Patent Search

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Abstract:

Materials capable of armor penetration and prompt chemical energy release are desired for future weapon systems in order to better couple the kinetic energy of a p its target. High-density metals used today such as tungsten are slow to react, and do not generate as much chemical energy as lower density materials, such as alumi boron. To design materials with a high density and reactivity, composites including boron, titanium and tungsten were prepared by mechanical milling. The specific co density was chosen to match that of steel, 7.8 g/cm3. The proportions of the elemental metals were selected to induce a highly exothermic formation of titanium bor would raise the material temperature and assist the initiation and combustion of tungsten. Composite powders were prepared using both single-step and staged mil protocols, and characterized by electron microscopy, x-ray diffraction, thermal analysis, and a custom constant-volume combustion test. Staged milling produced pov the best degree of refinement while preventing intermetallic reactions during milling. An optimized structure with well-refined components capable of a rapid combu prepared by milling elemental B and W for 4 hours, followed by the addition of Ti and milling for an additional 2 hours in a second stage. The combustion test showec tungsten combustion upon initiation of all prepared ternary materials in an oxidizing environment. The tungsten combustion occurred most effectively, generating th pressure and rate of pressure rise for the material with the optimal microstructure.

Complete Specification

Description:Starting materials and the overall composition of the prepared composites are described in Table 1. The particular composition used here was chosen i maximize the energy release by the TiB2 formation, using a 2:1 B:Ti atomic ratio. The amount of tungsten was chosen to yield a final theoretical maximum density e that of steel, or 7.8 g/cm3. After an initial set of composites prepared with -325 mesh tungsten, a different, finer, tungsten powder was used in order to improve refi of the components. Binary B•Ti and B•W composites were prepared with the respective component.

Composite B-Ti-W powders were prepared by mechanical milling. A SPEX 8000D shaker mill was primarily used. Five grams of powder were milled with 25 g of 3/8" (mm) balls, giving a ball-to-powder ratio of 5. Milling was performed under argon, and 10 mL of hexane were used as process control agent. Milling vials and media c hardened steel, and of stabilized zirconia were both used. Milling with steel media introduced noticeable levels of iron contamination in the resulting composite. Wh necessarily detrimental to performance, this did make sample analysis more challenging due to the formation of iron-bearing phases. The compositions characteriz detail here were therefore prepared using zirconia vials and milling media.

Two general milling protocols were followed: in one set of experiments, the component powders were loaded into the milling vials together, and then milled for var periods of time. Materials prepared using this single-step milling protocol will be denoted as B•Ti•W. In a second set of experiments, boron and tungsten powders w milled first in order to minimize the reaction between boron and titanium during milling. Combining mechanically harder boron and tungsten in the first milling ste helped achieving a more homogeneous distribution of tungsten in the final composite material. This first milling step produced binary B•W composites. Titanium po was added later.

Composites prepared using this two-stage milling protocol are designated as (B•W)•Ti. Milling times varied in the 2-7 hour range based on experience from prior wo

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