Chemical Vapor Deposition of Uranium Ditelluride (UTe_2)

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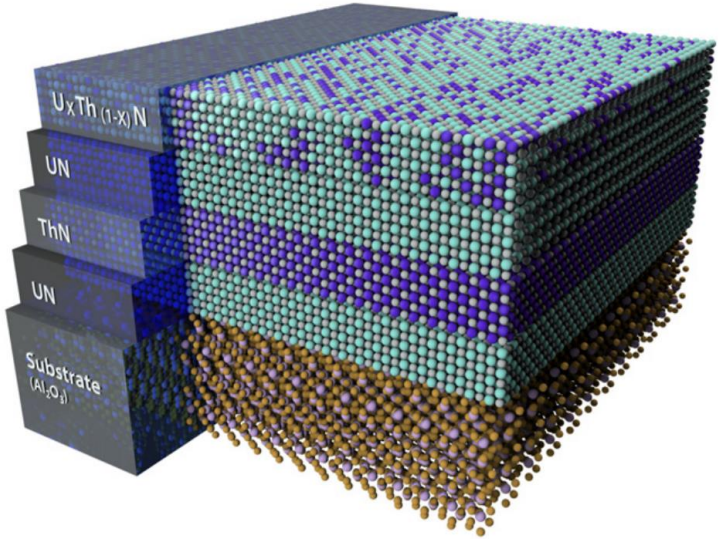
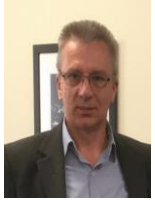
Outline:

- Goal
- Background
- Chemical Vapor Deposition of UTe2
  - Software Simulation
  - Experimental Setup
- Future Work
- Summary

What is our goal?

Grow thin films of actinides particularly UTe2

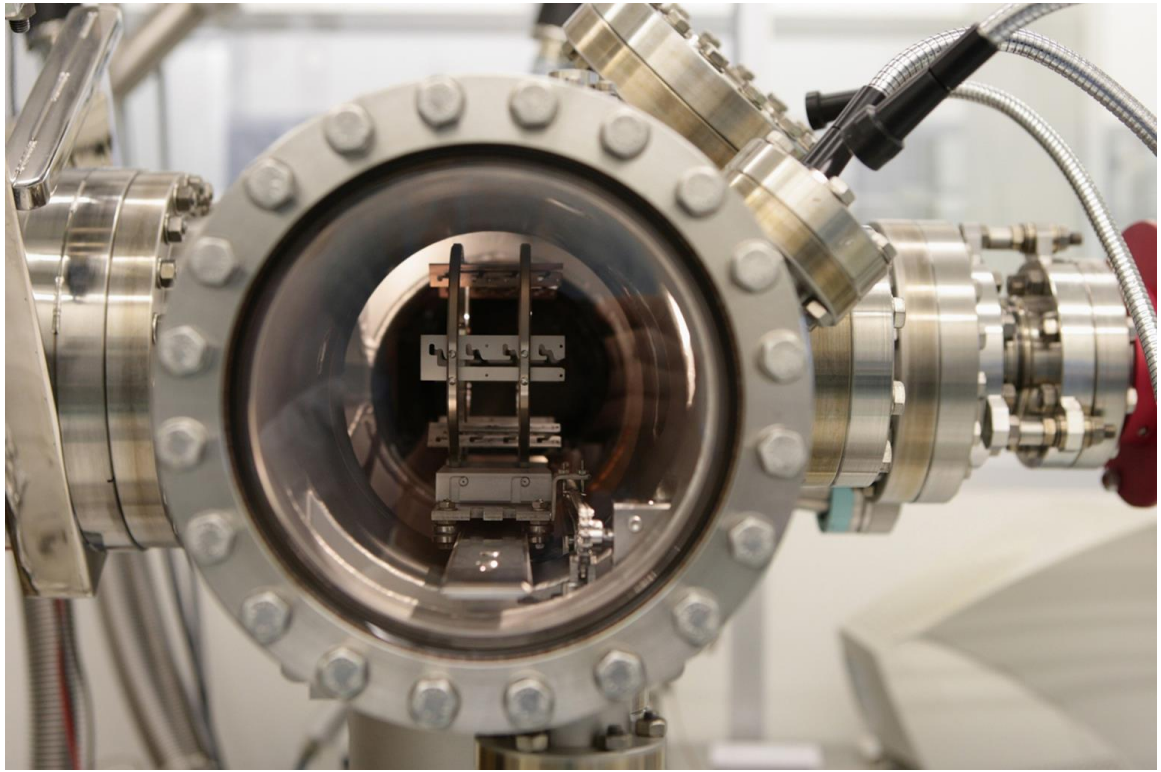




Citation Kevin D Vallejo *et al* 2022 *Rep. Prog. Phys.* 85 123101
DOI 10.1088/1361-6633/ac968e

Why?

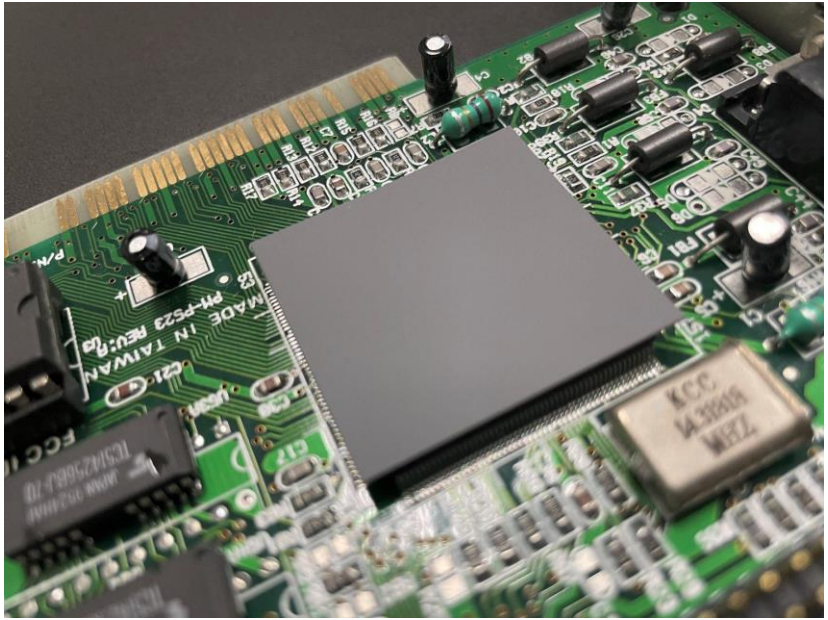
- Thin Films?
- UTe_2?
- Chemical Vapor Deposition?



