Advanced Materials for Underground Science and Applications (AMUSA)

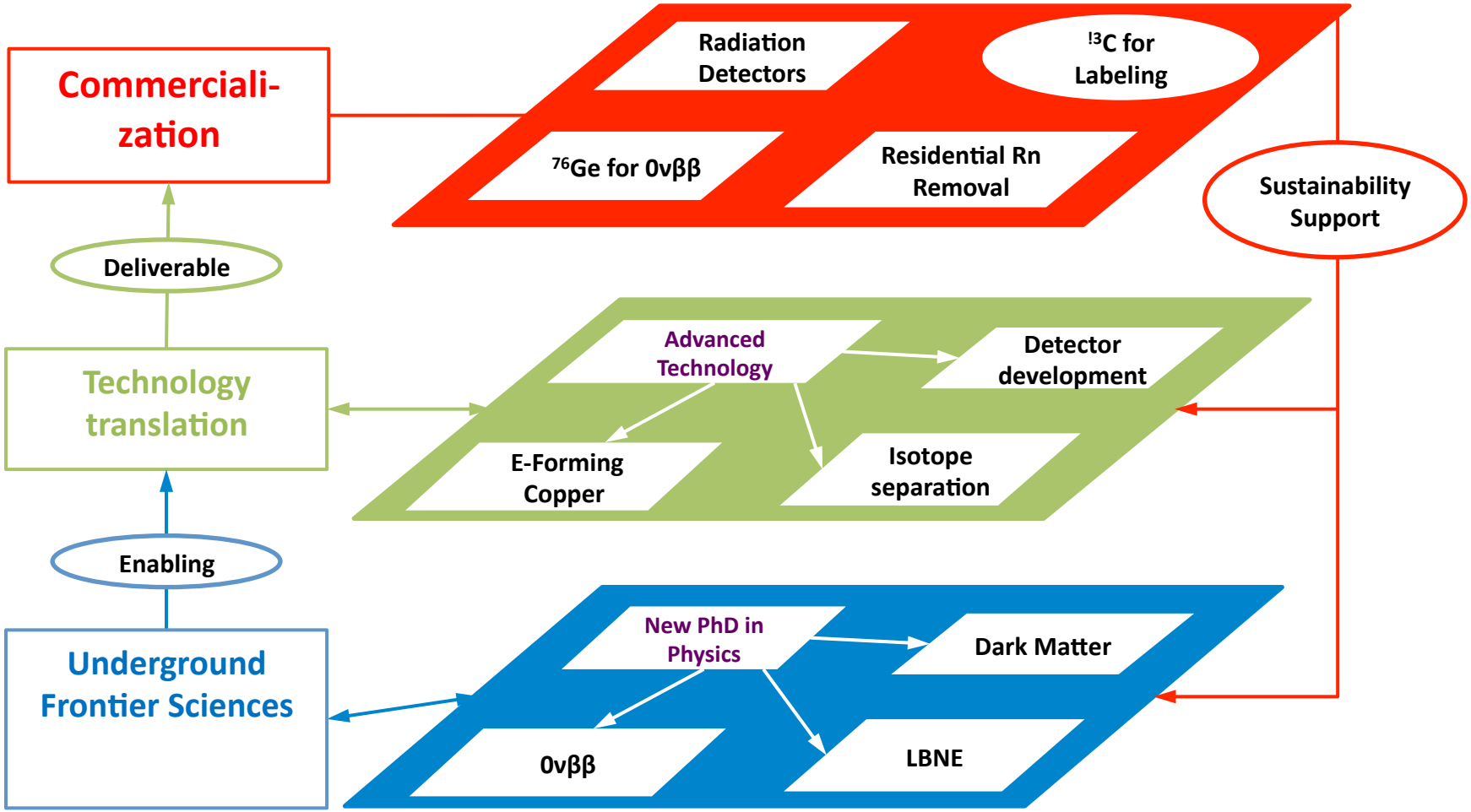
Dongming Mei for CUBED

Center for Ultralow Background Experiments In the Dakotas

Sanford Underground Research Facility (SURF) for Underground Science

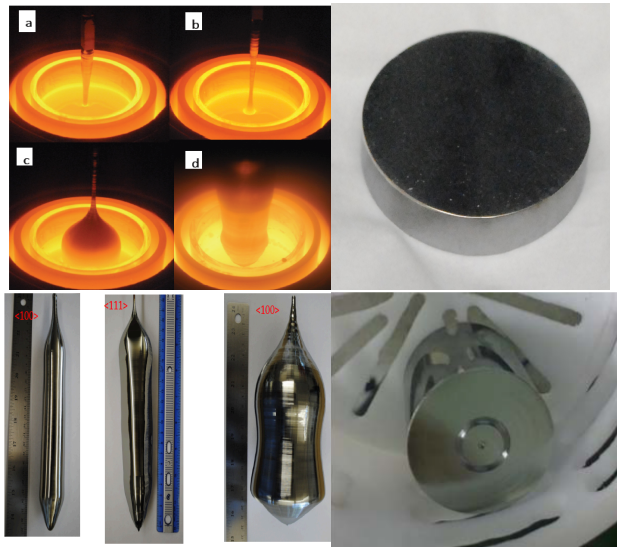
- Largest underground laboratory in the USA
- Supported by both DOE and NSF
- More than $120 M contributed by SD
- CUBED – successful SD collaboration focused on underground science
- SD is looking for returns
  - Economic return and educational return
- HOW!!! – Advanced materials are needed for underground experiments

Advanced Materials for Underground Science and Applications



Research Highlight (1)

Crystal Growth and Detector Development for Underground Experiments



Upper left : Crystal growth with the Czochralski Technique

Upper right: A fabricated planar detector with the amorphous germanium technique

Lower left: Three crystals we have grown, with sizes: 3.7 cm, 4.2 cm and 9 cm.

Lower right: Fabricated p-type point contact detector with the homegrown crystal.

Wang, G.-J. et al., Journal of Crystal Growth, 352 (1), 27-30.
Yang, G. et al., Journal of Crystal Growth, 352 (1), 43-46.
Yang, G. et al., Applied Physics A, DOI 10.1007/s00339-012-7518-x.
Khizar, M. et al., JP Journal of Structures and Solids, Accepted for publication, in press, (2012).

