A New Method for Coating Highly-Permeable Matrices for High-Power ISOL Production Targets

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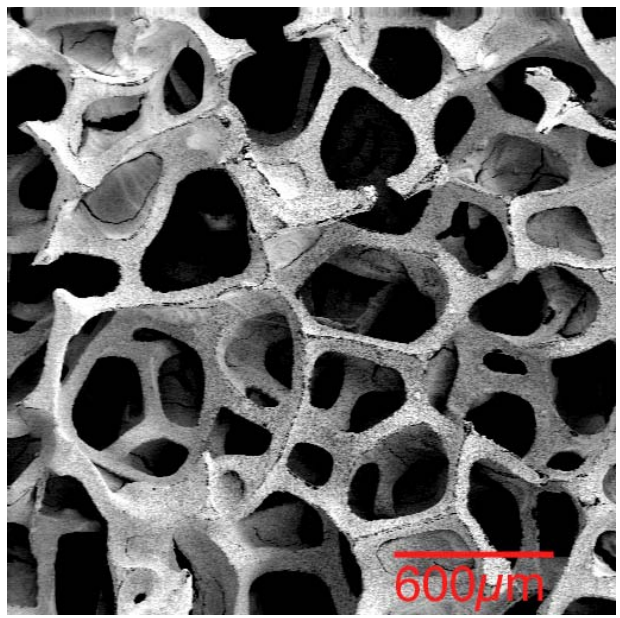

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Brief Description of Project

- Developed a technique to make ISOL targets for the production of radioactive ion beams
  - Thin layers of target material on carbon matrix
  - Universal application (carbides, oxides, …)
  - Fast and inexpensive
- Manufactured several different targets
- Performed on-line tests to measure the release rate of radioactive ions

ISOL Production Targets at HRIBF

- ISOL production targets must be
  - highly refractory (low vapor pressure at high T)
  - small dimensioned (short diffusion times)
  - highly permeable (short effusion times through the target matrix)
  - able to withstand high power densities
- At HRIBF, successful ISOL targets have been
  - fibers (Al_2O_3, HfO_2, SiC)
  - thin coatings on a low-density, rugged carbon matrix (UC/RVC, CeS/W-RVC)
  - liquid metals (Ge, Ni)

Objective

To develop an inexpensive, fast and universal method for coating complex-geometry matrices with refractory compounds or metals to prescribed thicknesses.

Relevance to RIA R&D

- This technique can be used to develop ISOL production targets for high-power applications
  - Identify useful target materials
  - Develop the manufacturing process to achieve the desired target thickness and density
  - Produce targets for testing
- Off-line and On-line tests at HRIBF
  - Investigate target stability and lifetime at high temperatures
  - Make release measurements
  - Target layer thickness can be optimized for production and release of desired isotope
  - Power densities in production targets at the HRIBF are comparable to the power densities that will be found at RIA

Compare power densities in UC

- Average power density at HRIBF is 32.5 W/g
  - 54 MeV proton beam at 20 μA (1 kW beam)
- Average power density of a 100 kW proton beam (1 GeV, 100 μA) is
  - 26.2 W/g if the beam is stopped
  - 18.9 W/g for a reasonable target thickness (less than 50 cm)

Recipe for Target Fabrication 'Paint' Technique

- make a very fine powder (~ 1 μm dia.) of the target material
  - Ball grinding technique used at ORNL
- suspend this fine powder in a liquid binder in initial solid/binder volume ratio of 1/4
  - Type YK binder from ZYP Coating, Inc., Oak Ridge, TN
- coat the support matrix with the paint using vacuum infiltration to draw the suspension into the internal surfaces
- heat the target to about 850 C to drive off the binder, leaving a thin coating of the target material on the fibers
  - Ramp to temperature over a 3-hour period
  - Hold at 850 C for at least an hour
  - Ramp the temperature back down over a 3-hour period
- The thickness of the resulting target layer is proportional to the weight gain of the sample

