GTF Aerospace Inc.

NANO COATINGS – AERO PERSPECTIVES

March 2009

AEROSPACE

Corporate

Overview

- GTF Aerospace Inc. was founded in 2001 and since then has experienced rapid development.
- The company's success is based on an extensive IP portfolio, combined with comprehensive development and application know-how.
- To date Process and Equipment Development consumed 32,000 PhD. Man hours and over 100,000 Mac. hours of Engineers

Strategy Pillars Aerospace

- Market Leadership in the field of high performance coatings for large OEM,MRO and PMA customers
- Continuing increase in the industrial scalability of our process applications
- Focus on research and development, as well as the protection of IP by patents associated with economic roll-out of our products
- Deliver high quality nanotechnology products on an industrial scale with high customer benefit

Technology Drivers Aircraft Engines

In 2002 the Advisory Council for Aeronautical Research in Europe Stated:

We need improved or new engine designs to reduce:

- CO2 emissions by 50%
- NOx emissions by 80%
- Fuel consumption by 20%
- Maintenance costs by 25%

BIG However - the possibility of obtaining improved mechanical properties by the conventional methods of cold working, solution hardening, precipitation hardening, etc., has been almost exhausted. Bulk Nano alloys are many years away from industrial relevance

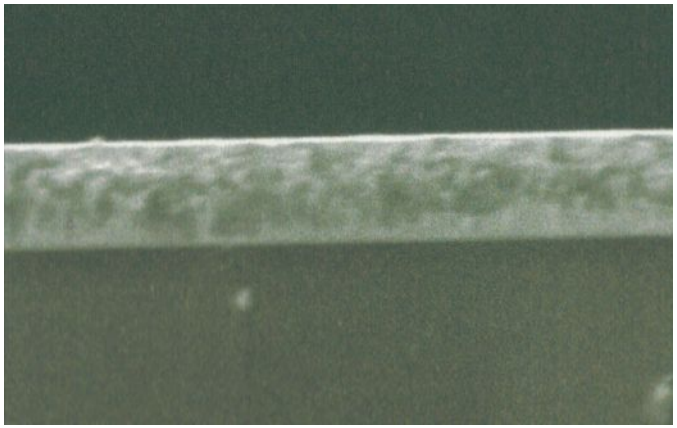
Design Gas Path Trends

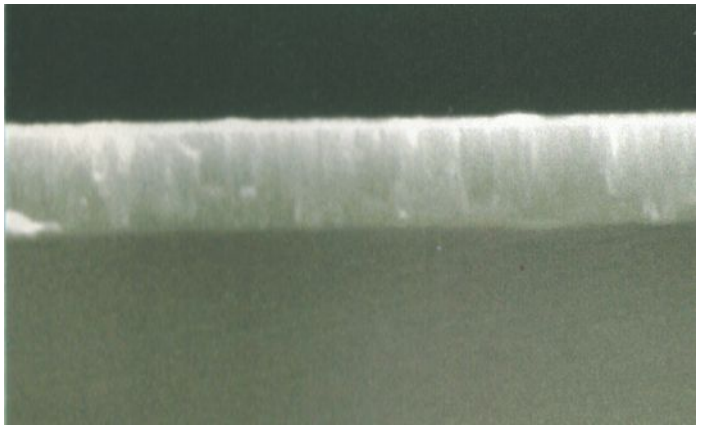
- Highly Loaded Axial Compressors – 40 to 1 ratio – Temperatures might increase to 800 C
- High Turbine Operating Temperatures – 200 C increase in Temperature capability
- Enhance fatigue, sulphidation, oxidation and erosion resistance in high temperatures

" To illustrate nanotechnology's potential on the world, if the aircraft industry had evolved at the same rate as microelectronic industry in the last 25 years, a Boeing 777 today would circle the globe in twenty minutes on five gallons of fuel". - Dr. Robert Hull (Professor of Nanotechnology, University of Virginia)

