



INDUSTRIAL TECHNOLOGIES PROGRAM

Development of Ultrananocrystalline Diamond (UNCD®) Thin Films for Low Friction/Low Wear Applications

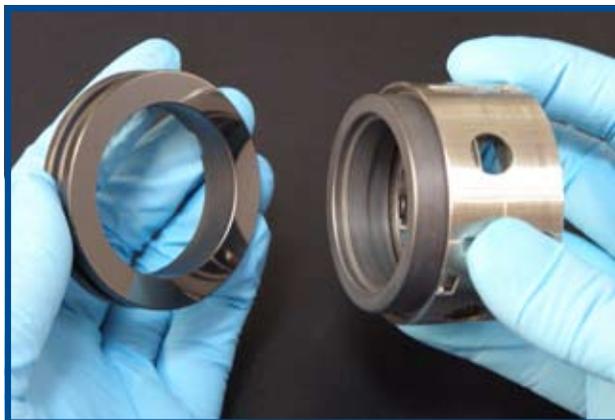
Energy Saving, Corrosion and Wear-Resistant Pump Seals can Impact All Industries

This materials project based on UNCD thin films, a form of diamond that was conceived and patented at Argonne National Laboratory, will have a major impact on many industries. UNCD thin films can be synthesized or “grown” on a variety of substrates by using a commercial-scale chemical vapor deposition system that turns ordinary methane into diamond. The UNCD thin films exhibit a unique microstructure comprised of nanometer-sized diamond grains that provide superior mechanical (high hardness and extreme fracture toughness), tribological (low coefficient of friction), chemical (inertness to chemical attack), and electronic (wide range of conductivity) properties.

To apply this technology commercially, work was needed to automate the diamond seeding process and to increase the scale of the process from single-unit runs to larger production volumes requiring UNCD layers on large-area substrates with uniform thickness and uniform mechanical properties. The project involved an interdisciplinary

effort between Argonne, John Crane, Inc.—the world’s largest manufacturer of mechanical seals, and Advanced Diamond Technologies, Inc., which provided the fundamental, applied, and technological base for this project.

The first commercial application identified for UNCD thin films was mechanical shaft seals for pumps, agitators, and gas compressors. In prior work, growing UNCD using conventional microwave plasma technology was demonstrated on a 2-inch diameter seal which showed an undetectable wear rate and a sixfold reduction in frictional energy loss in a bench-scale test. To make the project commercially viable, producing larger seals in production quantities and growing UNCD on multiple seals at one time was a requirement—and was achieved.



“Type A05 UNCD Seal” which includes a UNCD mating ring (left side) with its matching un-coated SiC rotary primary on the right.



Benefits for Our Industry and Our Nation

- The use of UNCD thin films as low-friction, and corrosion- and wear-resistant materials will optimize energy efficiency in a wide range of mechanical systems.
- UNCD-processed seals will result in a 75% reduction in frictional losses at the sealing interface in hard on hard pumping combinations.

Applications in Our Nation’s Industry

There are many rotating and or sliding components in mechanical systems, such as shaft seals used in multipurpose pumps, bearings, and gears that are critical to the operation of simple or complex systems in many industries:

- Agriculture
- Chemicals
- Metalcasting
- Aluminum
- Mining
- Petroleum
- Forest products
- Steel
- Glass

Project Description

Researchers developed UNCD films for use as wear-resistant, low-friction coatings for SiC multipurpose mechanical pump seals. These coatings are important in all industries. A specific application, fluid pumping, has been identified to take advantage of the unique materials properties of UNCD films. Pumping high-velocity, possibly corrosive, fluids at high pressures is an important process step for many industries. While fluid pumping is emphasized in this project, it is important to note that the development of corrosion-resistant, wear-resistant, low-friction coatings had a much broader useful impact.

Barriers Addressed and Resolved

- Obtained uniform nucleation and growth of UNCD resulting in smooth films with good adhesion.
- Scaled-up the UNCD deposition process to a system that would allow for batch processing of multiple seals.
- Limited seal testing facilities.
- Lack of a commercialization protocol.

Pathways

Much research and numerous tests have resulted in the development of the proper seeding technique. This seeding allows for a high nucleation density which leads to a dense, continuous, smooth film. The challenge of good adhesion has also been remedied. A typical pump seal can last for years, making lifetime testing of seals a difficult procedure. John Crane, the world's largest manufacturer of mechanical seals, has developed a test that mimics the harsh conditions in a chemical process pump. This 100-hour test simulates 2 years of extreme use. In addition to testing at Crane, an accelerated-wear rig and abrasive slurry rig were installed at Argonne for further UNCD optimization.

Progress and Milestones

- Consistently produce UNCD-coated seals which contain smooth films and good adhesion (complete).
- Commission and optimize a large area batch coating process on multiple seals (complete)
- Run the simulated long-term pump tests; verify the results and advantages of UNCD pump seals (complete)
- Complete field tests and analysis for pump seal application (complete)
- Launch seals to market (complete).

Commercialization

UNCD coatings for low friction rotating seals and other applications are now available from Advanced Diamond Technologies, Inc. ADT www.thindiamond.com

ADT's UNCD material was named the 2006 Diamond Thin Films Product Innovation of the Year by Frost & Sullivan. ADT was a runner-up in the Wall St. Journal's 2006 Technology Innovation Awards and was named a 2007 Technology Pioneer by the World Economic Forum. The original UNCD deposition platform developed at Argonne was a winner of an R&D 100 award in 2003. ADT is also a 2006 winner of the Nanotech Briefs' Nano 50™ Awards, which recognizes the top innovators to impact that state-of-the-art in nanotechnology.

Project Partners

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.



U.S. Department of Energy
Energy Efficiency
and Renewable Energy

Bringing you a prosperous future where energy
is clean, abundant, reliable, and affordable

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