Vacuum Infiltration Apparatus

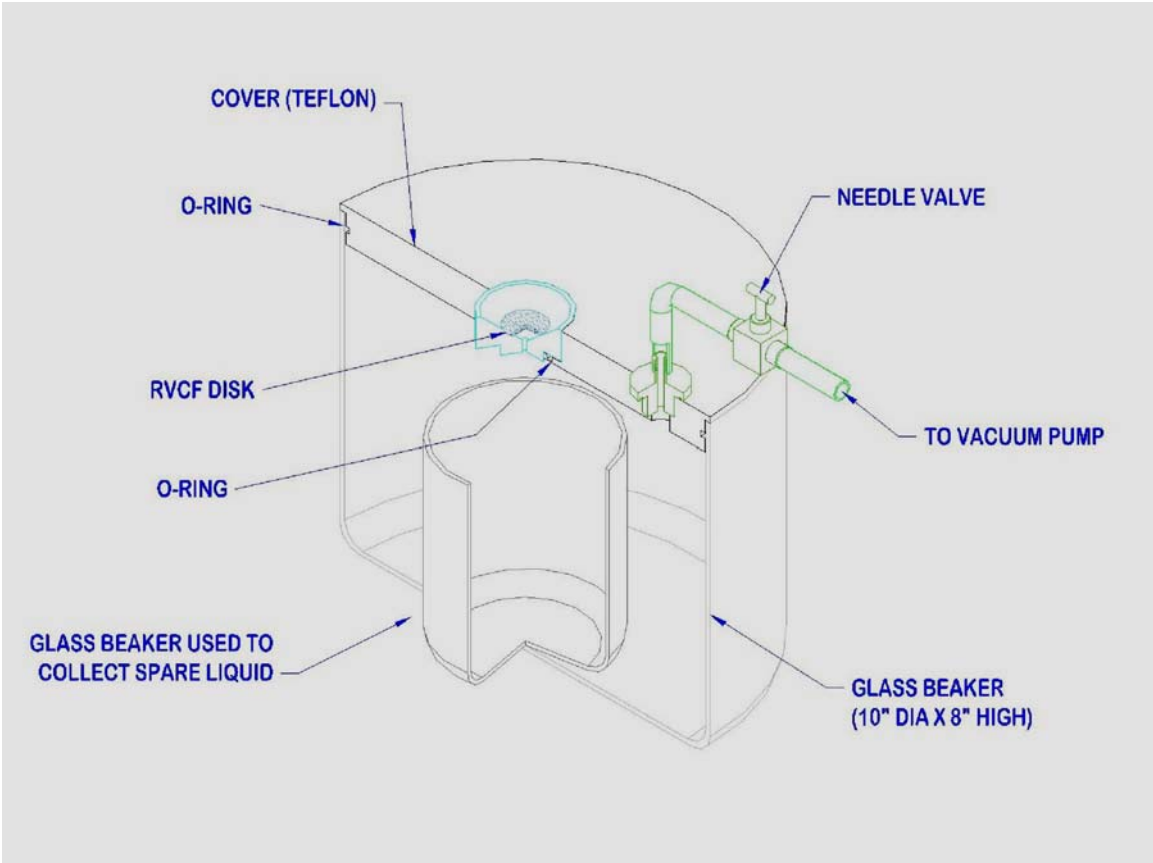
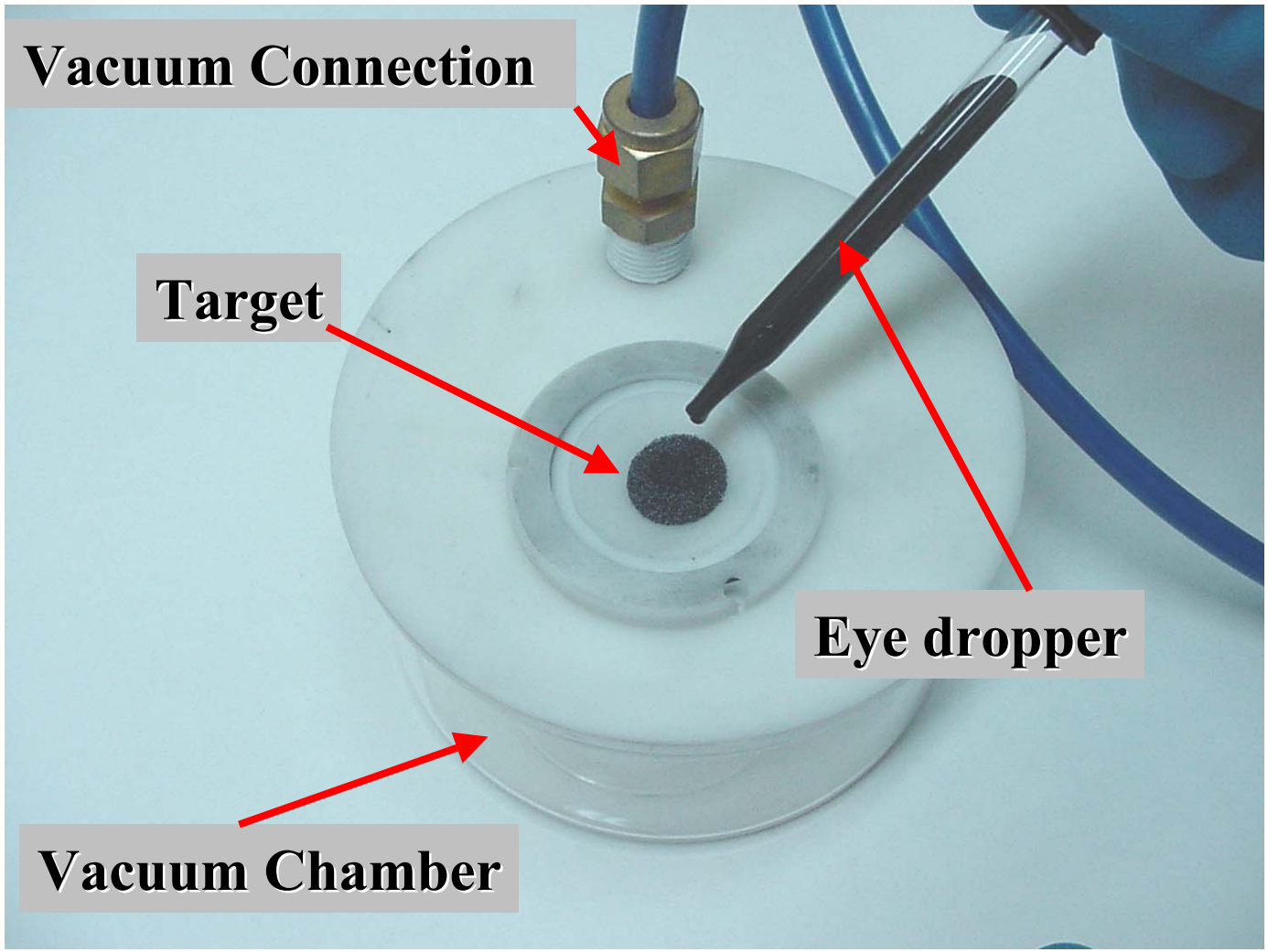