Nanocomposite And Nanostructured Coatings SEM

- 1 micron
- Nanocomposite

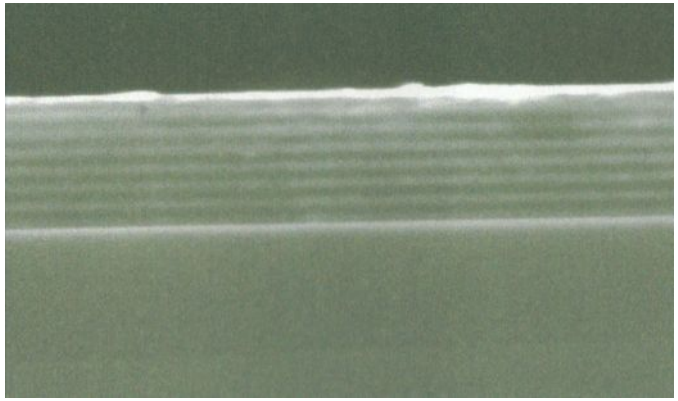


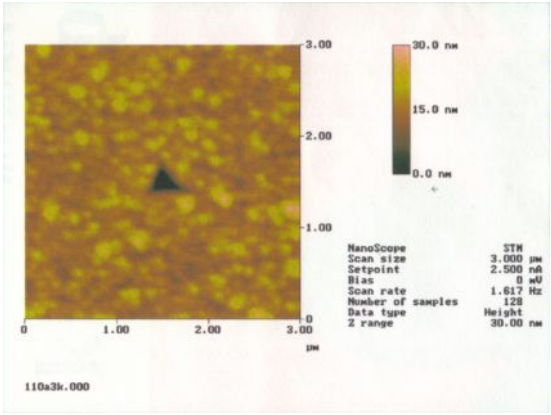


- Implanted Metal Oxide

Metal Oxide

- 1.2 micron
- Nanostructure



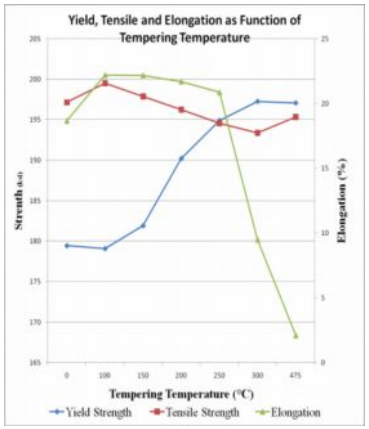


- Multi Nanolayer MeO/MeN (16)

AFM Features HV0.05 3850 SC 16.2 N

GTF Nanostructure Coating Mechanical Features
Steel Strip and Sheet Laminate – Remarkable Properties

- Stainless 0.0762 mm strip



	Maximum Load (N)	Tensile stress at Maximum Load (ksi)	Tensile strain at Maximum Load (%)	Load at Break (lbf)	Tensile stress at Break (ksi)	Tensile strain - Elongation (%)	Tensile stress at Yield (Offset 0.2 %) (ksi)	Modulus (E-modulus) (MPa)	Extension at Break (Standard) (mm)	Sample Name
1	1,433.08	201.36	18.82	321.60	201.00	18.82	170.87	144,193.98	18.29222	U17

