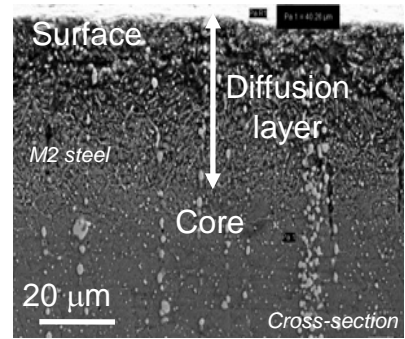
Salient feature: High hardness, high toughness, high wear resistance and high oxidation resistance.



Solid lubricant coating



Supertough coating

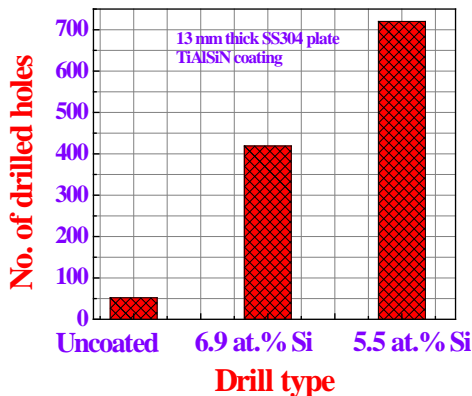


Plasma nitrided surface

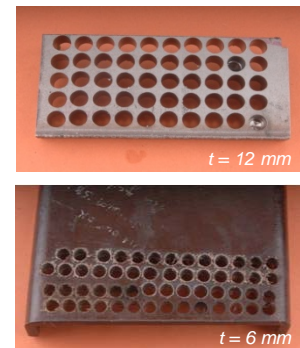
Design and Composition of Various High Performance PVD Coatings

| Coating Type | Composition |
|--|--|
| <ul style="list-style-type: none"> Ceramic/cermic nanolayered multilayer superhard coatings Superhard nanocomposite coatings | TiN/NbN, TiN/CrN, TiAlN/TiN, TiAlN/CrN, TiAlN/CrAlN, CrN/CrAlN, ZrO ₂ /Al ₂ O ₃ , ZrO ₂ /Y ₂ O ₃ TiN:a-C, TiN:Si ₃ N ₄ , TiAlN:Si ₃ N ₄ , CrN:Si ₃ N ₄ , CrAlN:Si ₃ N ₄ , TiAlSiN, TiAlCrYN |
| <ul style="list-style-type: none"> Nanostructured solid lubricant coatings Nitride coatings | WS ₂ , MoS ₂ , Cr-WS ₂ , CrN-WS ₂ , Au-WS ₂ , PTFE, Ag-Si ₃ N ₄ TiN, CrN, TiAlN, Si ₃ N ₄ , AlN, NbAlN, CrAlN, MoN, HfAlN, AlTiN, VN, NbN, TaN |
| <ul style="list-style-type: none"> Metal-ceramic supertough coatings Carbide coatings Oxide coatings | Cr:Si ₃ N ₄ , Ti:TiN, TiAl:TiAlN TiAlC, TiAlSiC, WC, TiC Al ₂ O ₃ , Y ₂ O ₃ , ZrO ₂ , SiO ₂ , TiO ₂ , HfO ₂ , ITO, MoO ₂ , ZnO, WO ₃ , Cr ₂ O ₃ |
| <ul style="list-style-type: none"> Plasma nitrided surfaces | M2 and M42 tool steel, maraging steel, die steel, Inconel 718 |