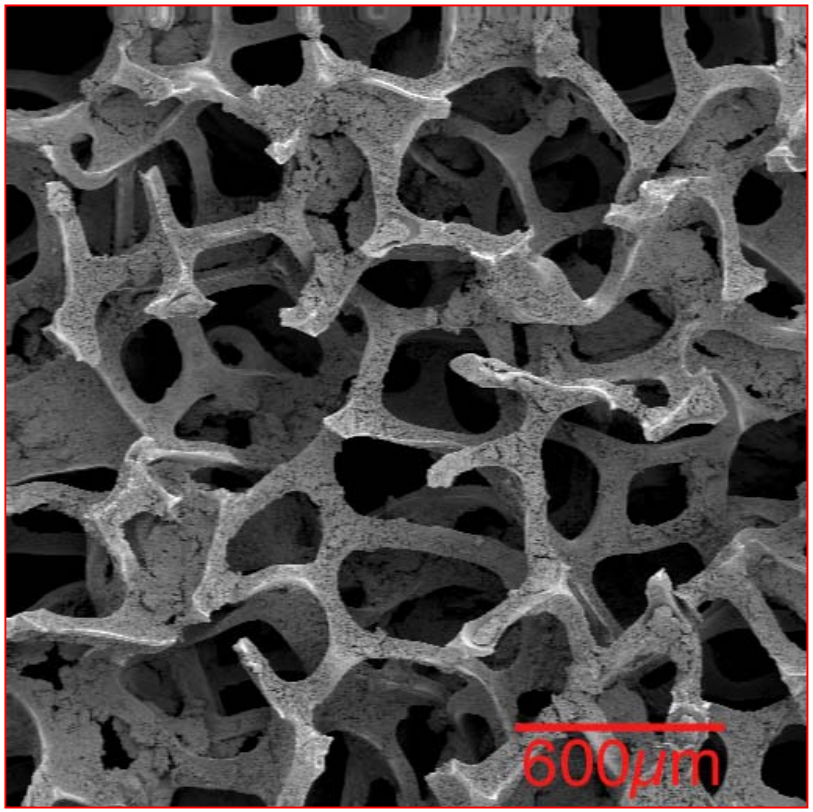
Illustration of the Vacuum Infiltration Apparatus