Thin Films Deposition
https://www.micronit.com/manufacturing/capabilities/thin-film-deposition

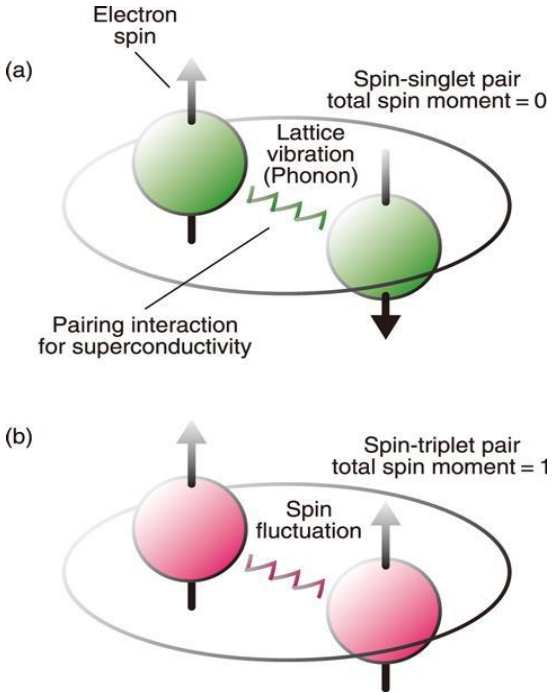
Thin Films (10^-9 m)

Image Credit: Laremenko Sergii/Shutterstock.com

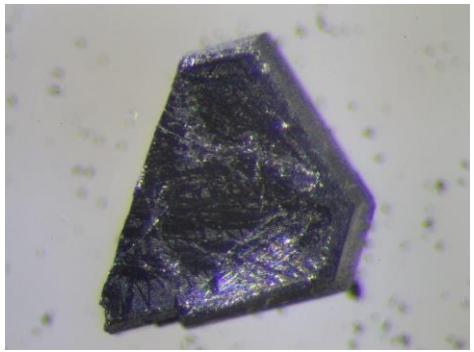


https://streuter.com/timtel-thermal-interface-materials/siltel-thermal-interface-silicone-film-materials-electronics-cooling/

UTe_2, a spin triplet superconductor



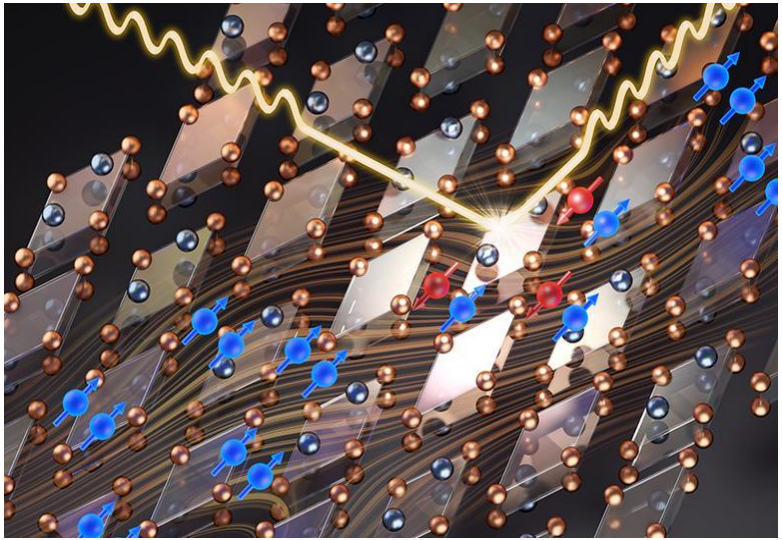
Two types of superconducting electron pairs
https://rdreview.jaea.go.jp/review_en/2020/e2020_3_3.html



