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PVD, PACVD and CVA Coatings for the Aerospace Industry

SJAC 2014 Meeting, Farnborough UK, July 16th 2014, Dr. Val Liebermann

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Ionbond Group Overview

A global leader in the CHF 1 bn coating services market.

- 2013 sales CHF 130 million
  985 employees
- Headquarters in Zürich, Switzerland
- 38 coating centers in 17 countries
  Europe, North America, Asia

- Broadest technological offering on the market
  - PVD
  - CVD
  - PACVD
  - CVA

Aerospace Applications

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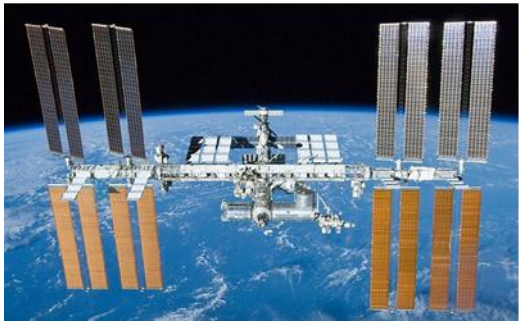
- Thin Film Coatings in Aerospace
  - Modern solution for increase of reliability and lifetime of mechanical components;
  - Environmentally friendly alternative to other coating technologies (e.g. electroplating);
  - Ability to boost performance while reducing weight, use of less expensive materials;
  - Indirect impact: Improving efficiency of manufacturing technology – cutting, forming, casting;



Jet Engine Applications

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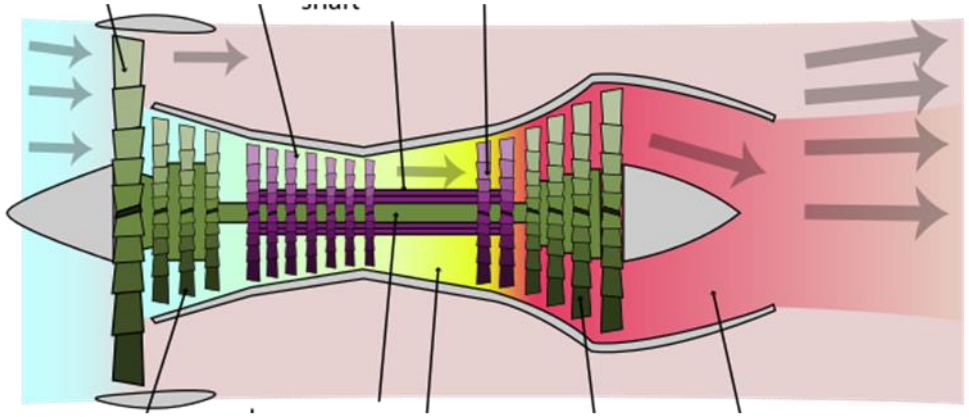
- Thin film coatings are applied for protection against:
  - Erosion;
  - HT Oxidation and hot corrosion;
  - Fretting;
  - Galling/seizure;
  - Surface fatigue;
  - (Sand) sticking;
  - Thermal impact (TBC);
  - General corrosion.

LPC Components – Erosion, Corrosion	HPC Components – Erosion, Buildup	HPT Components – HT Oxidation, Hot Corrosion



Surface fatigue: gears of geared fan engines	Fasteners: galling, oxidation	Fretting: vanes, blades, §bearings

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Jet Engine: Erosion Protection

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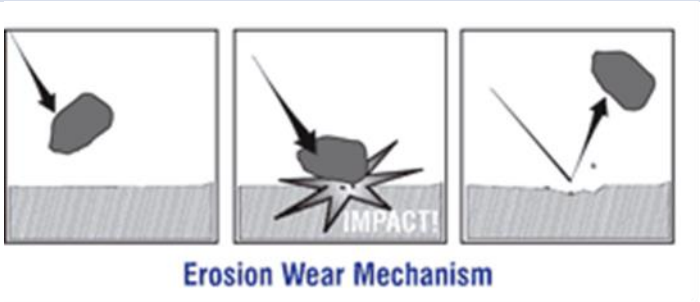
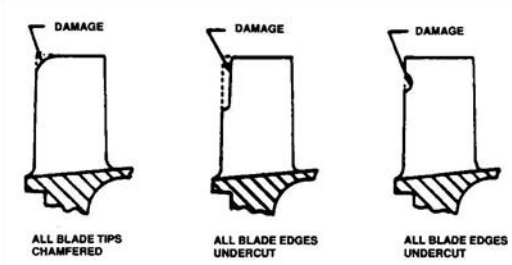
- Erosion of compressor blades:
  - Leads to:
    - power loss,
    - higher fuel consumption and emission of pollutants;
  - Manifests as:
    - leading and trailing edges chord loss;
    - profile change;
    - tip loss;
  - Caused by ingestion of sand, fly ash, salt, ice
- PVD coatings are applied on blades for protection against erosion in LPC and HPC;





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Jet Engine: Fretting Wear Protection