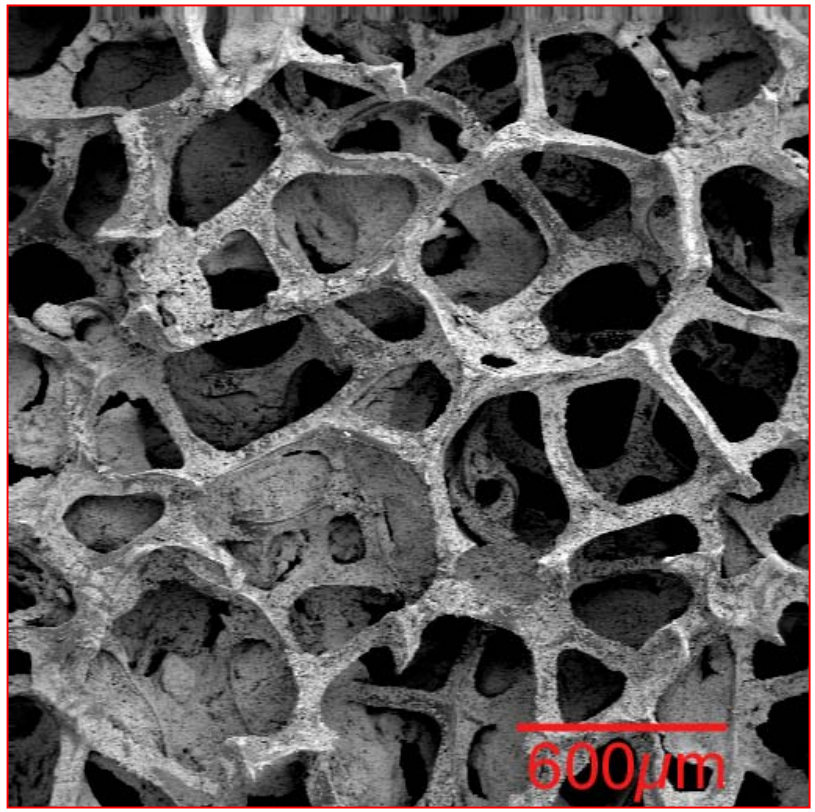
List of Targets Prepared using this Paint Technique

- Nitrides (BN)
- Carbides (SiC, TiC, NbC, VC, ZrC, HfC)
- Oxides (Al_2O_3, ZrO_2,Y_2O_3)
- Sulfides (CeS)

Examples of Targets (paint technique)

