The Depleted Uranium Uses R&D Program

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Presented at

University of Tennessee
Department of Material Science and Engineering Seminar
Knoxville, Tennessee
November 28, 2000

Background

- The U.S. government has ~500,000 metric tons of stored surplus depleted uranium (DU)
- This material is mostly (DUF_6) tails from uranium enrichment operations
- DOE issued a "Record of Decision (ROD) for Long-Term Management and Use of Depleted Uranium Hexafluoride" on August 2, 1999
  - Promptly convert DUF_6 inventory to more stable form
  - Initiate DU uses in R&D program
  - Ensure direct disposal to the extent that beneficial uses are not found

Paducah Gaseous Diffusion Plant

DUF_6 Materials Use Roadmap

- Characterizes and analyzes alternative disposition paths for DUF_6 conversion–related materials
  - Beneficial uses of DU
  - Fluorine product
  - Reuse of intact cylinders
- A link to roadmap can be found at *http://www.ne.doe.gov/*

DU Uses in Nuclear Fuel Cycle Applications

- Feed for further enrichment
- A fertile material in fast-breeder reactors
- A diluent to down-blend highly enriched uranium
- Potentially a component of a waste repository

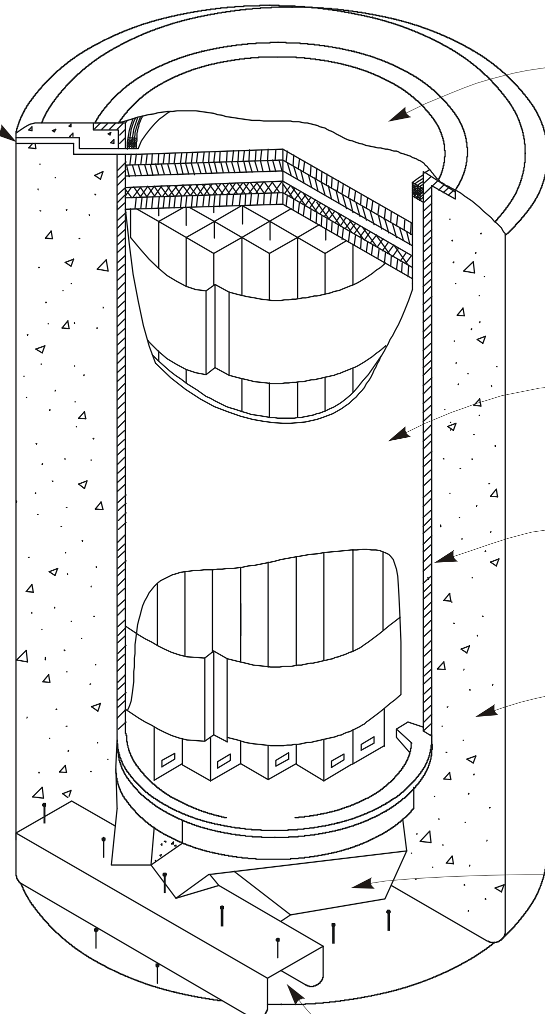
DU Uses in Conventional Military Applications

- Tank armor
- Armor-piercing projectiles

DU Uses as Radiation Shielding from X-Rays or Gamma Rays

- **High-density DU is substituted for coarse aggregate in conventional concrete and enclosed in stainless steel shells to provide structural strength**
- **Same radiation shielding performance with up to half the thickness required of normal concrete**
  - **Conventional concrete density: ~132 lb/ft^3**
  - **DU concrete: >400 lb/ft^3**
- **Other technologies for making high-density shielding**
  - **DUPoly: Brookhaven National Laboratory**

Ventilated Storage Cask



DU Uses in Commercial Applications

- Traditionally used as counterweights (e.g., aerospace industry)
- Novel potential uses
  - Uranium-oxide-based catalysts
  - UO_2-based semiconductors