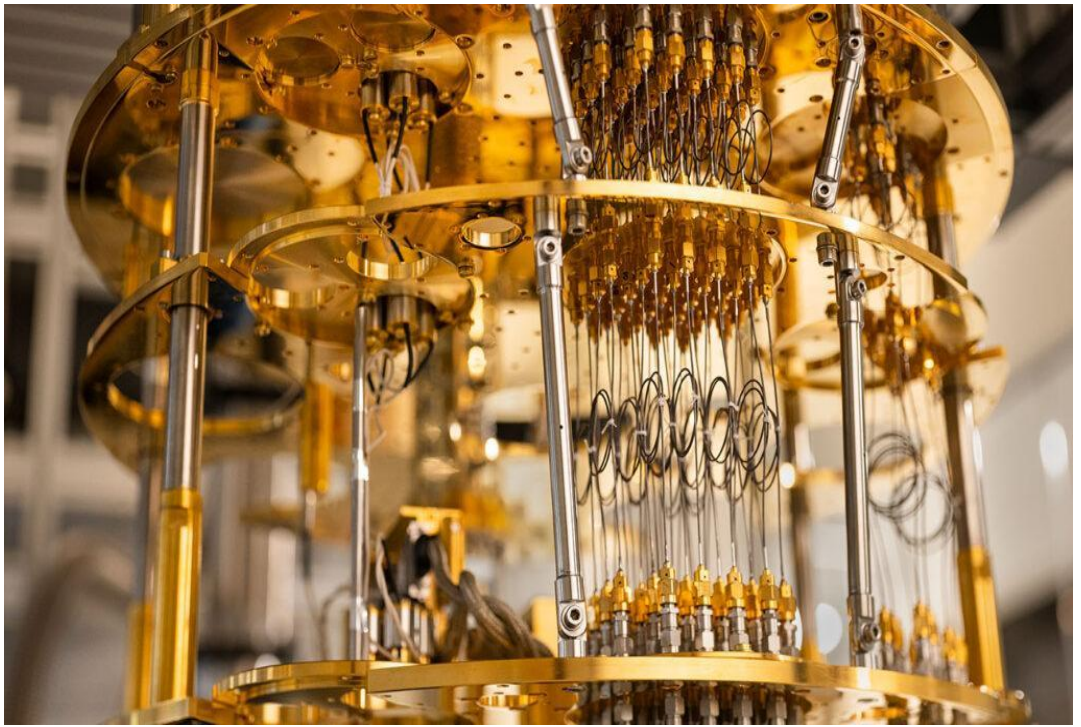
UTe_2 (CVT, Corey Frank)

Image Credit: F. Webber/NIST

UTe_2 and Quantum Computers?!

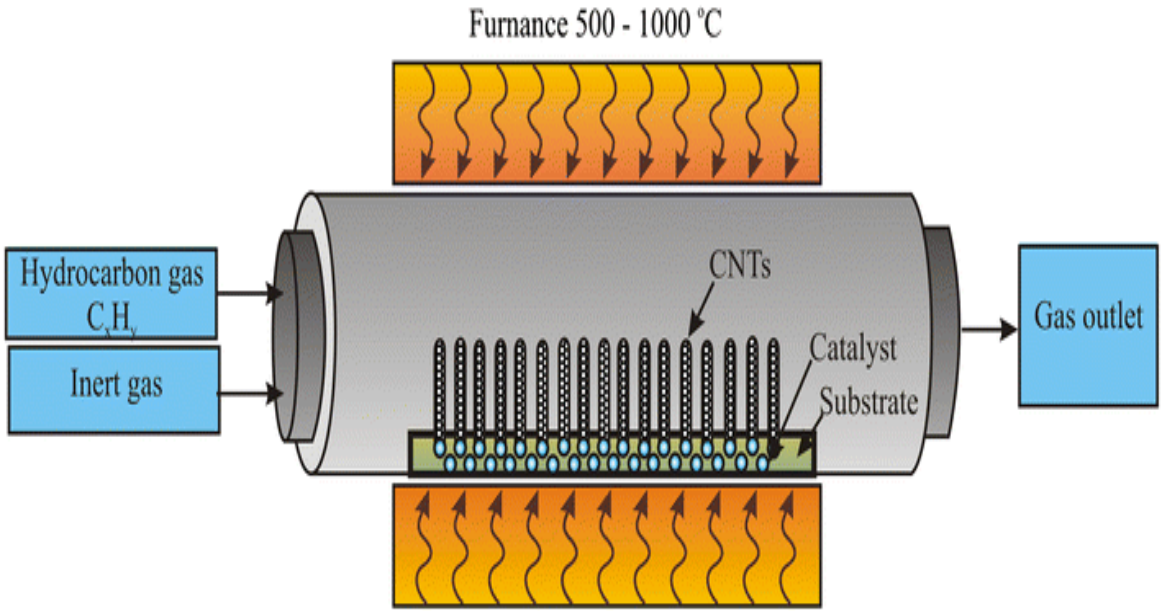


(Credit: Jill Hemman/ORNL)w54657r43www



https://www.microsoft.com/en-us/research/blog/microsoft-has-demonstrated-the-underlying-physics-required-to-create-a-new-kind-of-qubit/

What exactly is Chemical Vapor Deposition?

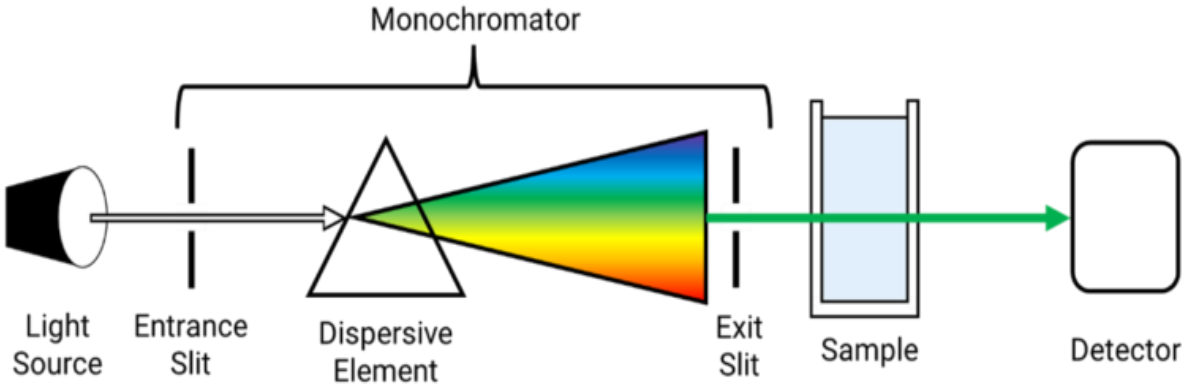


CNT: Carbon Nanotubes

Chemical and Biological Technologies in Agriculture. 3. 10.1186/s40538-016-0070-8.

What are we going to do differently in our experiments compared to others?