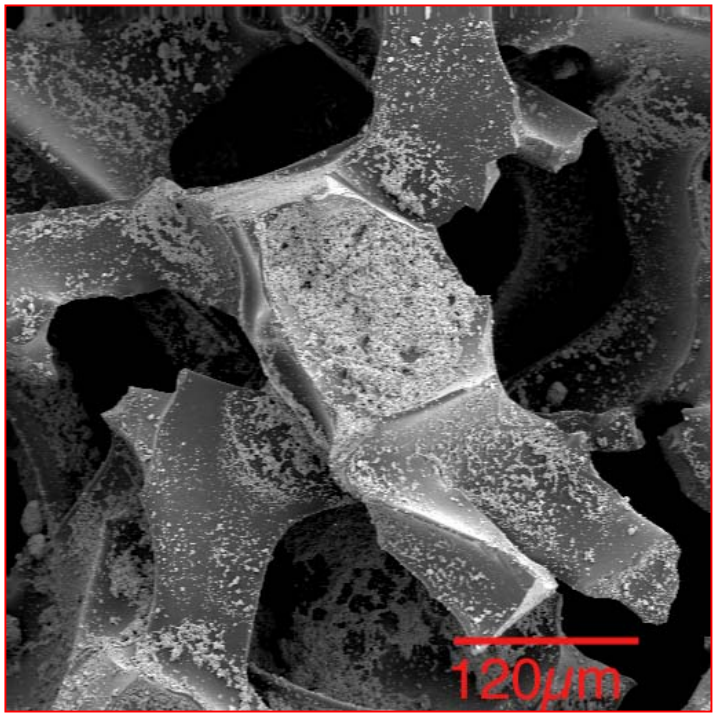


VC / 2xRVCF

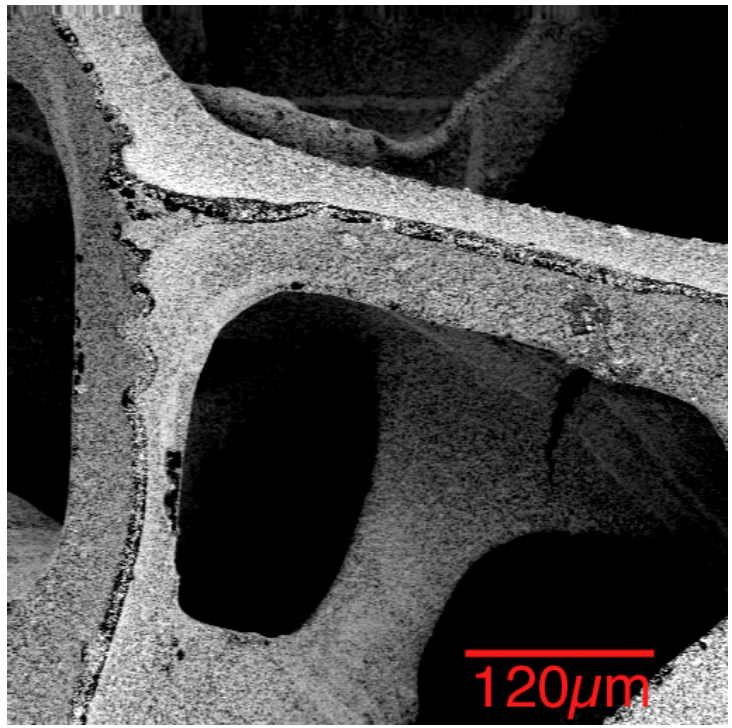


HfC / 2xRVCF

Examples of Targets (paint technique)

