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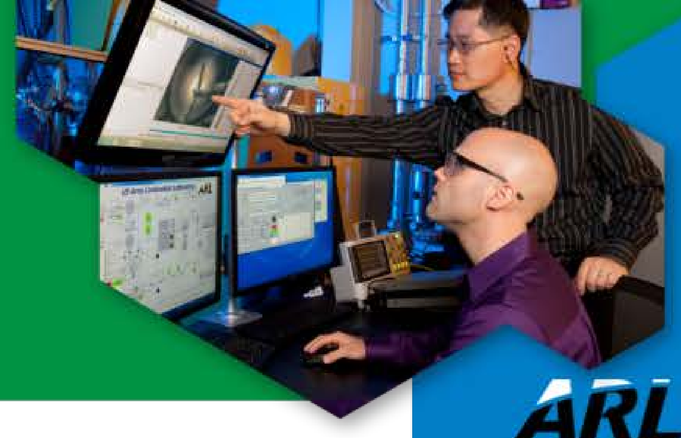
Projectile / Target Interaction: High-Velocity Impact on Boron Carbide (B_4C)



U.S. ARMY RDECOM

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S&T Campaign: Materials Research
Tier 2 High Strain Rate & Ballistic Materials

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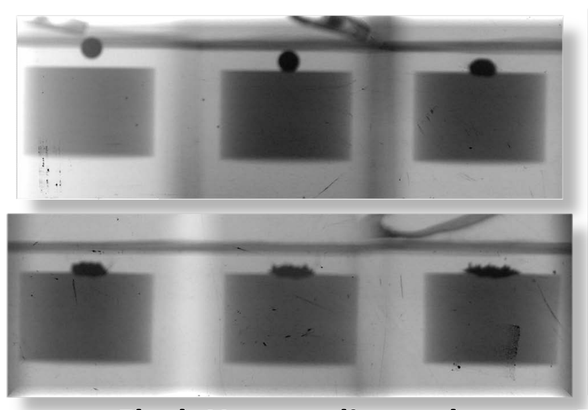
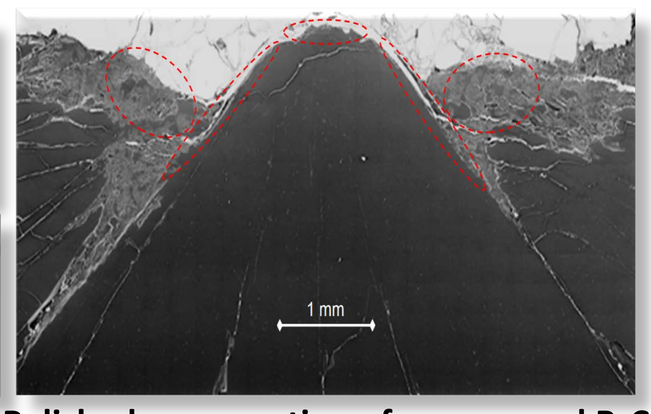
Research Objective

- Identify and understand the phenomena which govern the ballistic response of B_4C and how they are affected by material chemistry and microstructure.
- The ballistic response of B_4C is not well understood. Improved understanding of the governing fundamental mechanisms and the affect of chemistry and structure will be achieved through state-of-the-art characterization methods and "discovery" experiments. Findings support the development of multi-scale models needed for Material-by-Design by identifying the dependences between material characteristics and inelastic mechanisms.



Flash X-ray radiographs showing the impact of a WC-Co sphere on a B_4C cylinder.



