Georgia Tech

Research News

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FIREWORKS IN THE LABORATORY:

SELF-PROPAGATING THERMITE REACTIONS PRODUCE PURE, HEAT-RESISTANT POWDERS

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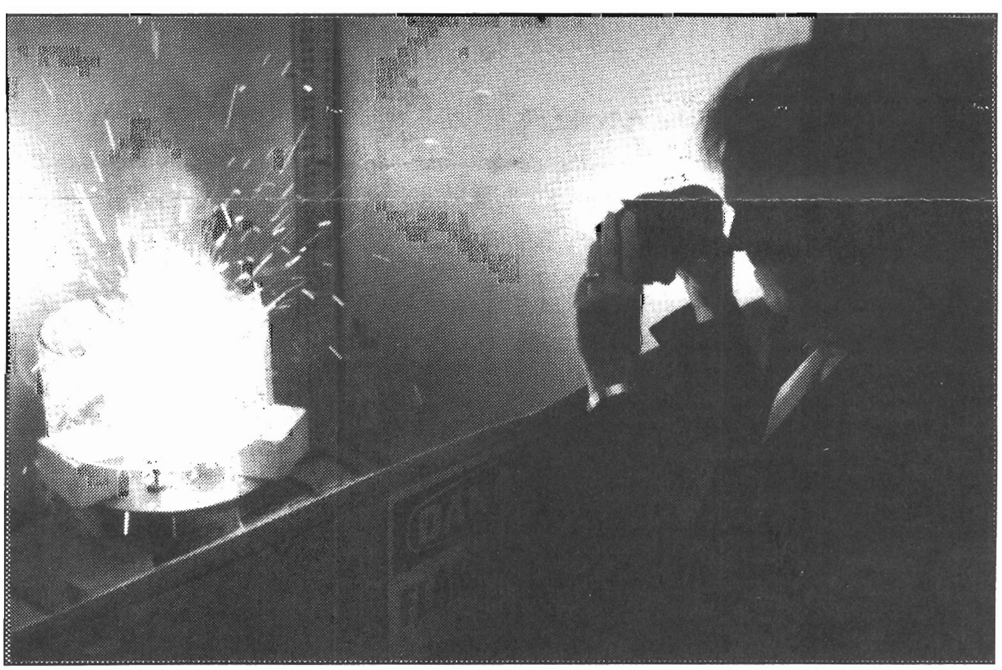
Color & B/W Available

The same type of energetic reaction that fuels brilliant fireworks can be harnessed to make pure, heat-resistant materials.

At the Georgia Institute of Technology, such materials are synthesized in the form of a very fine titanium diboride (TiB_2) powder that could lower the cost of aerospace components, industrial processes, and cutting tools with superior properties.

The Georgia Tech material withstands temperatures up to 3,000 degrees Celsius and conducts electricity while resisting acids and molten metals, according to Senior Research Engineer Kathryn V. Logan. For these reasons, she said, titanium diboride is ideal for use in molten metal pipelines and processes such as aluminum smelting. (Logan's team has already tested titanium diboride electrodes as potential replacements for the carbon electrodes currently used to smelt aluminum.) Other applications include semiconductor and aerospace materials.

"Titanium diboride is usually made by heating the raw materials to around 2,000 degrees Celsius until a reaction occurs," explained Logan, head of the Ceramics Branch at the Georgia Tech Research Institute. "Unfortunately, this process leaves traces of carbon and produces large particles, which are difficult to form into useable shapes. Because it is self-propagating, our process does not require external furnaces, and the result is a fine powder with no carbides."



Dr. Kathryn Logan watches an energetic thermite reaction that produces advanced materials at the Georgia Institute of Technology. Photo available on request in color or black & white.

Unlike the conventional process, Logan added, the patented Georgia Tech method generates powder particles that are smaller than one micron. At this scale -- there are 50 microns in the diameter of a single human hair -- powders can readily be shaped into useful products.

Larger, commercially-available titanium diboride particles

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must undergo further processing before shaping, reported Guillermo Villalobos, a research engineer working in Logan's laboratory. This additional effort to reduce particle size introduces tungsten and cobalt contaminants that can't be removed, he said, and the grinding step increases manufacturing costs. Logan estimates her processing costs are between two to three times less than the conventional method.

Whenever a metal such as aluminum or magnesium reacts with one or more metal oxides, a self-propagating thermite reaction occurs. This type of reaction has long been the basis for industrial welding, firework displays and gun powder.

By controlling the power of thermite reactions, Georgia Tech engineers are making advanced materials such as pure titanium diboride and composite titanium diboride/alumina.

First, a heat-resistant container or crucible is filled with the raw materials: titanium oxide (TiO_2) boron oxide (B_2O_3), and a reducing agent -- either aluminum or magnesium. The crucible is then placed inside a protective chamber. Next, about 15 volts of electricity is used to heat a wire to between 600 and 1,000 degrees Celsius. The hot wire is like a match that causes titanium oxide and boron oxide to react with the aluminum, Logan said. When the raw materials are drawn together, an energetic reaction generates a great deal of heat, reaching top temperatures of 2,000 to 3,000 degrees Celsius.

As a result, titanium diboride is uniformly dispersed through an alumina or magnesium oxide matrix. In one step, a homogenous, lightweight foam composite can be shaped into a crucible or other desired product. By infiltrating the foam with metal, the material could be useful for various applications such as mechanical components, Logan said.

To harvest pure titanium diboride, engineers simply dissolve the foam matrix. In ongoing research, Logan is learning how to make thermite materials in a continuous process. "A number of refractory, high-temperature ceramics like silicon carbide, boron carbide, titanium carbide and other borides, nitrides and silicides can be produced using this technology," Logan said. "We want to learn more about the process so we can control it and synthesize refractory materials which are otherwise too expensive."

Through the Advanced Technology Development Center (ATDC) at Georgia Tech, Logan formed a company, Powder Technologies, Inc., to help transfer the technology into the commercial arena. Established by the Georgia legislature in 1980, the ATDC provides start-up assistance to promising high-technology firms.

Logan's research was originally funded in 1983 by the U.S. Army Materials and Mechanics Research Center (later named the Materials Technology Laboratory). The U.S. Army Research Office supports current research under Contract No. DAAL03-89-K-0177. (Information in this release does not necessarily reflect the position or policy of the Government; no official endorsement should be inferred.)

EDITOR'S NOTE: For photography or additional information, the media is invited to contact Ginger Pinholster or John Toon at (404) 894-3444. Non-media inquiries should be directed to Kathryn V. Logan.

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