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The effect of activation duration on the performance of non-evaporable getter coatings

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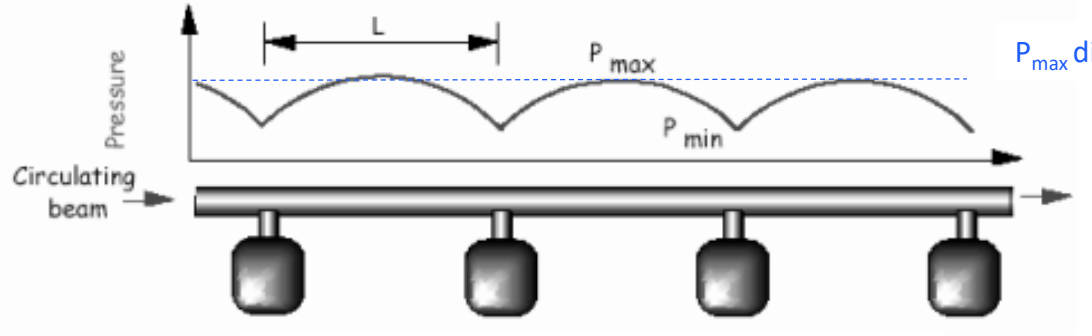
The Cockcroft Institute of Accelerator Science and Technology

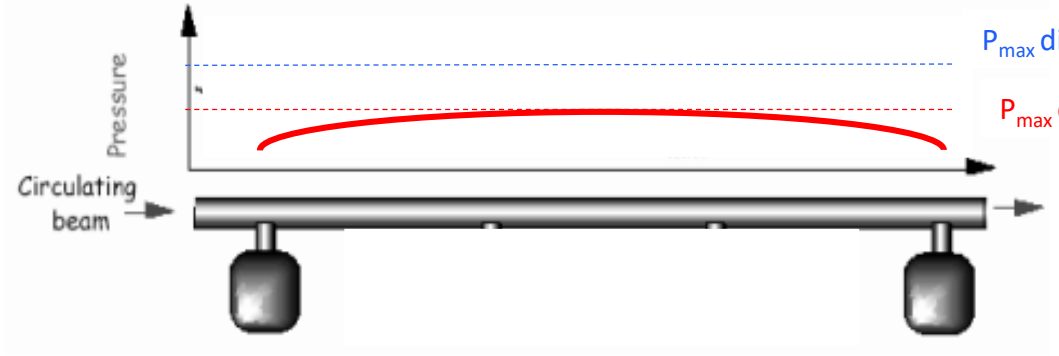
Vacuum Requirements for Accelerators

	Pressure Range (mbar)
Atmosphere	1013
Low Vacuum	10^{3} - 1
Medium Vacuum	$1\text{-}10^{-3}$
High Vacuum	$10^{-3}\text{-}10^{-9}$
Ultra High Vacuum	$10^{-9}\text{-}10^{-12}$
Extreme High Vacuum	$<10^{-12}$