Uranium Dioxide–Based Catalysts

Uranium Oxide–Based Catalysts

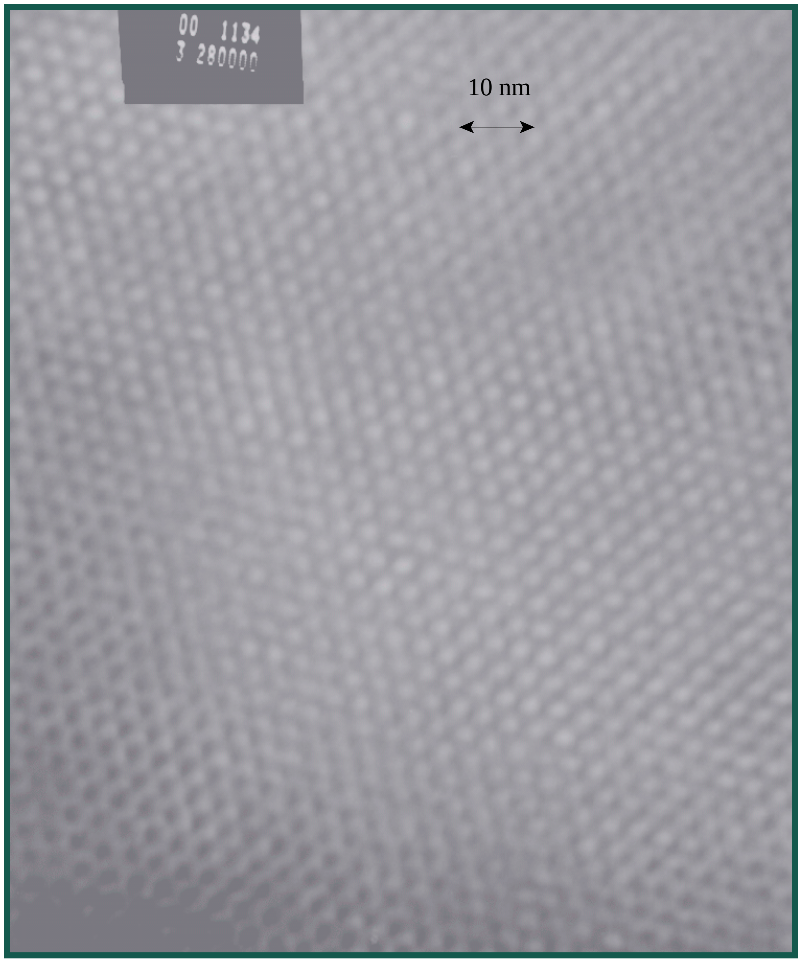
- Investigate a new class of mesoporous sol-gel catalysts containing DU oxides as the active component
- Initially investigate volatile organic compounds of interest in environmental restoration
- Demonstrate high efficiency and long-term stability
- Mesoporous uranium oxide (U_3O_8) surface area is at least 650 times larger than that of commercial U_3O_8

Volatile Organic Compound Destruction Over Uranium Catalysts[a]

Catalyst	VOC type	Temperature (°C)	Conversion (%)	CO_x selectivity (%)
U_3O_8[b]	Benzene	400	99.9	100
U/SiO_2[b]	Benzene	400	99.9	100
$Cu/U/SiO_2$[b]	Benzene	400	99.9	100
U/SiO_2[c]	Toluene	400	99.9	100
U_3O_8[b]	Butane	600	81	100
U/SiO_2[b]	Butane	500	99.9	100
$Cu/U/SiO_2$[b]	Butane	450	95	100
U_3O_8[c]	Cyclohexanone	300	99.9	100
U/SiO_2[c]	Cyclohexanone	300	99.9	100
U_3O_8[c]	Butylacetate	350	99.9	100
U/SiO_2[c]	Butylacetate	350	99.9	100
$Cu/U/SiO_2$[c]	Butylacetate	350	99.9	100

[a]G. J. Hutchings et al., "Uranium-oxide-based catalysts for the destruction of volatile chloro-organic compounds," *Nature* 384 (November 1996).
[b]Pelleted catalyst.
[c]Powdered catalyst.

