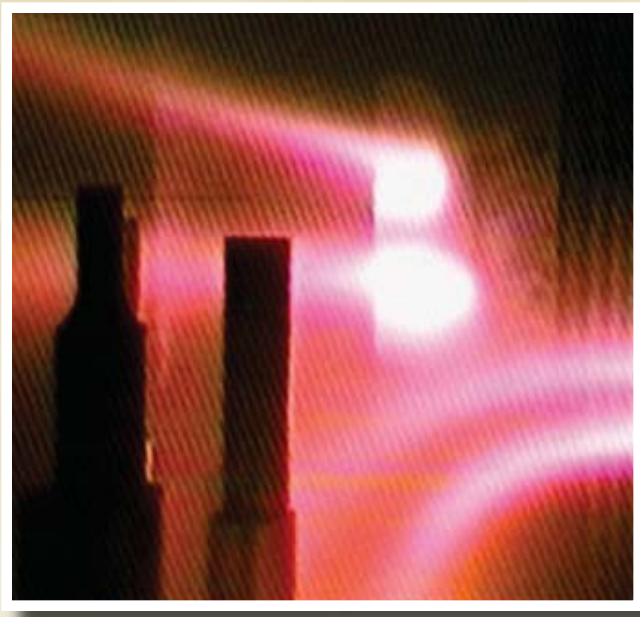
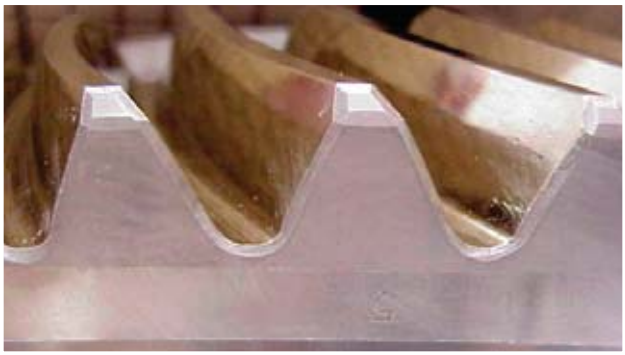
# Nano-Composite Coatings for F-35 LiftFan and RL-10 Rocket Engine Turbopump

***Accomplishment:*** Composite coatings combining nanocrystalline particles with an amorphous metal matrix have been developed that give an order of magnitude decrease in component wear, good corrosion prevention in salt environments, and enable system operation under demanding lubricant starvation requirements.



***Impact:*** This advancement satisfies operational requirements for endurance and reliability in liftfan gears and bearings of the short takeoff-vertical landing (STOVL) F-35 aircraft. Conventional coatings are unable to satisfy the full range of operation conditions, placing successful accomplishment of mission requirements at risk. This advanced coating is being certified for F-35 aircraft gears and is also being validated in component-level testing for gears in the RL-10 liquid rocket engine turbopump.

***Motivation and Approach:*** Gears and bearings in jet engines and rocket turbopumps must perform under difficult conditions that include high contact stresses, high wear conditions and corrosive environments. The F-35 STOVL LiftFan adds the demanding requirement of continued engine operation after 60 seconds of unlubricated runtime, which could not be satisfied by any previously available coating. This new class of wear resistant nano-composite coatings has an unusual combination of high hardness that exceeds ceramic materials, and fracture strength similar to that of tough metal alloys. These properties result from the combination of 3-5 nanometer grains of very hard carbides or oxides embedded in an amorphous metal matrix. The material design was further enhanced by introducing coating interfaces with corrosion prevention layers and by using carbon in the composite matrix to reduce friction during unlubricated operation. Subsequent applied research and process development is establishing these nano-composite coatings for use in F-35 STOVL propulsion system components and RL-10 liquid rocket engine turbomachinery, where component-level testing is now underway.



***Team:*** These coatings were conceived and developed under the leadership of Dr. Andrey Voevodin, with significant contributions from Dr. Jeff Zabinski, Dr. John Jones and Benjamin Phillips, (all at the Materials and Manufacturing Directorate), and from Dr. Chris Muratore (Universal Technologies, Corp.) and Dr. Jiaunjun Hu (University of Dayton Research Institute). Funding was provided by the Air Force Office of Scientific Research (Maj. Jennifer Gresham, Program Manager). Small Business Innovation Research programs with Arcomac Surface Engineering, Inc. and Tribologix, Inc. developed processes to apply these coatings, which are being validated by component testing by the Rolls-Royce Corporation (for the F-35 LiftFan) and Pratt and Whitney (for the RL-10 rocket engine).