2 micron

762 microns

2 microns

- Stainless Laminate
- 19% Yield Increase
- 22% Elongation Increase

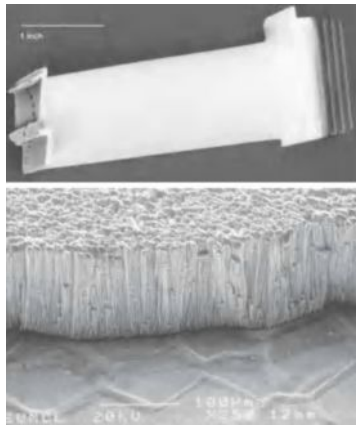
	Maximum Load (N)	Tensile stress at Maximum Load (ksi)	Tensile strain at Maximum Load (%)	Load at Break (lbf)	Tensile stress at Break (ksi)	Tensile strain - Elongation (%)	Tensile stress at Yield (Offset 0.2 %) (ksi)	Modulus (E-modulus) (MPa)	Extension at Break (Standard) (mm)	Sample Name
1	1,427.47	213.94	21.76	319.86	213.24	21.81	207.08	150,631.54	19.68556	A1
2	1,406.81	210.84	23.09	315.40	210.26	23.11	202.32	147,417.37	21.01852	A2
3	1,403.73	210.38	20.64	312.97	208.65	20.94	204.75	147,658.58	19.92422	A3
4	1,386.85	207.85	24.03	305.81	203.87	25.89	202.41	145,292.93	21.82290	A4
Avg	1,406.22	210.75	22.38	313.51	209.01	22.94	204.14	147,750.11	20.61280	
Min	1,386.85	207.85	20.64	305.81	203.87	20.94	202.32	145,292.93	19.68556	
Median	1,405.27	210.61	22.43	314.18	209.46	22.46	203.58	147,537.98	20.47137	
Max	1,427.47	213.94	24.03	319.86	213.24	25.89	207.08	150,631.54	21.82290	
Range	40.62	6.09	3.38	14.05	9.37	4.95	4.76	5,338.61	2.13734	
St Dev	16.6667	2.50	1.4844	5.8720	3.9146	2.1629	2.2594	2,195.4098	0.9938	
CoV	1.1852	1.19	6.6323	1.8730	1.8730	9.4289	1.1068	1.4859	4.8212	

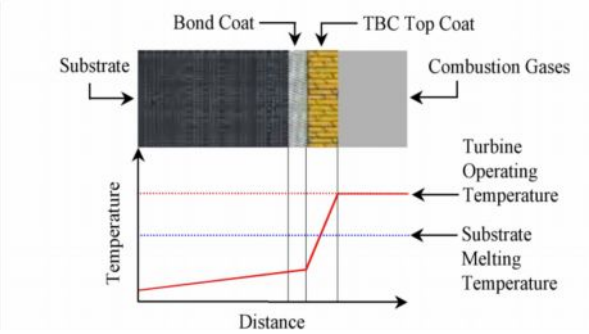
GTF Nanocomposite And Nanostructure Features