TEM Image of Ordered Mesoporous SiO_2 Used to Support Uranium Oxide Catalysts

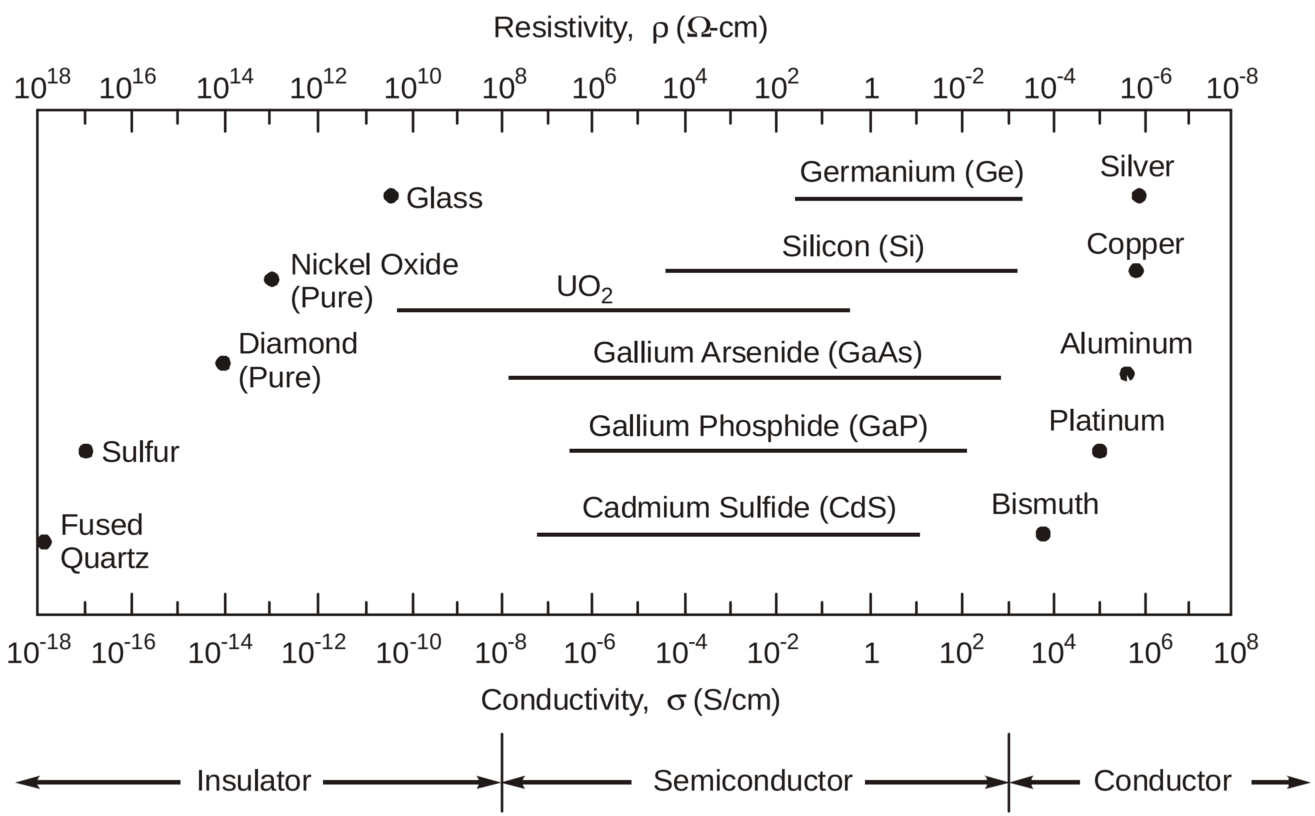


Mahesh Konduru Setting Up the Reactor for Uranium Catalyst Tests

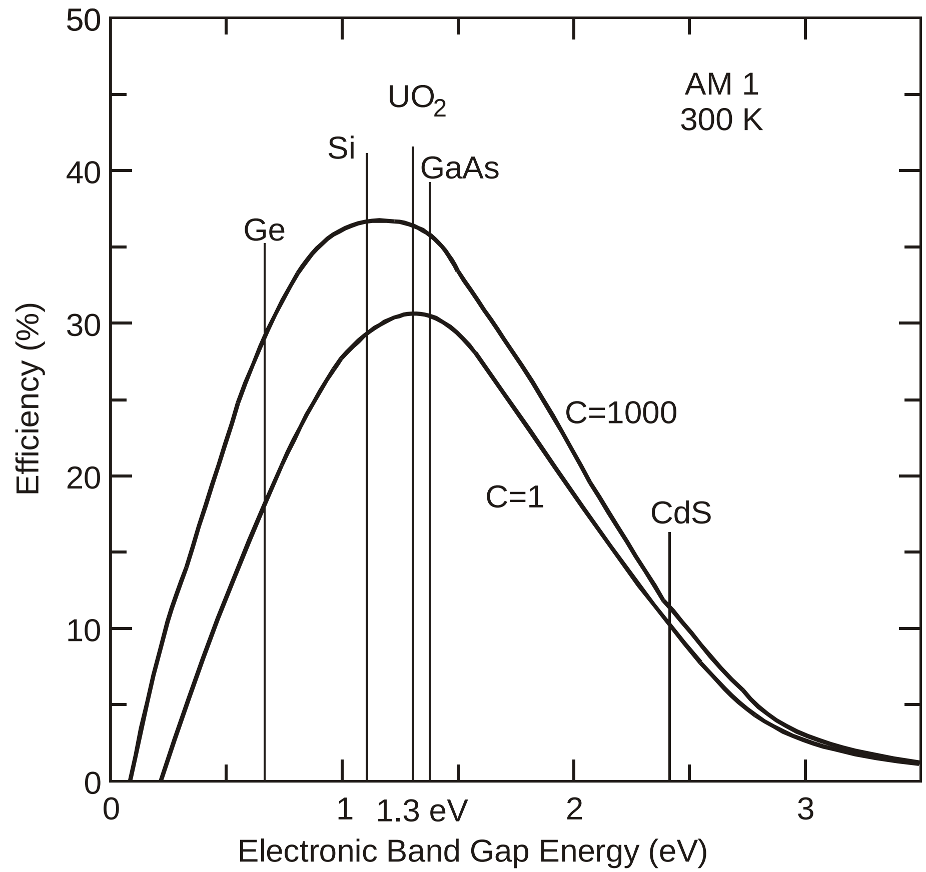
Erin Myers Holding Uranium(VI) Oxide Supported in a Transparent Mesoporous SiO_2

Uranium Dioxide–Based Semiconductors

Comparison of UO_2 Conductivity to a Typical Range of Conductivities for Insulators, Semiconductors, and Conductors [Sze 1985]



Ideal Solar-Cell Efficiency at 300 K for 1- and 1000-Sun Concentrations [Sze 1985]



Semiconductive Properties of UO_2

- **Intrinsic electrical and electronic properties of UO_2 are equivalent to or much better than Si, Ge, GaAs**
  - **Electronic band gap for UO_2 lies between Si and GaAs**
  - **Electronic conductivity of UO_2 is approximately equal to GaAs**
  - **Dielectric constant of UO_2 is two times greater than that for Si**
  - **Seebeck coefficient is three times better than that for current best thermoelectric material (Tl_2 Ge Te_5)**
  - **UO_2 can withstand much higher temperatures (~2600 K) than Si can (~473 K)**
  - **Ceramic oxide, UO_2, is more resistant to radiation damage**
- **Thus, a variety of semiconductive devices are possible: electronic (integrated circuit), solar cell, thermoelectric, etc.**