Machining Performance of the Nanostructured PVD Coated Tools



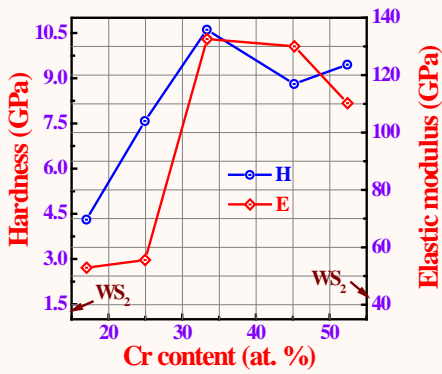
Nimonic 75



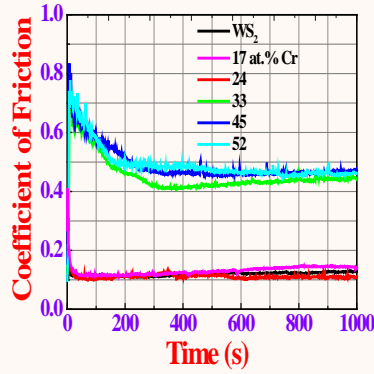
Ti6Al4V and carbon composite

Salient feature: Superalloys, Ti alloys, carbon composites and stainless steel can be machined efficiently.

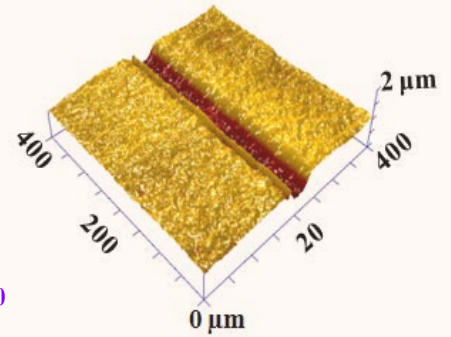
Nanostructured Solid Lubricant Coatings for Aerospace Applications



Mechanical properties



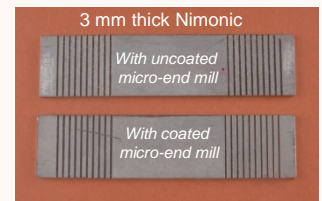
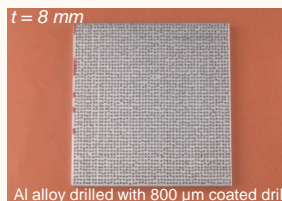
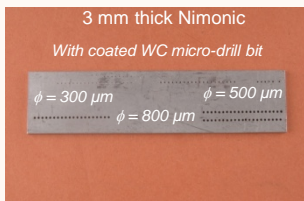
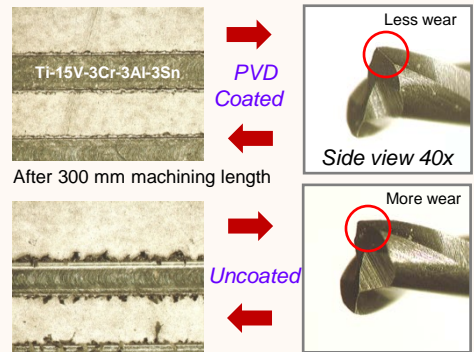
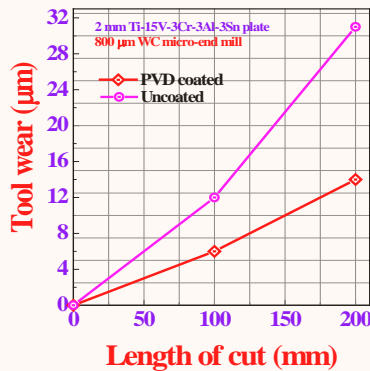
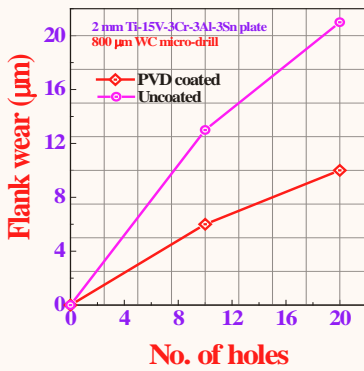
Tribological properties



Wear track

Salient feature: Can operate under harsh conditions in vacuum and ambient conditions.

Micro-machining of Difficult-to-Cut Aerospace Alloys



Salient feature: Coated tools as small as 300 μm in diameter have been tested on Ti and superalloys.

Funding: CSIR, NAL, DST

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