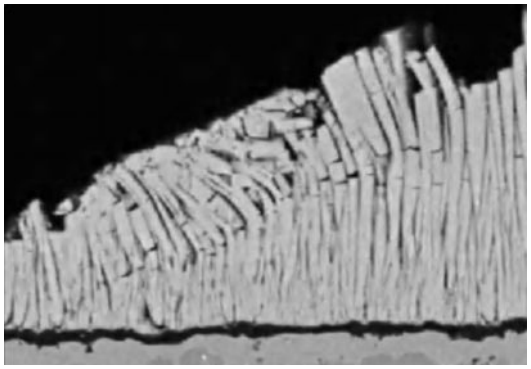
- EB PVD

Functional Design

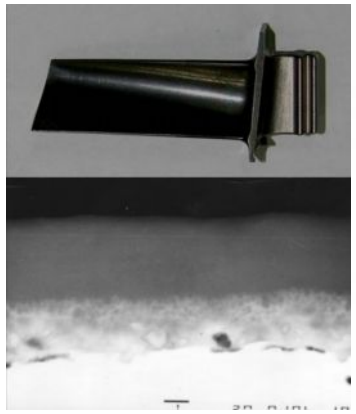
Erosion and Impact Failure

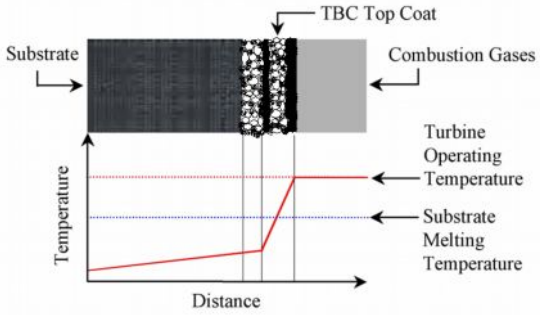


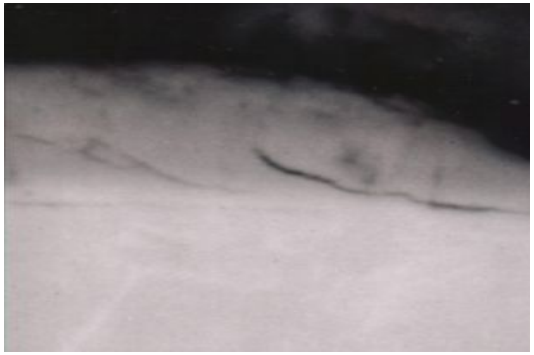




- CIMO

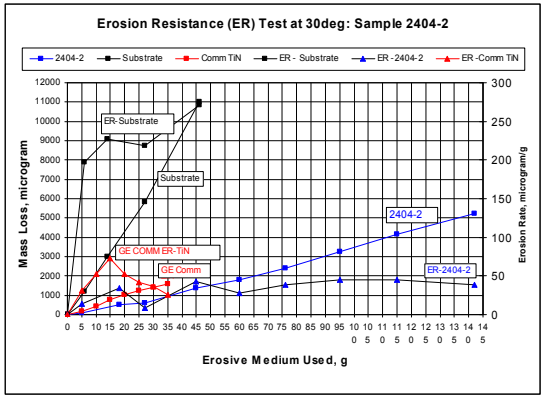


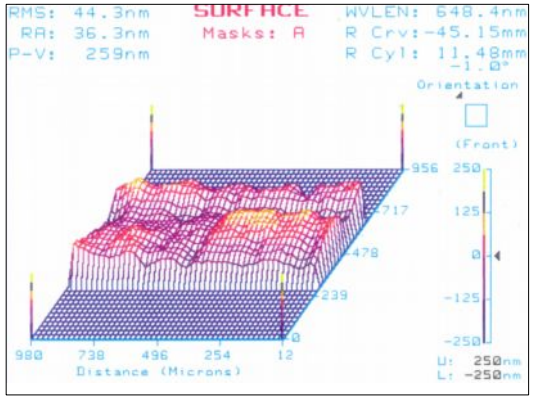




GTF Nanocomposite And Nanostructure Features

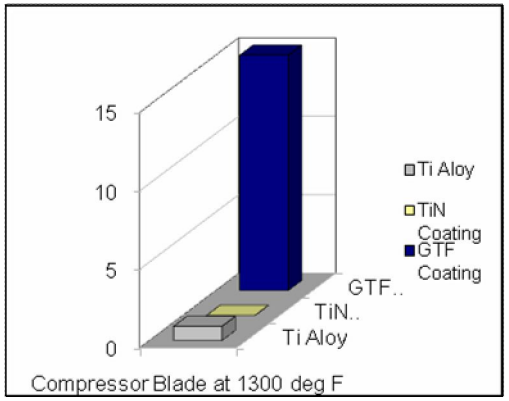
- Compressor – Slow Degradation And Superior Surface Finish