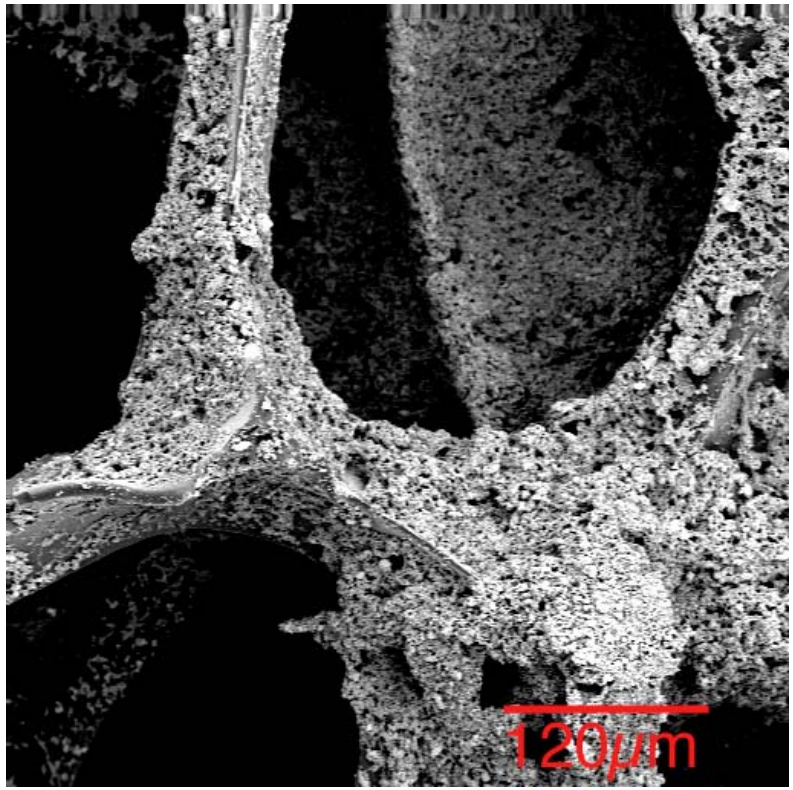


SiC / 2xRVCF

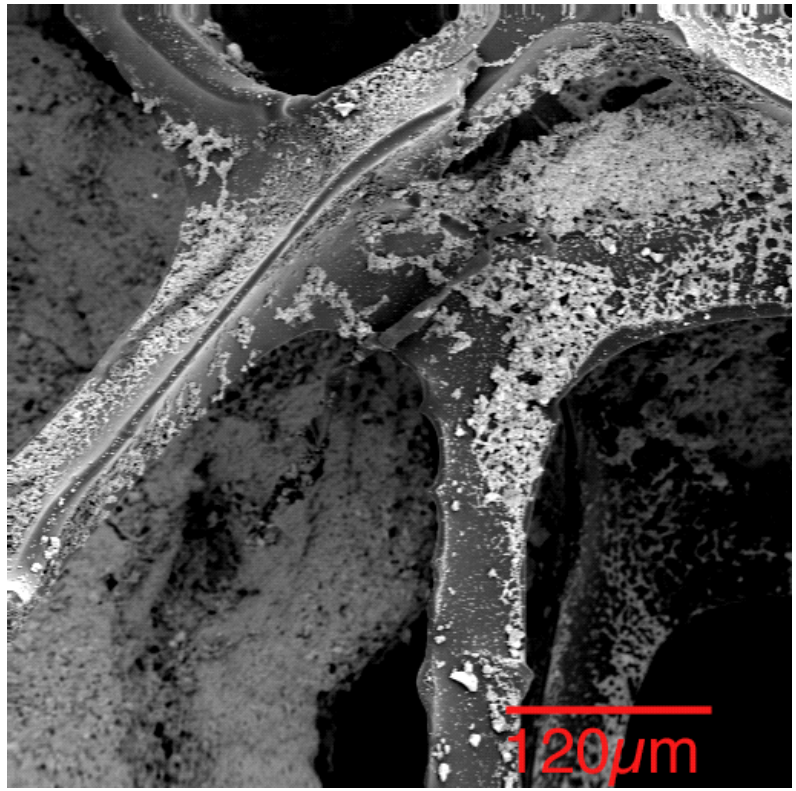


Al_2O_3 / 2xRVCF

Examples of Targets (paint technique)