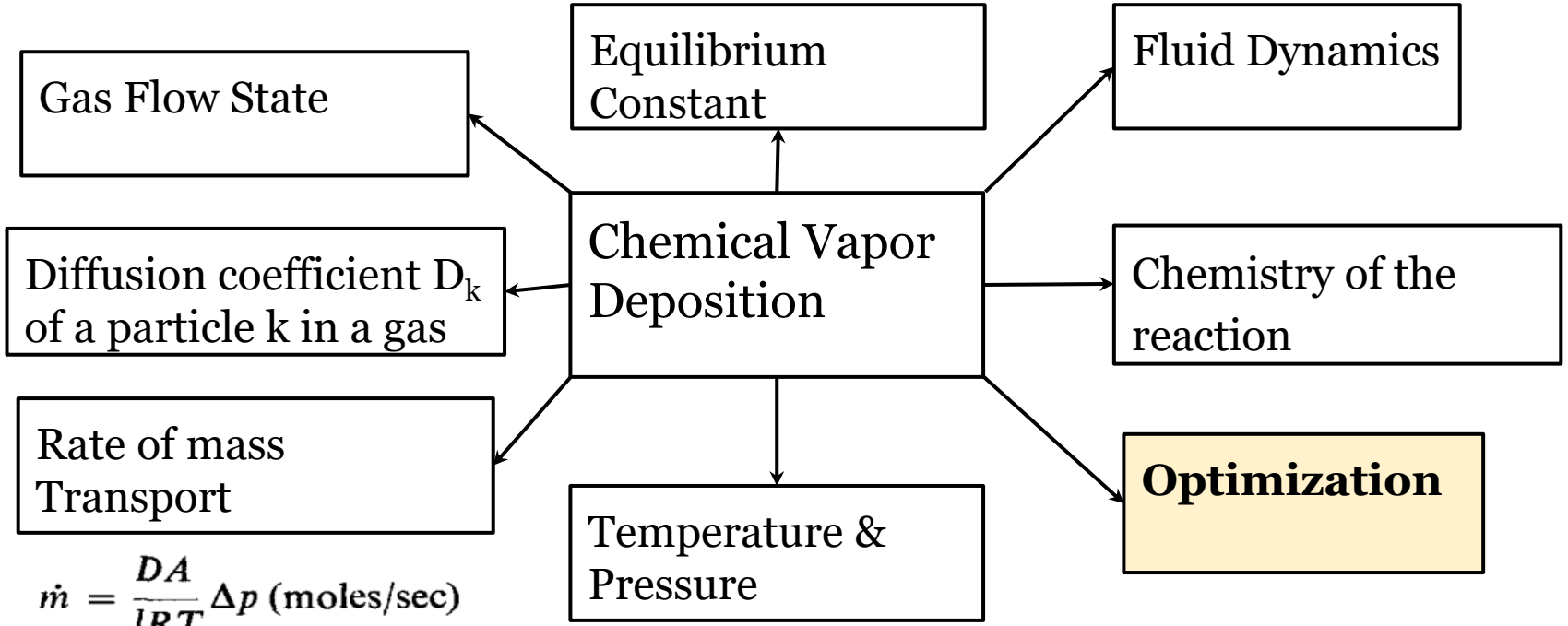
- Monitor and control the reaction on real-time



A basic block diagram of the elements in a single beam UV-Visible spectrometer
https://jascoinc.com/learning-center/theory/spectroscopy/uv-vis-spectroscopy/instrumentation/

Developing a Simulation Software

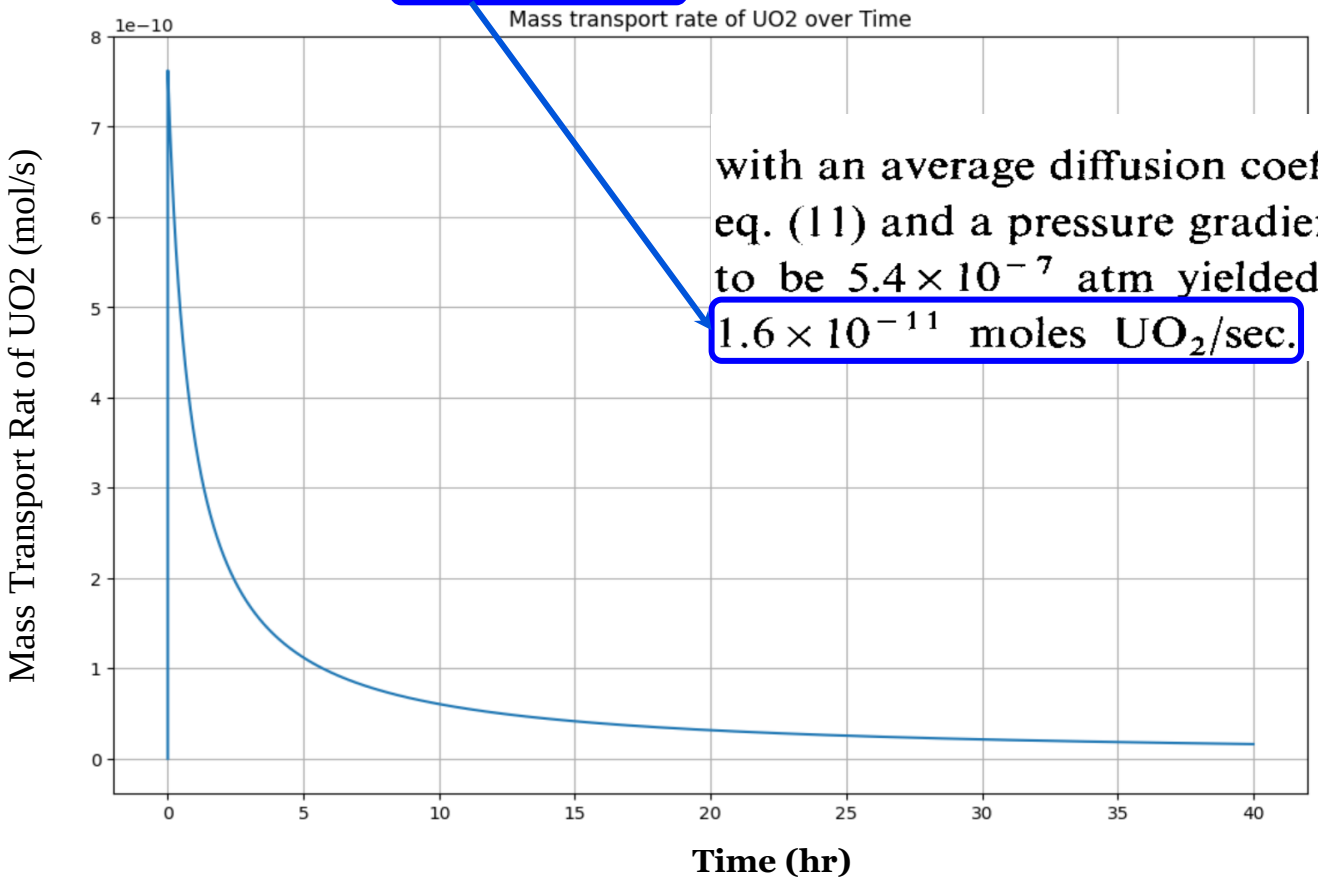
Why do we need a simulation software?



