High Power Impulse Magnetron Sputtering (HIPIMS) of Ultra-Hard and Low-Friction Nanocomposite Coatings for Improved Energy Efficiency and Durability in Demanding Industrial Applications

In recent years, there has been an overwhelming interest in the manufacturing and widespread utilization of multifunctional, nano-structured and nano-composite coatings in various industrial processes. Specifically, increasing demands for greater power density, better reliability, productivity, and energy efficiency in advanced mechanical systems have necessitated the development and uses of such coatings in very large volumes. Because of their superior mechanical properties (in particular, superhardness and supertoughness) and high chemical inertness, these nanocomposite coatings have the potential to significantly lower friction and wear losses in systems that are subject to rolling, rotating, sliding, cutting, grinding, chopping, drilling, milling and forming type operations in all kinds of industrial operations.

However, when such coatings are manufactured by current industrial scale deposition processes and used under such extreme operating conditions, they often delaminate prematurely due to poor adhesion or fracture due to poor cohesion. Accordingly, the goal of this nanomanufacturing concept definition study is to explore the effectiveness of a revolutionary technology in industrial scale deposition systems – HIPIMS – in achieving the highest possible levels of adhesion between superhard, nanocomposite coatings and their substrates as well as super tough and strong cohesion within the films so that they cannot delaminate or crack when used under the very harsh and cycling operating conditions of advanced manufacturing and other industrial operations.

HIPIMS requires the use a special high-current, medium-voltage power sources in an existing deposition system and is certainly regarded as a most exciting development in the field of thin film deposition in recent years due to its extremely high ionization efficiency and very energetic nature which literally disappears the sharp interface between coatings and substrates (where adhesive failure occurs) and columnar grain morphology which is the main cause of cohesive failures in such functional coatings. It also overcomes the micro-droplet problem that is very typical of cathodic arc deposition (which is a current technology used to achieve stronger film-to-substrate bonding). With the use of such smooth and strongly-bonded, dense structured, nanocomposite coatings, the energy efficiency, durability, and environmental compatibility of mechanical systems used in all kinds of industrial processes can further be improved. ANL has extensive coating facilities and significant expertise and experience in the development and characterization of nano-structured, ultra-hard, and superlow-friction coatings. With the successful demonstration of this concept, we expect strong industrial interest and partnership opportunities with several coating and manufacturing companies.

Project Partners:

Argonne National Laboratory
Argonne, IL
Principal Investigator: Osman Eryilmaz
(eryilmaz@anl.gov)

For more information contact:
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

March 2009