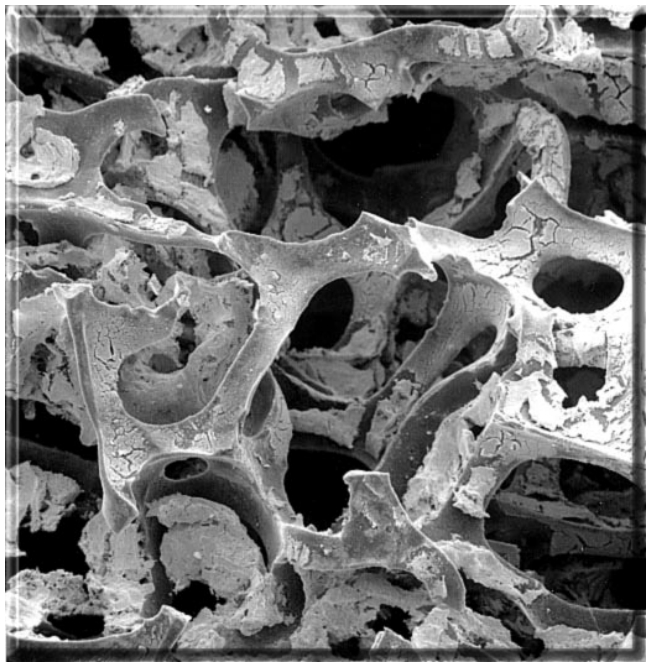


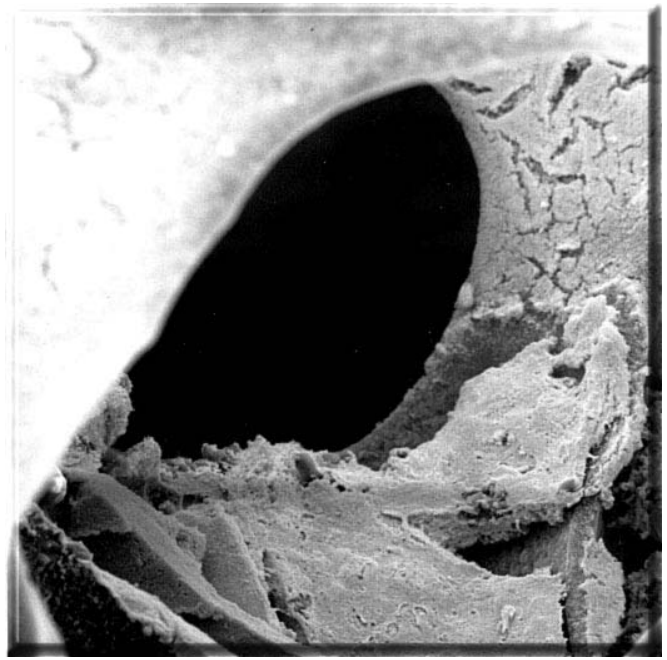
ZrC / 2xRVCF



ZrO_2 / 2xRVCF

UC Target (wet-chemistry technique)

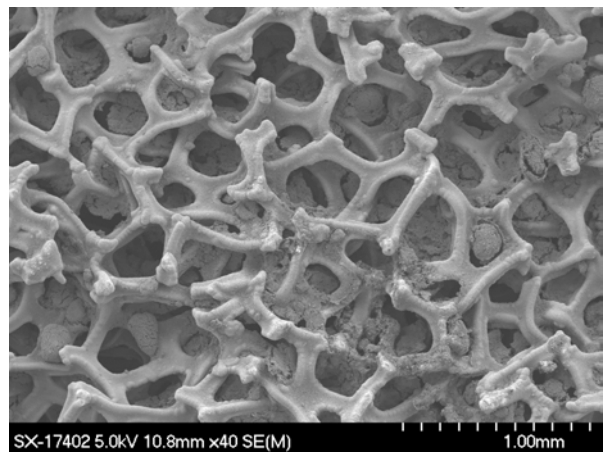




- RVC matrix saturated with uranyl nitrate solution
- Uranyl nitrate converted to uranium oxide at 300 C
- Repeat process to build up desired amount of uranium
- Uranium oxide converted to uranium carbide at 1950 C
- Long useful lifetimes
  - more than 50 days irradiation with 10 μA of 40 MeV protons

CeS target on RVC matrix

- Thin layer of CeS (5 μm thick) deposited onto a tungsten-coated carbon matrix
- Maximum operating temp. is 1900 C
- Used to produce ^{33}Cl and ^{34}Cl beams
  - $^{32}S(d,n)^{33}Cl$ ($T_{1/2}$ = 2.5 sec)
  - $^{34}S(p,n)^{34}Cl$ & $^{34}S(d,2n)^{34}Cl$ ($T_{1/2}$ = 32.2 min)
- Initial on-line tests
  - measured 10^4 ions/sec/μA of ^{34}Cl
  - extracted from ion source as $AlCl^+$
  - very little Al vapor was present in the target
  - ^{nat}S used to make target (natural abundance of ^{34}S is 4.2%)
- Will measure yields with negative ion source (similar to fluorine)
- Targets showed no change during tests



Status and Future Plans

- Manufactured targets of 11 different compounds using ‘paint’ technique (universal method)
- Tested CeS for release of radioactive chlorine
- Need more on-line tests with different targets
  - performance at high temperature
  - release rates
  - high-power capabilities
- Will soon manufacture UC targets
  - compare to present UC targets that were made using a ‘wet chemistry’ deposition technique