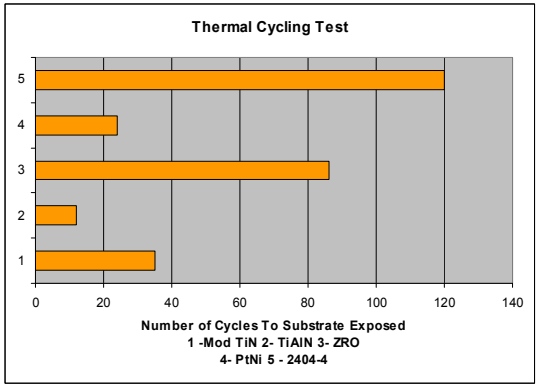


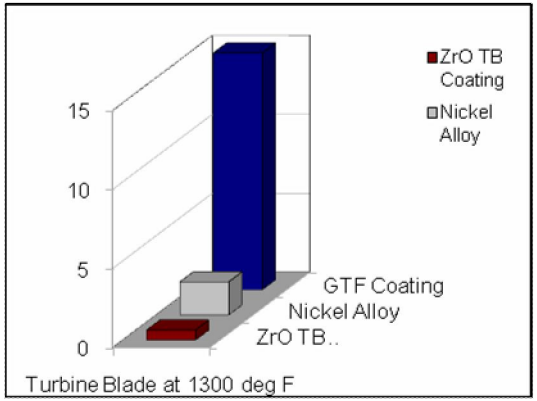


Potential New Inspection Features

- Compressor – Erosion And Corrosion Resistance in Elevated Temperatures





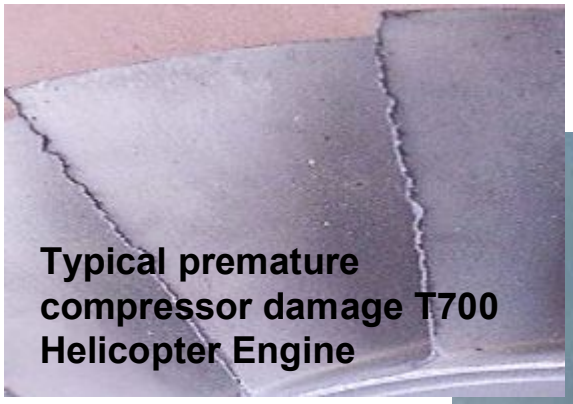


How Fuel Efficiency Deteriorates With Commercial Engine Cycles

Main Causes Of Materials Deterioration	Erosion Flight Loads	Erosion Flight Loads	Hot Corrosion Erosion Clearance Loss Hot Distortion	Hot Corrosion Erosion Clearance Loss Hot Distortion
Loss In Efficiency	**Low Pressure Compressor**	**High Pressure Compression**	**Low Pressure Turbine**	**High Pressure Turbine**
New	0.62%	0.16%	0.10%	0.48%
3000 Cycles	1.46%	2.94%	0.538%	2.43%
6000 Cycles	2.61%	9.40%	1.078%	3.81%

Huge Fuel Savings Possible

Military Aviation Is Suffering High Maintenance Cost And Poor Assets Availability



Typical premature compressor damage T700 Helicopter Engine

Operating Conditions

Typical premature compressor damage AGT 1500 Tank Engine

Operating Conditions

Engines are a vacuum cleaner

Military Engine Erosion = Poor Readiness/Asset Availability High Maintenance Cost

	Manufacturer Engine Model Engine Year	OEM Specified Life	Actual Life Reported By
 CH53 Helicopter	GE Aviation T-64 1964	1200 →	100 hours US Navy Iraq
 M1A Abrams Tank	Lycoming/Honeywell AGT 1500 1992	2000 →	700 hours US Army Iraq
 NH90 Helicopter	GE Aviation T-64C 2000	1000 →	150 hours German Air Force Afghanistan
 V 22 Osprey Helicopter	Rolls Royce A1107C 2006	2000 →	200 hours US Marines Iraq

GTF Brampton Coating Facility

Clean Room Class 10 000

Nanostructure And CAPVD Plasma Sources

Ion Beam Magnetron

PECVD

Sigmatic TQC Software

Surface Preparation Facilities

Research And Commercial Interest

Nanostructures and Nanocomposite Coatings

- Continue New Thermal Barrier Characterization And Validation (TRL5)
- Develop Anticorrosion Coatings – Cadmium Replacement , but Wear and Erosion Properties Enhanced (TRL1) – Al ,Si and Ti Oxides
- Thin Strip and Sheet Coatings – Corrosion, Wear Resistance, Self Cleaning
- Investigate Anticorrosion Coatings – Mg Coating Feasibility (TRL1)
- Anti Erosion Coatings – (TRL9)

Interest in Poland

Why Poland?

- Sizable domestic aerospace industry
- GTF plans for Polish NanoCoating Service Centre Aerospace Profiled
- R&D – High Skill Moderate Cost
- EU Incentives
- I was born in Poland 57 years ago

AEROSPACE

Darek Molenda - President and CEO holds Msc in Engineering. In 1980's in senior management and consulting engineering positions in various Ontario manufacturing businesses in the area of surface science and organic thermal and radiation curable coatings . Since 1992 in thin film equipment and process development.

In 2001 he founded GTF Aerospace Inc., corporation committed to development and commercialization of nanotech coatings directly targeted to aerospace and aviation industries. He holds the rights in 8 USPTO applications as co inventor and inventor.

GTF Aerospace Inc.
2023 Williams Parkway, Brampton, Ontario, Canada
L6S 5N1
Phone : 416 848 7677
E mail : darek.molenda@gtfaerospace.com
www.gtfaerospace.com