Today, well over 50 companies incorporate features of these new techniques in their own ceramic processing facilities. The sizes of their in-house programs on the new processing techniques range, in some cases, to more than 100 people. Published papers and reports indicate that foreign firms are also applying these concepts.

Ceramics fabricated by these methods and their extensions are now being used in a variety of applications. These include automobile turbochargers (rotors), microelectronic circuits, high-temperature energy converters, engine parts, computers, televisions, aircraft, and vital defense weapons, among others.

More generally, many varied ceramic compositions with fine grains can now be fabricated. Major improvements in the mechanical and electromagnetic properties of ceramic formulations have been reported as a result of better processing. Previously unrecognized avenues of materials fabrication, such as layering of different ceramic materials, have been opened up, and totally new electronic components and devices are now possible as a result.

The original decision to eschew further tinkering with recipes and to proceed, instead, with more fundamentally oriented research into the chemical processing of ceramics led directly to these results. In this way, Basic Energy Sciences provided the seed money and critical initial sponsorship of a risky venture. This work, in turn, generated the concepts and the experimental verification that allowed others to appreciate the advantages of the new approach and encouraged them to pursue practical applications.

NICKEL ALUMINIDE

The continuing quest for improved efficiency in the use of combustible fuels is often limited by the properties of the materials used to make up the fuel burning engines. In theory, higher operating temperatures make possible higher efficiencies. In practice, the physical limitations of materials call for moderation to ensure engine reliability and longevity.

Recently, Basic Energy Sciences researchers contributed significantly to the emergence of a new metallurgical alloy, called nickel aluminide, which promised to combine the best of both worlds. It is made up of nickel and aluminum, combined in a ratio of about 3 parts to 1, with trace amounts of boron added. When properly prepared, it exhibits extraordinary properties.

For example, nickel aluminide is much stronger than steel. In contrast to most other materials, it actually increases in strength with higher temperatures, up to about 1300°F. It then maintains this strength to more than 1600°F. It is also lightweight and strongly resists corrosion by oxidation.

Important for fabrication and durability, it is malleable and ductile. This makes the material easy to form into different shapes and forgiving to shock and stress. Yet, with the addition of certain other elements, it can be made to resist strongly permanent deformation and rupture at high temperatures—two common modes of metal failure.

The mechanical properties of nickel aluminide provide significant advantages over many currently available heat resistant materials in a number of important applications. These range from machine tools and boilers to parts for the automotive and aerospace industries. For example, at 1500°F, a temperature well within the operating temperature ranges experienced by most metal parts in today's gas turbines, jet engines, and diesels, nickel aluminide is four times stronger than most high-temperature speciality steels.

Because of its high strength and resistance to oxidation at these temperatures, the alloy is now being examined under exclusive license by Cummins, Inc., a major United States manufacturer of heavy diesel engines. While more expensive than most ordinary steels, nickel aluminide promises to be cost competitive with other specialty materials, such as heat resistant alloys made of nickel, titanium, chromium, and cobalt.

An initial application under investigation is its use in strengthening exhaust valves. This part of the engine, which is subjected to high temperatures, corrosive environments, and repeated pounding, is often the first part to fail. Extending valve life with an improved material would increase the engine's reliability, stretch out maintenance schedules, reduce costs of repairs under warranty, and make the entire engine more competitive in international trade. Ultimately, new designs may capitalize on the added strength, raise combustion temperatures, and improve fuel efficiency.