Scientific Achievement

- Developed methods to reduce impurity levels from multiple sources (crucibles, growth chamber, starting materials).
- Have successfully grown small size (~ 4 cm) detector-grade crystals, positioning ourselves to continue to develop methods for large size (7-10 cm) detector-grade crystal growth.

Significance and Impact

- The large detector-grade crystals will support the ton-scale ultra-sensitive germanium-based underground experiments search for dark matter and neutrinoless double-beta decay.
- It has contributed significantly to scientific workforce development in South Dakota by supporting more than 20 students and 54 collaborators, consistent with the project's economic development plan.

Research Details

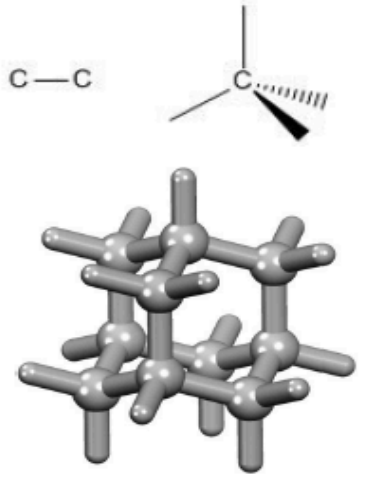
- Zone refine germanium ingots to reduce impurity level from ~10^{14} to ~$10^{10}/cm^3$
- Grow crystals to reach the impurity level of ~$10^{10}/cm^3$
- Characterize the grown crystals for impurity level and dislocation density
- Fabricate detectors

Work was performed at The University of South Dakota

U.S. DEPARTMENT OF ENERGY | Office of Science | EPSCoR DEPARTMENT of ENERGY | UNIVERSITY OF SOUTH DAKOTA | SCHOOL OF MINES & TECHNOLOGY | South Dakota 2010 Research Center | Sanford Underground Research Facility SURF