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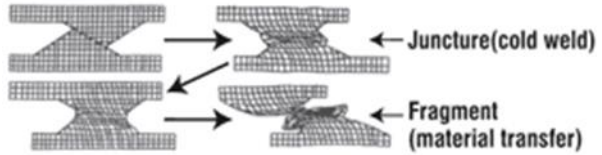
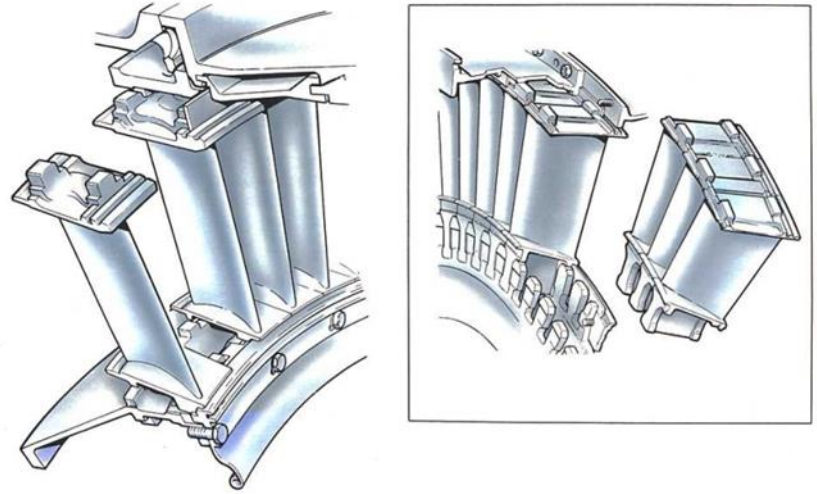
- Fretting motion occurs between dovetail joint (root) of a blade and disk;
- Fretting: adhesive transfer of material between contacting surfaces: leads to pits, abrasive wear, crack formation;
- Remedies:
  - High hardness – PVD coatings;
  - Low friction – PVD coatings;
  - Material selection – PVD coatings;
  - Compressive stress – PVD coatings.



Adhesive wear occurs in highly-loaded, poorly lubricated slidingmachine contacts.



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Jet Engine: Micro Spark Coating

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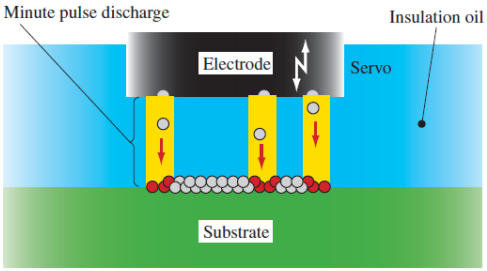
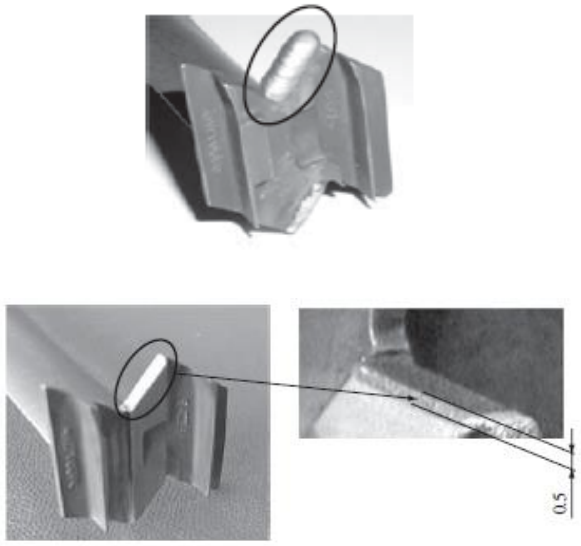
- Micro Spark Coating (MSC) is a variant of electro spark deposition;
- Protects against wear and fretting at normal and elevated temperatures;
- Wide range of deposited materials, including application-specific compositions;
- Thickness of more than 50µm; repair applications are possible;
- Applications: shrouds, blade tips, cladding repair, labyrinth seals.





Low pressure turbine shroud: welding (above), MSC coating (below)

Source: IHI Corp.

Applications on Aerospace Fasteners

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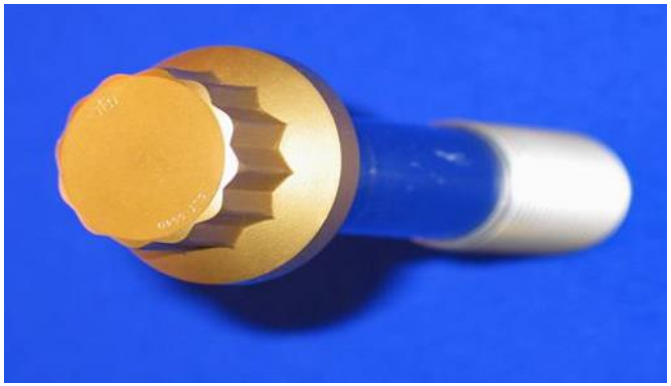
- Function:
  - Protection against galling and seizure;
  - Corrosion protection;
- Working temperatures from -60 of up to 800 C;
- Traditional coating: Ag electroplating; Cd plating (not permitted for the engine use);
- Potential replacement: TiN, CrN, CrON; DLC (for temperatures < 350 C);



CVD Aluminizing (CVA)

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- Diffusion bond coating for turbine components; Ni_xAl_y intermetallide based;
- Provides protection against HT oxidation and hot corrosion; forms alumina (TGO) for reliable bonding of TBC layer;
- Halide CVD process for aluminizing;
- Alternative to powder-based techniques (pack, out-of-pack, slurry);

Ionbond Bernex CVD Aluminizing Reactor

Applications for Airframe Components

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- Protection against fretting is one of the most common coating appications;
- Use of fretting-prone materials (Ti, Al, SS) in combination with vibrations accentuates fretting issues;
- Spherical bearings, mounts, knuckle joints are among typical components benefiting from thin film coatings;
- Typical coatings are nitrides and carbon-based films;






Conclusions

- Thin Film Coatings use in aerospace industry increases; however they still remain a relatively exotic solution;
- High cost of testing and ‘risks of change’ deter quicker penetration of thin films;
- In certain aerospace applications, thin films are‘designed-in’ solutions for wear and corrosion protection;
- Further promotion of thin film benefits will help with their broader acceptance in the industry;

Questions?

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