Conclusions

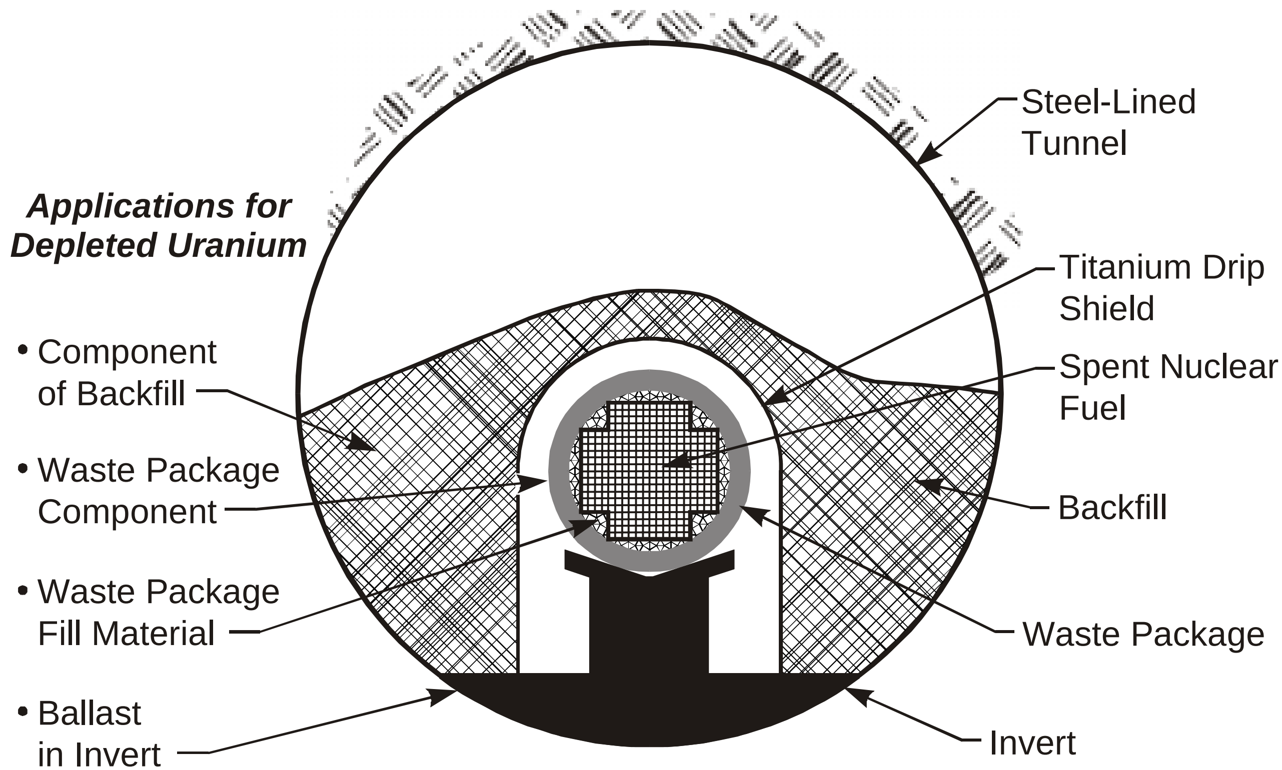
- DU is an asset with realistic potential for cost-effective uses
- Novel uses for DU continue to be discovered
- Issues must be resolved before commercial uses are implemented, including technical, regulatory, and user acceptance

Depleted Uranium as a Component of Waste Repository

DU Oxide Used as Fill, Invert, Backfill, Steel-DU Cermet at Repository

- **In DU fill concept, void space between fuel pins and spent nuclear fuel assemblies filled with UO_2 particles**
- **Benefits**
  - **Reduce shielding requirements if DU is incorporated into waste package structure**
  - **Reduce probability of nuclear criticality event**
  - **Reduce release of radionuclide constituents into environment (chemically reducing conditions, reduced groundwater flow, adsorption and filtering)**

Schematic of Potential Depleted Uranium Uses at a High-Level-Waste Repository



Catalyst Market and Potential DU Consumption

- Annual world catalyst production, ~3 × 10^9 lb/year[a]
- The U.S. Department of Energy's (DOE) DU inventory, ~10^9 lb
- A niche new uranium-based catalyst market could consume DOE's DU inventory
- Catalysts are high-value products; some are precious metal based (e.g., platinum)
- Projected 2003 annual sales, $8.9B/year[b]
- Industries that use catalysts: oil refining; commodity chemicals; synthesis gas–based products (e.g., hydrogen, methanol, ammonia); automotive; environmental; drug companies

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[a]Electronic mail from C. Payne to W. F. Myers, Catalyst Group (research and consulting firm), Spring House, Pennsylvania, Aug. 23, 2000.

[b]M. McCoy, "Catalyst Makers Look for Growth," *Chemical and Engineering News*, pp. 17–23, Sept. 20, 1999.