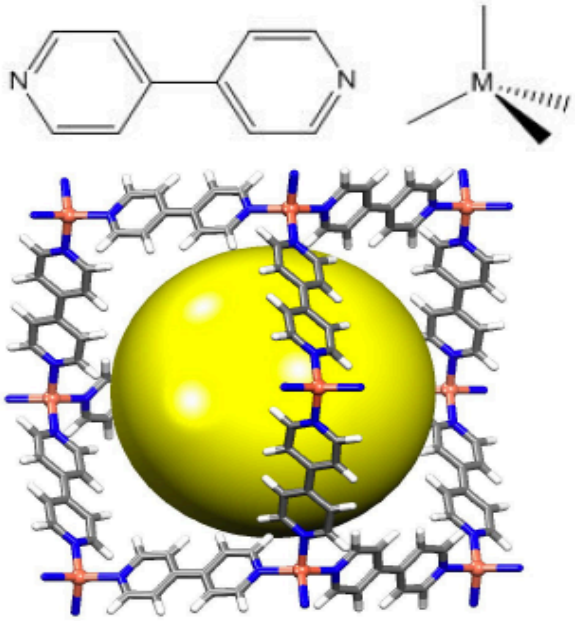
Research Highlight (2)
Radon and Krypton Removal:
Metal Organic Framework – Large surface area up to 7000 m^2/g

Porous crystalline lattices containing metal ions linked by organic bridging linkers