$$\dot{m} = \frac{DA}{lRT}\Delta p \text{ (moles/sec)}$$

$$UO_2\,(s) + 2Cl_2(g) \leftrightarrow UCl_4(g) + O_2(g)$$

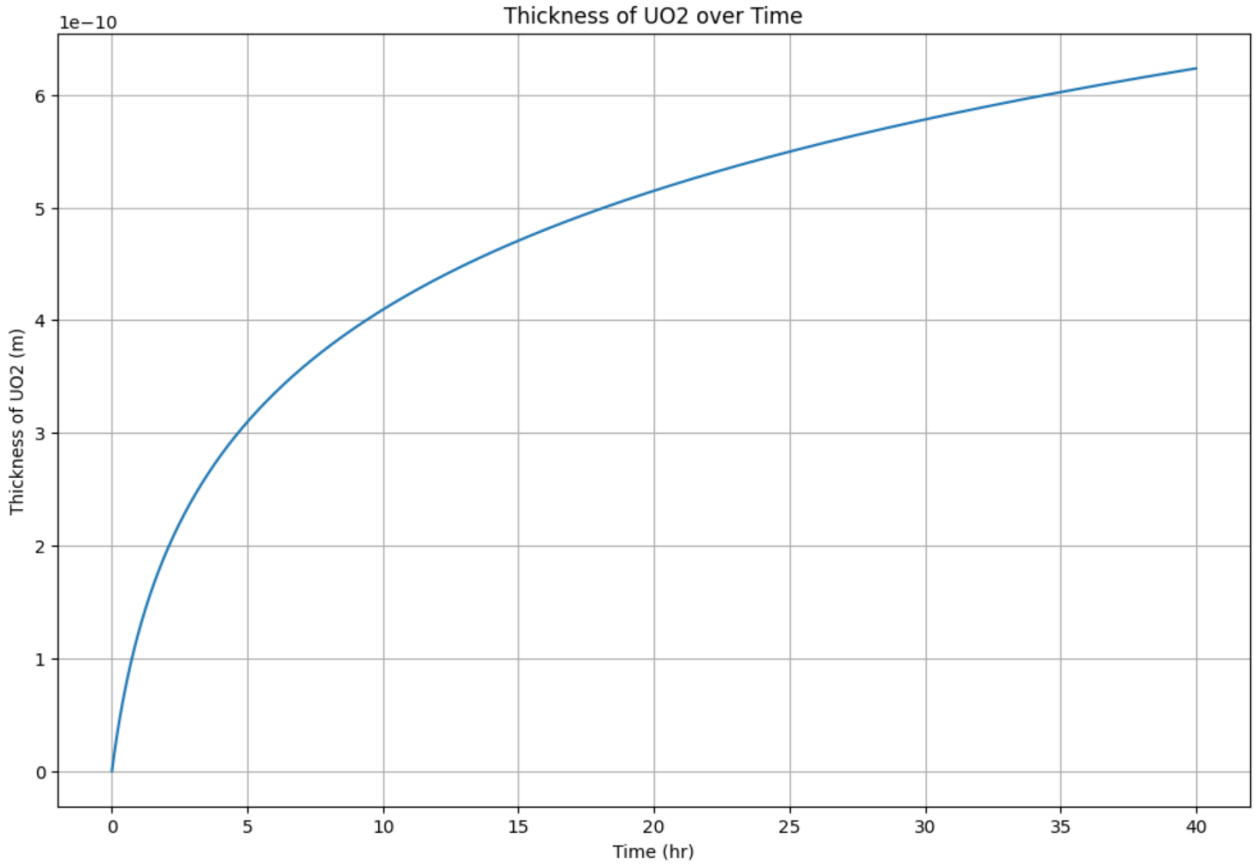
Mass transport rate at 40 hours is 1.6053915428818343e-11 mol/s



with an average diffusion coefficient $D = 9\ cm^2/sec$ by eq. (11) and a pressure gradient determined by eq. (12) to be 5.4×10^{-7} atm yielded a mass transport value 1.6×10^{-11} moles UO_2/sec. The agreement between

