Superhard Nanocomposite Coatings (SHN)

Reduce Friction and Wear

FEATURES AND BENEFITS

- √ Superhard (35 to 65 GPa): 2-3 times as hard as DLC.
- √ Super-tough: Prevents crack initiation and growth.
- √ Extreme wear resistance: Virtually zero wear under lubricated sliding conditions.
- √ Outstanding corrosion resistance.
- √ Strong bonding to metallic surfaces that can endure contact pressures as high as 5 GPa.
- √ Excellent compatibility with oils, greases, and other fluids. Reacts preferentially to form a very slick boundary film.
- √ High deposition rates.
- √ Applicable to complex shapes.
- √ No post-deposition machining: very smooth surface finish, no roughening of original surface.

POTENTIAL MANUFACTURING/ PROCESSING APPLCATIONS (UNDER LUBRICATED CONDITIONS)

- √ Sliding, rolling, and rotating tribological surfaces.
- √ Metal/polymer bearing surfaces.
- √ Engine and drive-train components.
- √ Ring/liner assemblies.
- √ Gears, bearings, and cam-roller followers, piston pins, valves, tappets, chain links.
- √ Fuel injectors.
- √ Power transmission and transaxle components.
- √ Low-sulfur fuels and lubricants.
- √ Metal-cutting and forming tools.
- √ Razor blades.
- √ Lightweight materials (Ti, Al, Mg-based alloys) and all kinds of steel components.

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Increasingly harsh operating conditions of today's mechanical systems demand continuing improvements in the performance, durability, and efficiency of their components. Superhard nanocomposite (SHN) coatings developed jointly by Argonne National Laboratory and Istanbul Technical University meet the requirements of these demanding applications. They do so by preventing wear, and by dramatically reducing friction, even under marginally lubricated sliding conditions.

The unique SHN coatings are based on special formulations of hard and soft phases that provide friction coefficients of 0.02 to 0.05 under boundary lubricated sliding conditions and prevent wear. By comparison, the friction coefficient of steel on steel under the same conditions is about 3-5 times greater (e.g., 0.1-0.15).

Working with an industrial coating company, Argonne researchers developed a production-scale deposition system employing new protocol and procedures for depositing SHN films on critical engine parts and components. The new system uses a modified version of existing plasma coating equipment that is well-suited for demonstrating flexible, production-scale coating for large-volume industrial applications. Figure 1 shows the nanostructured and composite morphology of a superhard coating that was deposited on a high-speed steel.

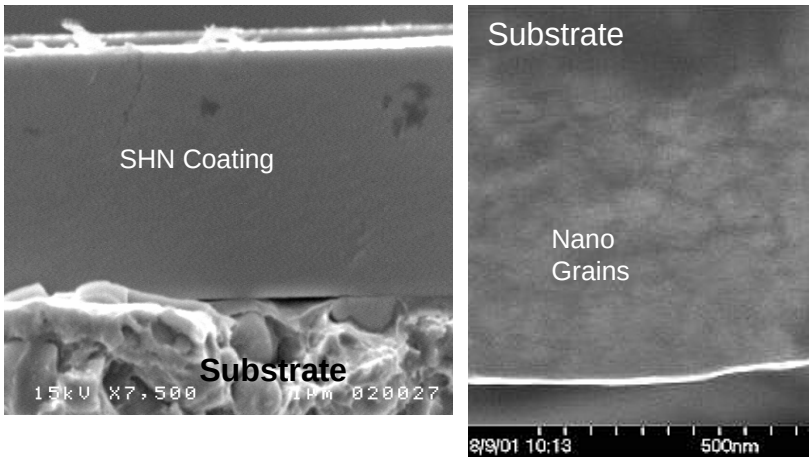

Figure 1—General and detailed morphology of SHN Coating that shows a featureless microstructure at lower magnification; yet, with nano-grains at much higher magnification (photo on right) after a brief ion etching.

STATUS

Argonne is seeking industrial partners to assist in completing the development of this technology for different applications. The technology allows the coating composition and process to be optimized to meet the specific needs of each application.

Argonne researchers are working closely with several industrial partners to optimize the coating properties and process parameters for components in selected reciprocating engines. A series of screening tests under conditions of actual engine use has been completed, and superior performance has been demonstrated.

SHN TECHNOLOGY IS NOW AVAILABLE FOR LICENSING

Argonne's patent-pending SHN coatings are currently available to industry through licensing agreements. Technical support is available for complete technology transfer.

CONTACTS

For information on partnering with Argonne, contact William D. Ingle, III, Manager, Programs and Operations, Office of Technology Transfer, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439. Phone: 630-252-4694; e-mail: wingle@anl.gov.

For technical information on the SHN technology, contact Dr. Ali Erdemir, Senior Metallurgist, Argonne National Laboratory, Energy Technology Division, 9700 South Cass Avenue, Argonne, IL 60439. Phone: 630-252-6571; e-mail: erdemir@anl.gov.

ABOUT ARGONNE TECHNOLOGY TRANSFER

Argonne National Laboratory is committed to developing and transferring new technologies that meet industry's goals of improving energy efficiency, reducing wastes and pollution, lowering production costs, and improving productivity. Argonne's industrial research program, comprising leading-edge materials research, cost-saving modeling, and unique testing and analysis facilities, is providing solutions to the challenges that face U.S. manufacturing and processing industries.

Recent studies have demonstrated that SHN films with thickness levels typically ranging between 3 – 10 micrometers can be produced on several materials including steel, aluminum, magnesium, and titanium alloys at high deposition rates (determined by the system configuration), enabling a wide range of applications.

The coated SHN parts provide much lower friction and wear in lubricated mechanical applications involving rolling, sliding, and rotating contacts. Special ingredients included within the film react favorably with additives in automotive grade oils to produce a low-shear boundary film that provides low friction and excellent protection against wear. Figure 2 highlights reduced friction under boundary lubricated sliding conditions in a bench-top tribological test machine

Argonne researchers have tested these films over a wide range of test conditions and are currently evaluating the effects of various oil additives on friction and wear properties. These same researchers are also investigating how to further modify the film's structure and chemistry to achieve even lower friction and wear in both dry and marginally lubricated bearing applications.

Tribological Properties

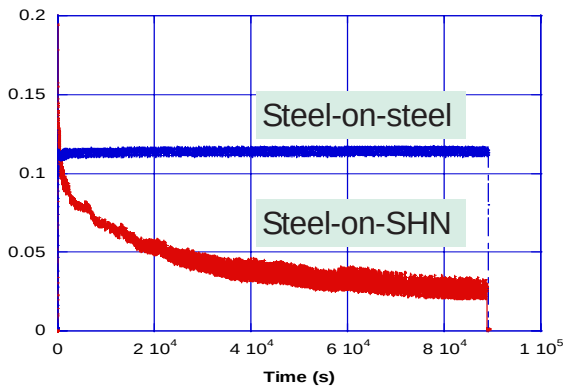

Figure 2—Comparison of the friction performance of an SHN coating verses that of H13 steel under boundary lubricated sliding conditions. The friction coefficient of steel is 0.12,