NRC STUDIES ON REDUCING CsCl AND Am-Be DISPERSIBILITY

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BACKGROUND

- NRC workshop conducted in September 2002
  - National laboratories and radiation source manufacturer participation

- Major recommendations from workshop
  - CsCl Conduct research to minimize dispersibility by incorporation in Ceramicrete and glass
  - Am-Be Conduct research to harden Am-Be sources, harden stainless steel capsule by using surface modification technologies, and identify alternate materials to stainless steel

TECHNICAL CHALLENGES FOR CsCl

Performance-related

- High specific activity in a small volume
- Dense, strong, and fracture resistant source
- Irradiation behavior similar to existing source
- Sizes comparable to current source size to minimize design changes

Material processing and testing-related

- Prevent CsCl volatilization or loss by other means during processing
- Develop process using non-radioactive CsCl to minimize dilution factor to < 3
- Identify relevant properties to assess dispersibility and methods to measure such properties
- Fabricate radioactive CsCl using optimized composition and process for non-radioactive CsCl

TECHNICAL CHALLENGES FOR Am-Be

Performance-related

- Dense, strong, and fracture-resistant source
- Irradiation behavior similar to existing source
- Sizes comparable to current source size to minimize design changes

Material processing and testing-related

- Achieve high-density compaction and sintered product
- Develop process using non-radioactive surrogate with no or minimum additive that will not adversely affect the radiation response and a product that improves dispersibility resistance
- Identify relevant properties to assess dispersibility and methods to measure such properties
- Fabricate and test radioactive Am-Be based on the results of the surrogate

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Results

- Excellent compressive and flexural strength
- Low percentage of material in 100 mesh sieve after impact of 2.75 kg from 5 feet 8 inches
- EPA's Toxicity Characteristic Leaching Procedure test results showed excellent leaching resistance. Chemical complexes are formed during fabrication that act as excellent microencapsulants of cesium.
- ANSI 16.1 long-term leaching tests indicated excellent leaching resistance of CsCl-loaded Ceramicrete samples

RESEARCH AT AMES NATIONAL LABORATORY

Objectives

- Establish the feasibility of hot pressing/sintering Am-Be surrogate to yield a dense, strong, and fracture-resistant product
  - Apply this process to fabricate and test representative Am-Be source and characterize its radiation properties
- Demonstrate technical feasibility of surface modification of stainless steel capsule used for Am-Be to yield a cutting-resistant product
- Identify potential alternate materials to stainless steel irradiation capsule

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Deficiencies of current Am-Be sources

- Fabrication method is cold pressing of AmO_2 and Be powders
- Product characteristics
  - Particles held together by mechanical bonding – cohesive forces between the ceramic (AmO_2) and metallic (Be) particles
  - Relatively low strength
  - Can be crushed and ground to loose powder by conventional communition methods
  - Can be dispersed readily as rather fine particles in an explosion
- Proposed solution was to investigate sintering process
  - Liquid-phase sintering using surrogate

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Materials processing

- Mg metal powder and Y_2O_3 ceramic powder surrogates studied
- Particle size range was 45 to 75 µm, considering the flammability hazard of submicron Mg powders
- Processes studied
  - Blending in inert atmosphere at two different loading fractions, typical of powder compacts in actual source capsules
  - “Vacuum” hot pressing
  - Die pressing
  - Pressureless sintering with and without additives
- Al choice of additive for sintering
  - In solid solution with Mg
  - Forms a Mg-rich eutectic at 437 ºC

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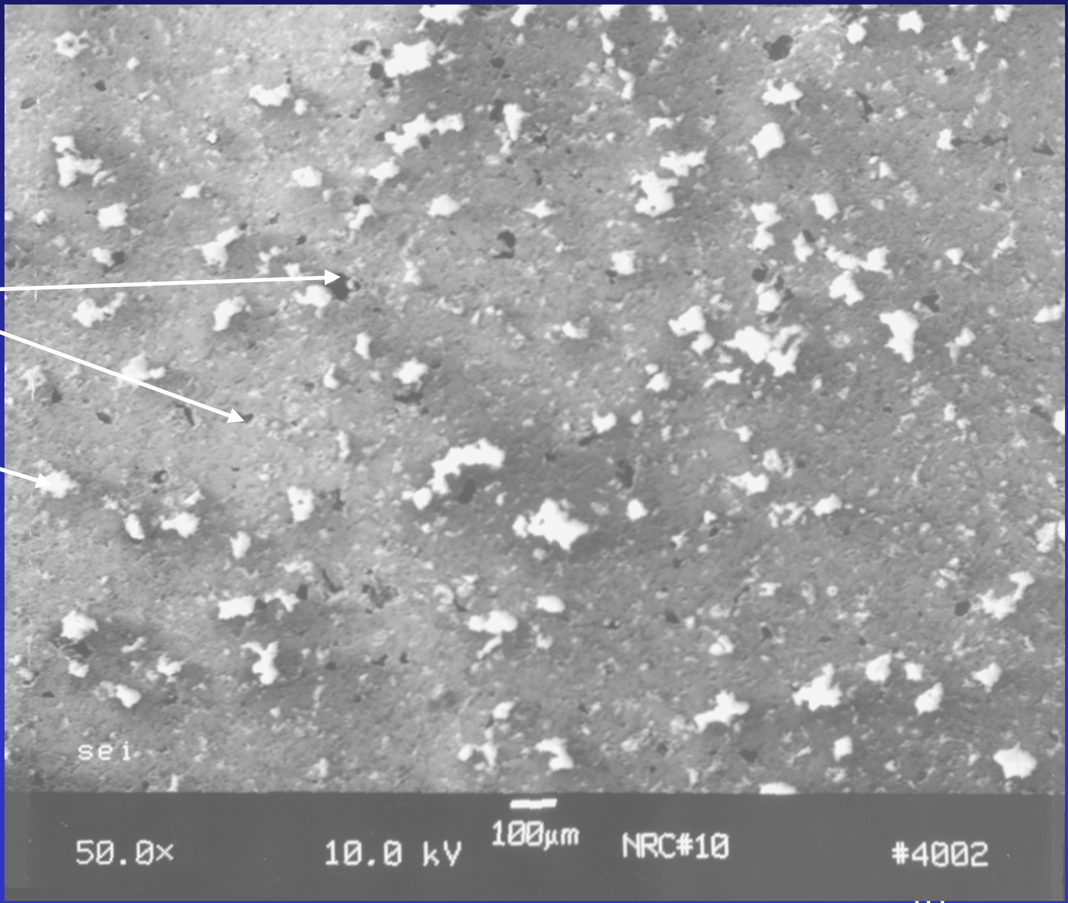
Typical microstructures

- Black dispersants
  - Y_2O_3 reinforcement particles
- White dispersants
  - Aluminum added as a liquid-phase sintering aid



Surrogate microstructure

CONCLUSIONS

Materials processing

- **Manufacture of inherently-safe radiation sources is feasible**
- **Physical properties, such as density, strength, and fracture resistance, (fracture toughness) are enhanced by using novel fabrication**
- **Surface hardening of stainless steel capsules can be realized using state-of-the-art shallow-depth gas-nitridation process**

CONCLUSIONS

CsCl sources

- **Manufacture of CsCl sources with reduced dispersibility in water and resistance to powdery fragmentation is possible using novel, potentially low-cost, room-temperature cement fabrication**

Am-Be sources

- **Hardening of Am-Be sources is possible to minimize easy dispersibility by using ceramic fabrication techniques, such as liquid phase sintering at relatively low temperatures for ceramic fabrication process**