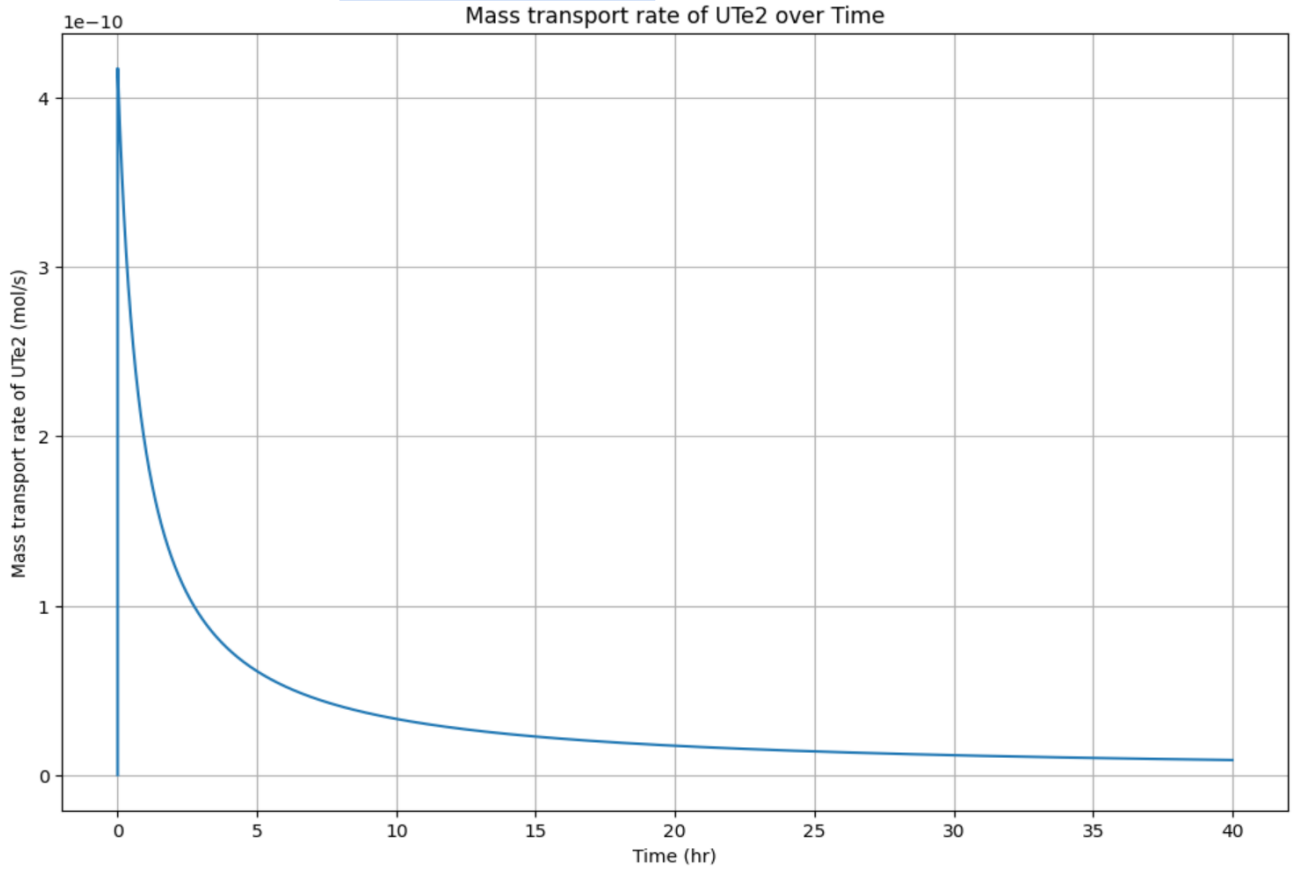
GROWTH OF URANIUM DIOXIDE SINGLE CRYSTALS BY CHEMICAL VAPOR DEPOSITION* R. N. SINGH and R. L. COBLE

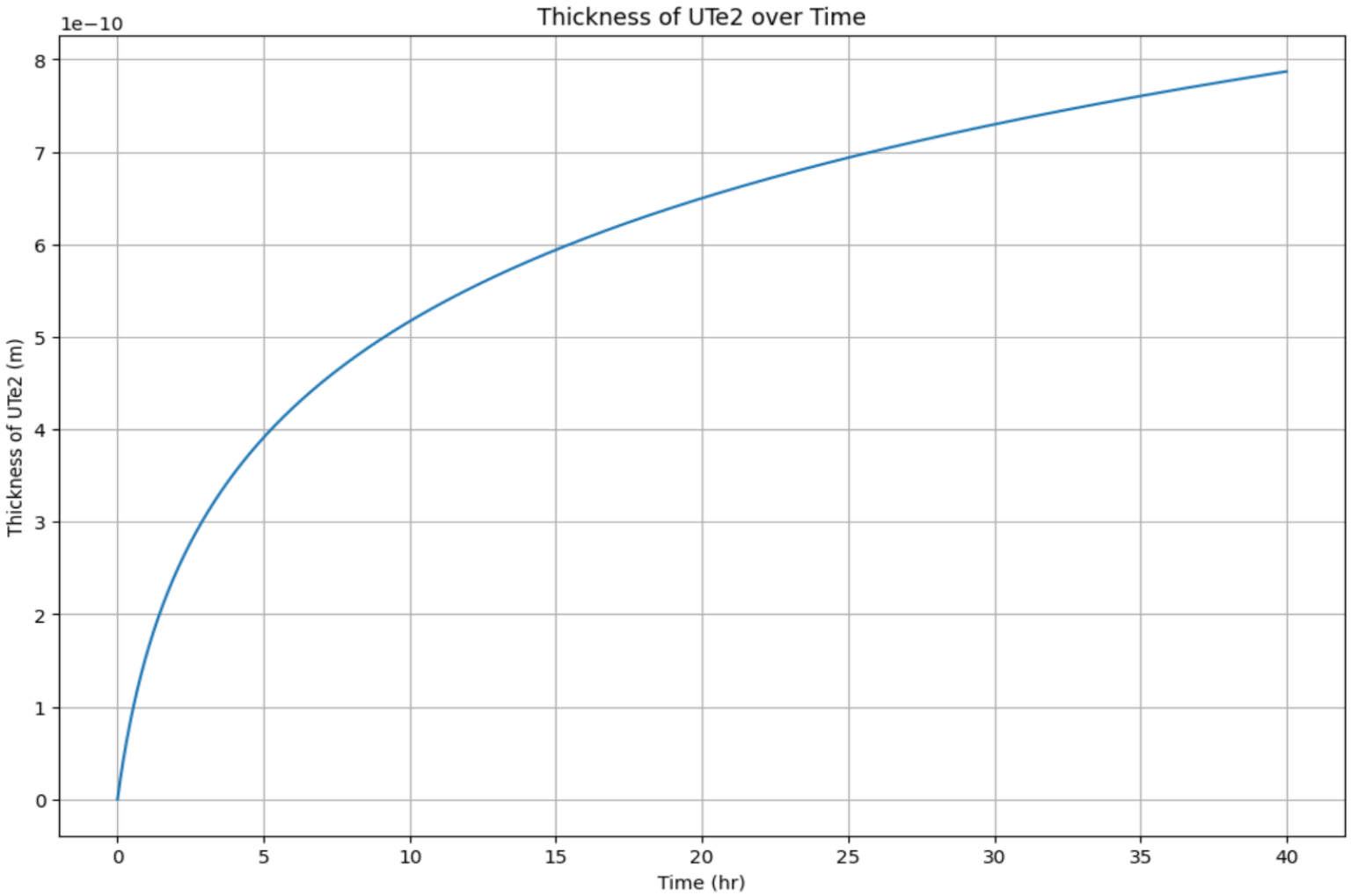
Predicting the thickness of UO2 on the substrate over time