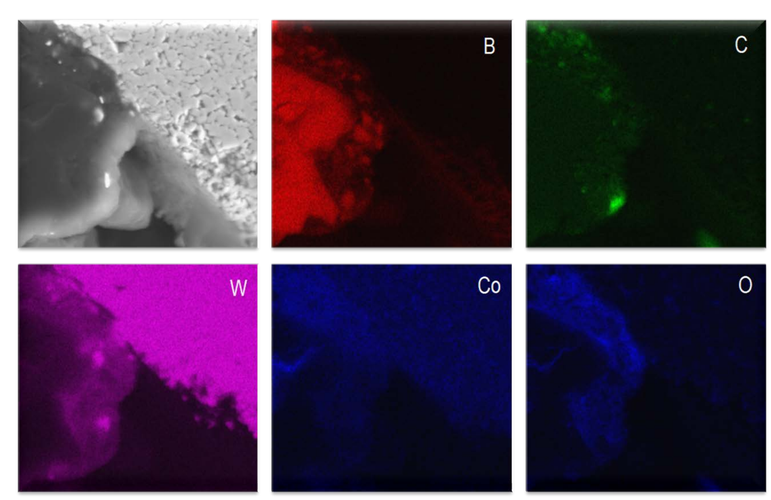
Polished cross-section of a recovered B_4C cylinder revealing inelastic deformation, damage, and other relevant phenomena.

Challenges

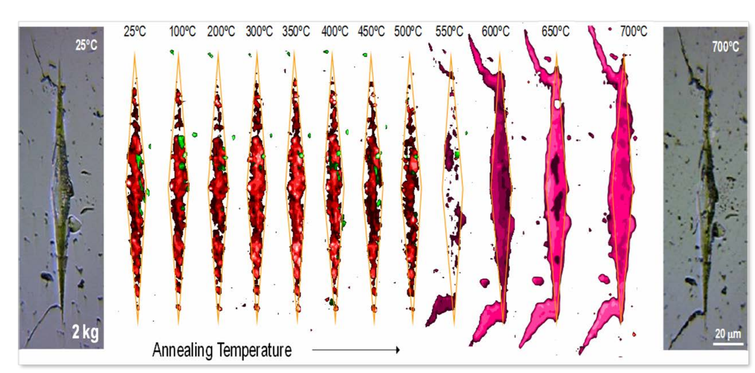
- In-situ diagnostics to measure relevant physical metrics (e.g. pressures, temperatures, etc.) and phenomena (at scales of interest).
- Relate post-mortem characterization findings to dominant events and relevant phenomena (e.g. cracking, fragmentation, amorphization, melting, etc.).
- Specimen preparation for post-mortem characterization.
- Relevant "discovery" experiments.

ARL Facilities and Capabilities Available to Support Collaborative Research

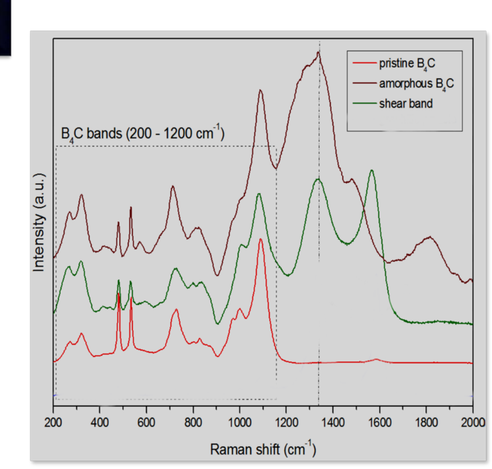
- Instrumented ballistics (flash X-rays, photon-doppler velocimetry, etc.) and materials characterization (XRD, Electron Microscopy (SEM, TEM, FIB), low- and high-rate mechanical testing) facilities.
- Continuum, mesoscale, and atomistic simulation tools, including hydrocodes. High-performance computing center.
- High-pressure / high-rate physics, testing, and modeling.
- B_4C not only undergoes stress-induced amorphization, but appears to interact chemically with the WC-Co sphere impactor and O_2 in the atmosphere!



Elemental maps of a WC-Co / B_4C interface showing chemical interaction with each other and O_2.



Effect of annealing treatments on amorphous B_4C within Knoop microindent.



Raman spectra from pristine, microstructural feature, and amorphized regions.

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Dynamic crack propagation.
- Granular flow of comminuted B_4C.
- In-situ diagnostics.
- Ultra-high localized heating of material interfaces.
- Sub-Angstrom resolution microscopy.
- Atom-probe computed tomography.
- Molecular dynamics modeling.
- Others … LET'S TALK!

Unusual microstructural features observed in and near cone-crack.

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