Storage Ring Requirements



Pressure profile with external pumps



Pressure profile with distributed pumping

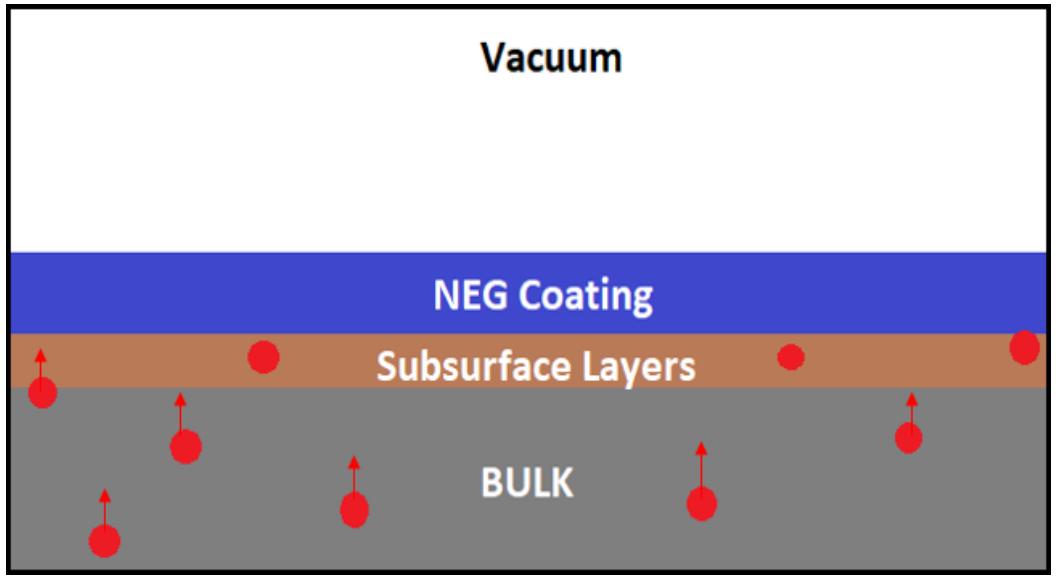
Mazzolini, F., & Trieste, E.-S. (n.d.). *The use of NEG pumps and coatings in large vacuum systems: experience and limitations*.

What are Non-Evaporable Getter (NEG) Coatings?

Coatings used in pipelines with limited conductance

Why?

- Barrier for hydrogen diffusion from beamline in dense structure.
- Chemisorption of residual gasses (CO, CO2, H2, O2, not methane)
- Reduced photo- and electron- stimulated desorption (PSD and ESD) once it is activated.



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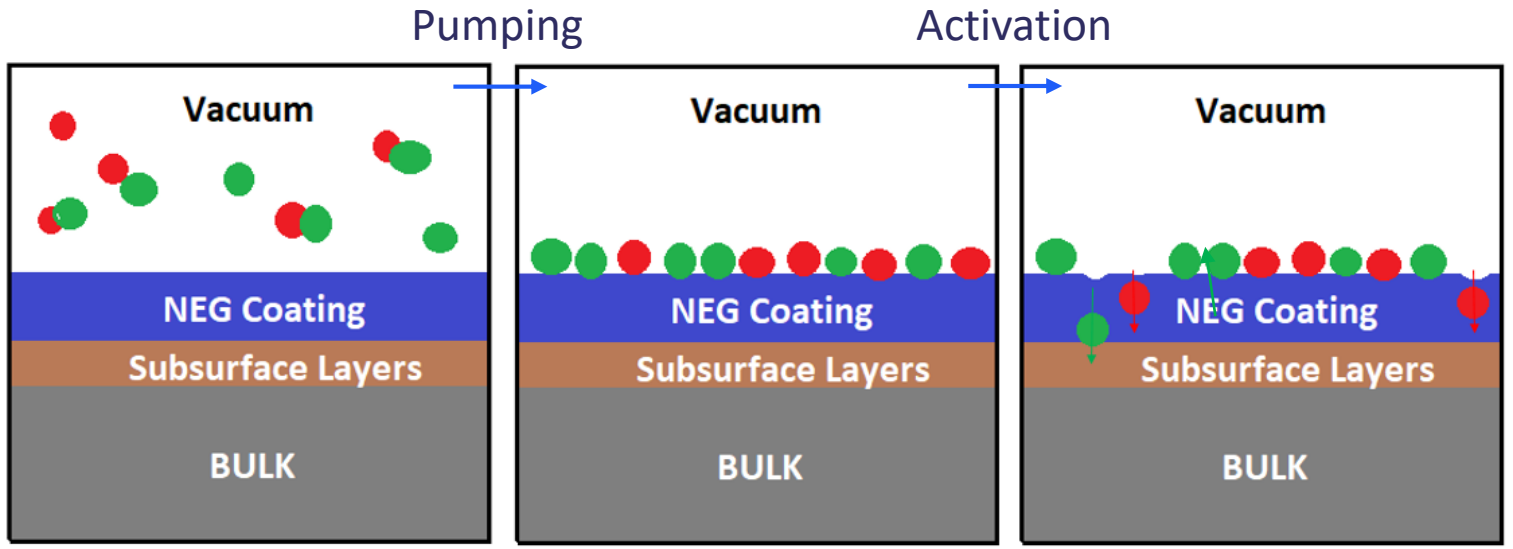
The Investigation