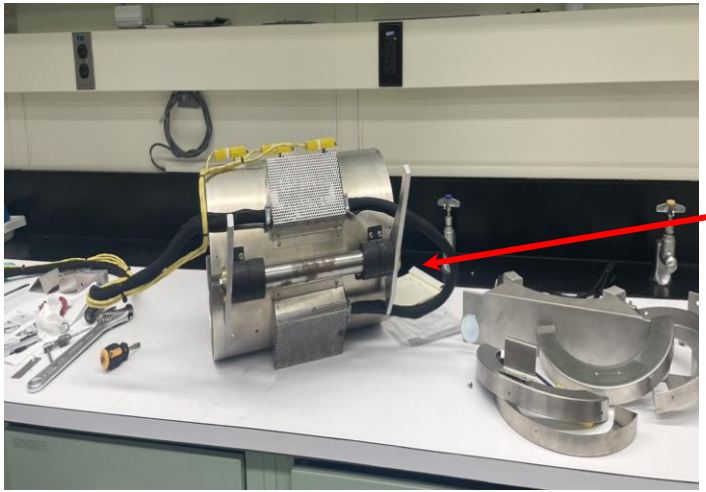
Mass transport rate (mol/s) vs Time (hr) UTe_2

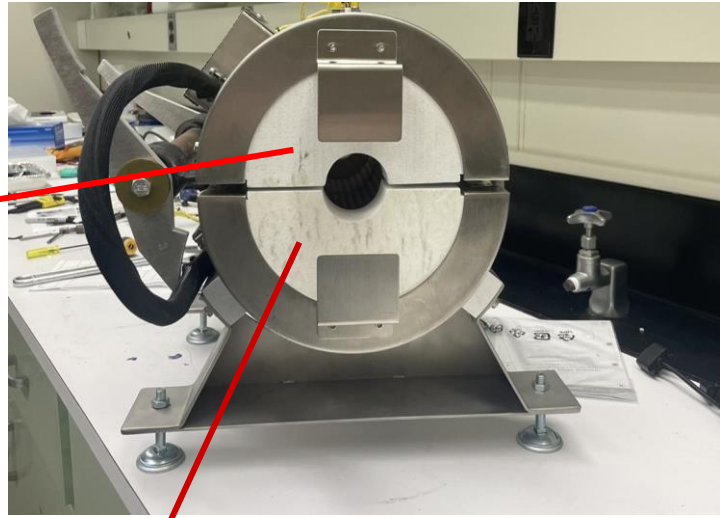
Mass transport rate at 40 hours is 8.789081733154545e-12 mol/s → 8.8e-12 mol/s




Thickness of UTe2 over Time
1e−10
Thickness of UTe2 (m)
Time (hr)
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
40