C-C distance: 1.54Å

Diamond

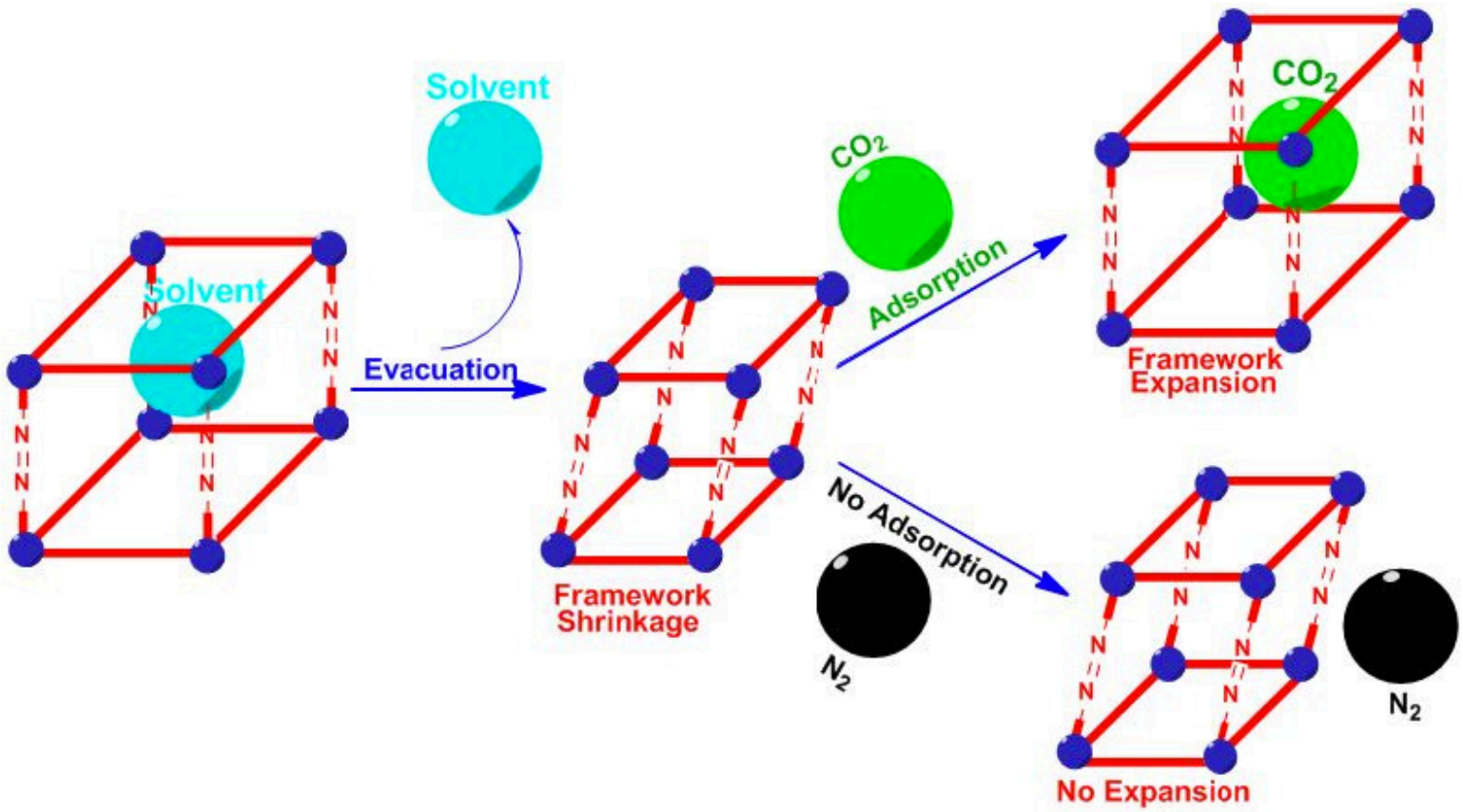


M-M distance: ~11.3Å

Diamondoid MOF

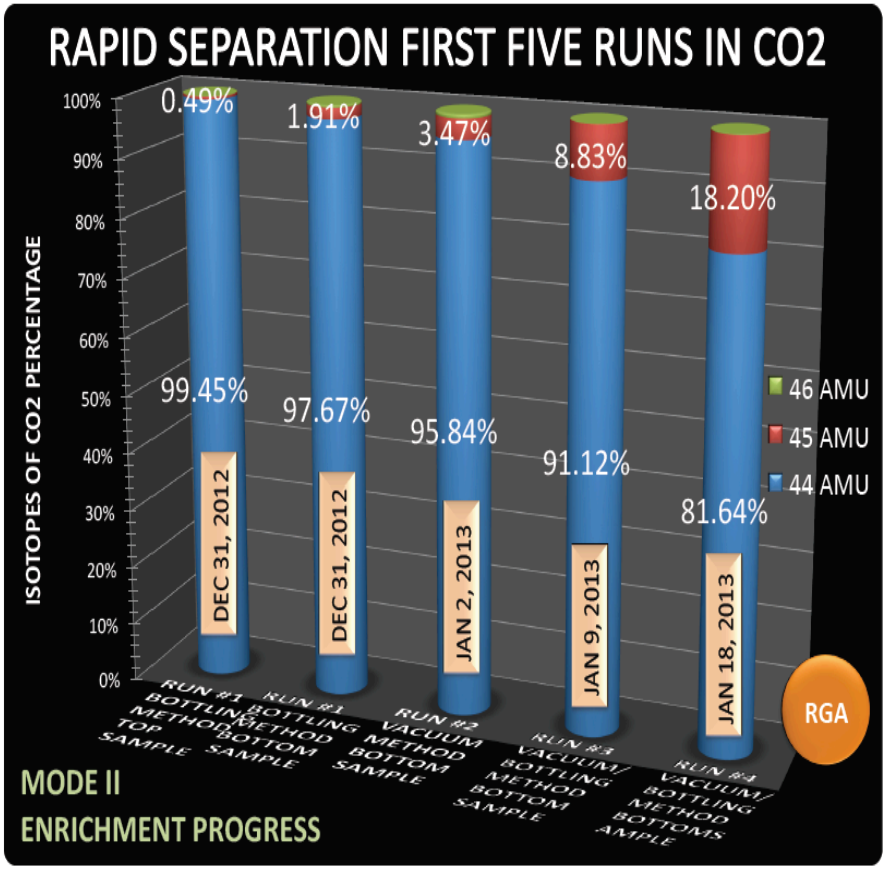
J. Am. Chem. Soc. **1990**, *112*, 1546

Research Highlight (2)
Selective Adsorption Mechanism



Research Highlight (3)
R&D on Isotope Separation Using Selective Condensation

R&D Apparatus AT USD for germane gas (GeH_4)



Test with CO_2 (4 hours run) due to a similar workable temperature to GeH_4 and the tolerance of safety