



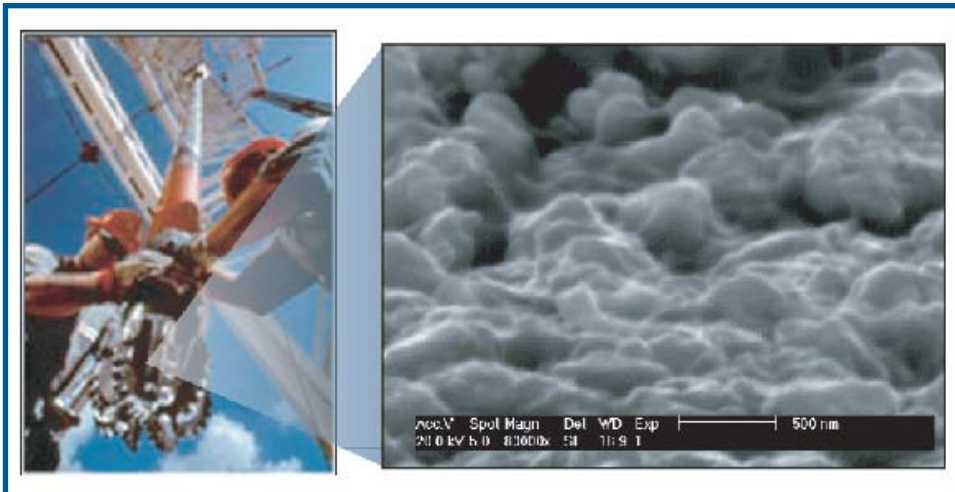
INDUSTRIAL TECHNOLOGIES PROGRAM

Development of Bulk Nanocrystalline Cemented Tungsten Carbide for Industrial Applications

Tools with Nanocrystalline Structure Will Possess Improved Toughness, Durability, and Reliability

Cemented tungsten carbide materials are indispensable in many manufacturing sectors of our economy. The material is used for wear-resistant applications and for tools in the metalworking, drilling, and mining industries. However, its performance is limited by its relatively low fracture toughness. There is significant potential to improve the fracture toughness of the material by producing WC-Co cermets with truly nanocrystalline grain structure. Although nanocrystalline WC-Co powders have been produced in the past, the technology to produce bulk materials from these powders needs further development.

The purpose of this project is to develop powder synthesis and consolidation processes to enable the fabrication of WC-Co cermets with grain structures less than 100 nm in size. WC powders and WC powders coated with Co will be produced using a novel vapor-phase synthesis process. Consolidation will be performed by a new ultrahigh-pressure sintering process, incorporating rapid heating that has the potential to minimize grain growth and therefore retain the advantages of the nanocrystalline structure.



Nanocrystalline cemented tungsten carbide will result in improved tools.



Benefits for Our Industry and Our Nation

Economic benefits will be realized through increased durability and reliability of wear-resistant materials and tools, resulting in improved productivity. Energy benefits will be achieved through the use of a more energy-efficient process for the manufacture of tungsten carbide powders and a reduction in the sintering cycle time used for component fabrication.

Applications in Our Nation's Industry

The improved materials will find applications in the aluminum, mining, petroleum, and steel industries. These applications include drill bits, rock comminution equipment, and machining tools.

Project Description

The focus of this project is to develop bulk nanocrystalline WCCo cermets for various industrial wear and cutting tool applications.

Barriers

Major barriers to be overcome include:

- Lack of knowledge about the feasibility of producing nanosized WC-Co powders with sufficient uniformity in size, composition, and yield;
- Lack of control in maintaining the grain size of materials below 100 nm during sintering at high temperatures; and
- Lack of information on the mechanical properties of bulk structures with nanoscale grain size.

Pathways

The objectives of the project will be achieved through (1) producing uniformly mixed nanosized WC as well as directly producing cobalt-coated WC powder by the vapor-phase co-reduction of chloride vapor mixtures with controlled grain sizes and cobalt content; (2) developing a rapid-heating technique and ultimately an economically viable, semi-continuous process for the consolidation of nanostructured WC-Co powder; (3) sintering nanopowders while achieving less than 100 nm grain size in the consolidated bulk WC-Co cermets; (4) understanding strengthening and toughening mechanisms through microstructural evaluation and mechanical property testing; (5) optimizing the microstructure of and developing superior mechanical properties for the bulk nanocrystalline materials; and (6) evaluating test components in various applications.

Progress and Milestones

- Produce nanosized WC-Co powder using vapor-phase synthesis (Complete)
- Develop a new consolidation process involving rapid-heating and ultrahigh pressures (Complete)
- Consolidate nanosized WC-Co powders to achieve grain sizes of less than 100 nm (Complete)
- Demonstrate superior mechanical properties of WC-Co with true nanometer grain size
- Fabricate representative components using optimized compositions and processes
- Perform functional testing of new materials in laboratory and industrial environments

Commercialization

The project team includes a university that will lead the technology development; a national laboratory; one of the world's largest producers of tungsten carbide powders, which also fabricates and supplies components; and an original equipment manufacturer. This team structure ensures the availability of manufacturing facilities for producing powders and components. The existing customer base can also be utilized for the testing and adoption of the new technology.

Project Partners

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Idaho National Engineering and
Environmental Laboratory
Idaho Falls, ID

Kennametal Inc.
Rogers, AR

Smith International, Inc.
Houston, TX

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.



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Energy Efficiency
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