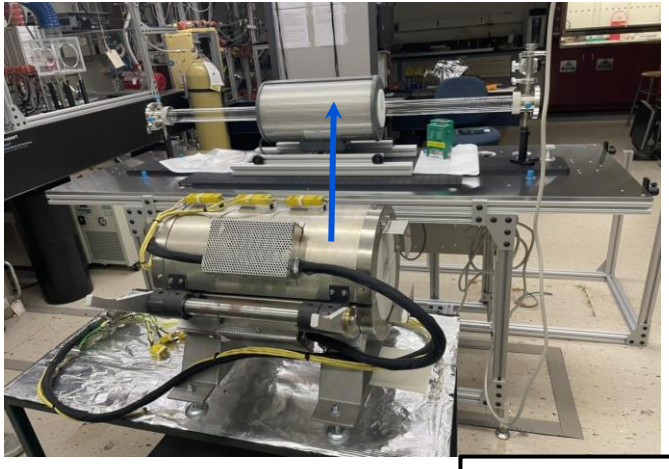
Experimental Setup





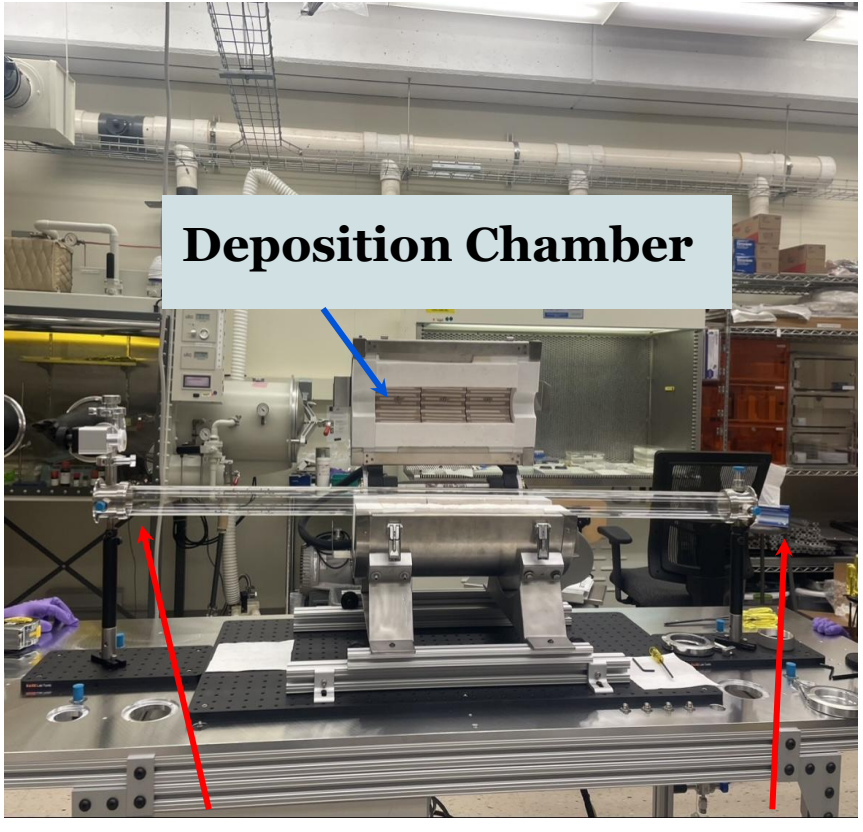
Changed high temperature thermal insulator

Experimental Setup Continued



Replaced

Plastic Cage -> Safety

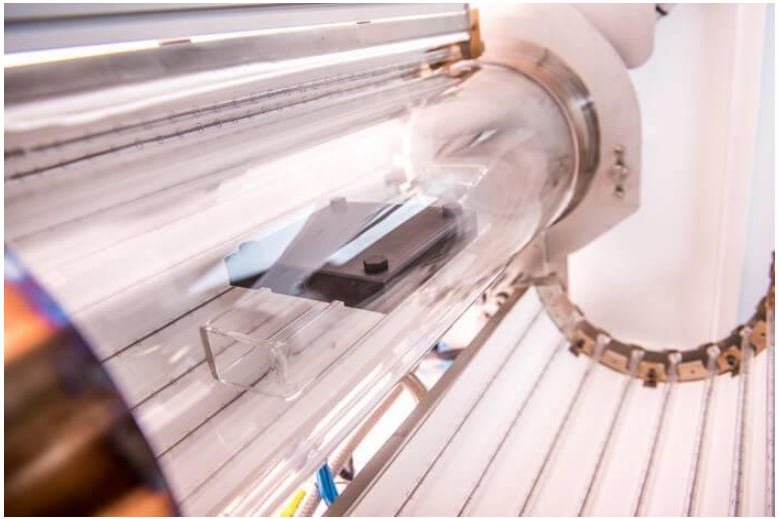


Exhaust Side

In Take Side

Next Steps

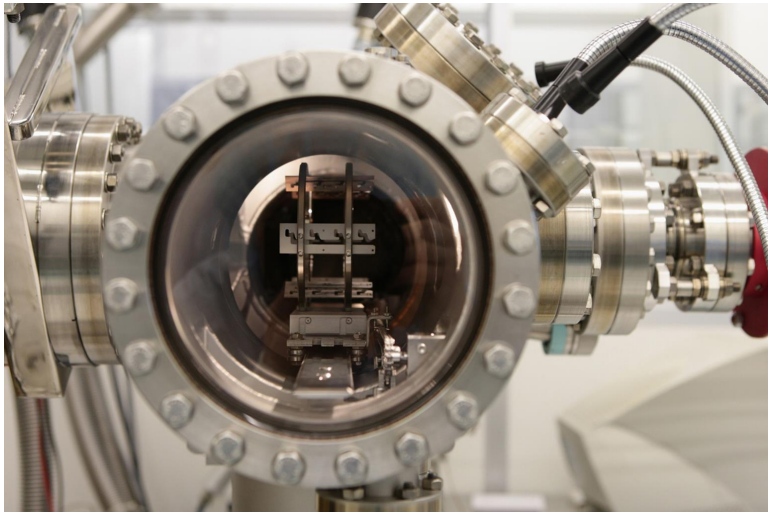
- Standard Operating Procedure
- Advancing the Software
- Completing the set up
- Testing
- Growing UTe_2 thin films



https://angstromengineering.com/tech/chemical-vapor-deposition/

Let’s Summarize!

- Chemical Vapor Deposition of UTe2
  - Software Simulation
  - Experimental Setup
- Future Work



Thin Films Deposition
https://www.micronit.com/manufacturing/capabilities/thin-film-deposition

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Nearly Ferromagnetic Spin-Triplet Superconductivity | Science, www.science.org/doi/10.1126/science.aav8645. Accessed 31 July 2023.

Advances in Actinide Thin Films: Synthesis, Properties ... - Iopscience, iopscience.iop.org/article/10.1088/1361-6633/ac968e. Accessed 31 July 2023.

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CHRNS