- NEG coatings require activation at high temperatures
  - Typically better properties after higher temperature activation
  - Typically performed at 180°C-300°C

- Technical materials used for UHV:
  - Stainless Steel: <400°C
  - Copper: <250°C
  - Aluminium: <200°C

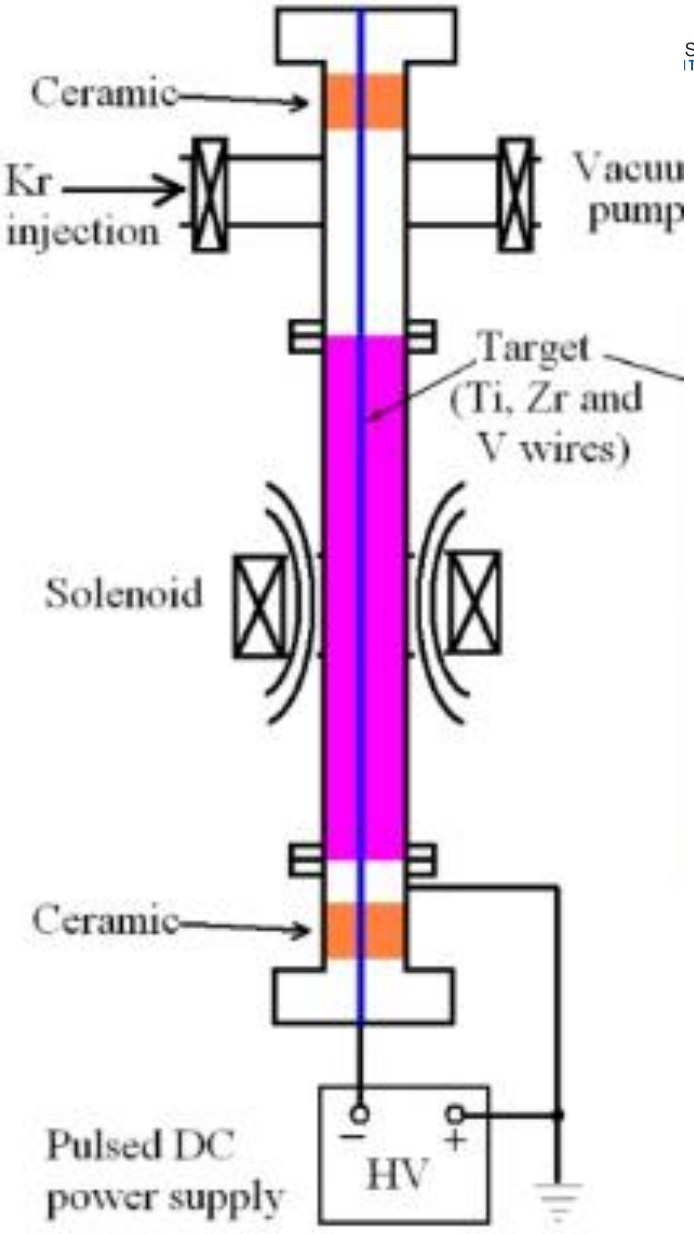


The Deposition

- Physical Vapour deposition is used
- Cylindrical magnetron plasma sputtering

- Krypton rich atmosphere
- TiZrV alloy rod used as the target.

Parameter	S-Cu	S-Al
Diameter	20mm	36mm
Layers	Dense/Columnar	Dense
Duration	2hrs 20m + 3 hrs 45m	5 hrs
Power Supply	Pulsed DC/DC	Pulsed DC
Pressure	$10^{-2} – 10^{-1}$ mbar	10^{-3} mbar
Power	70 W	70 W



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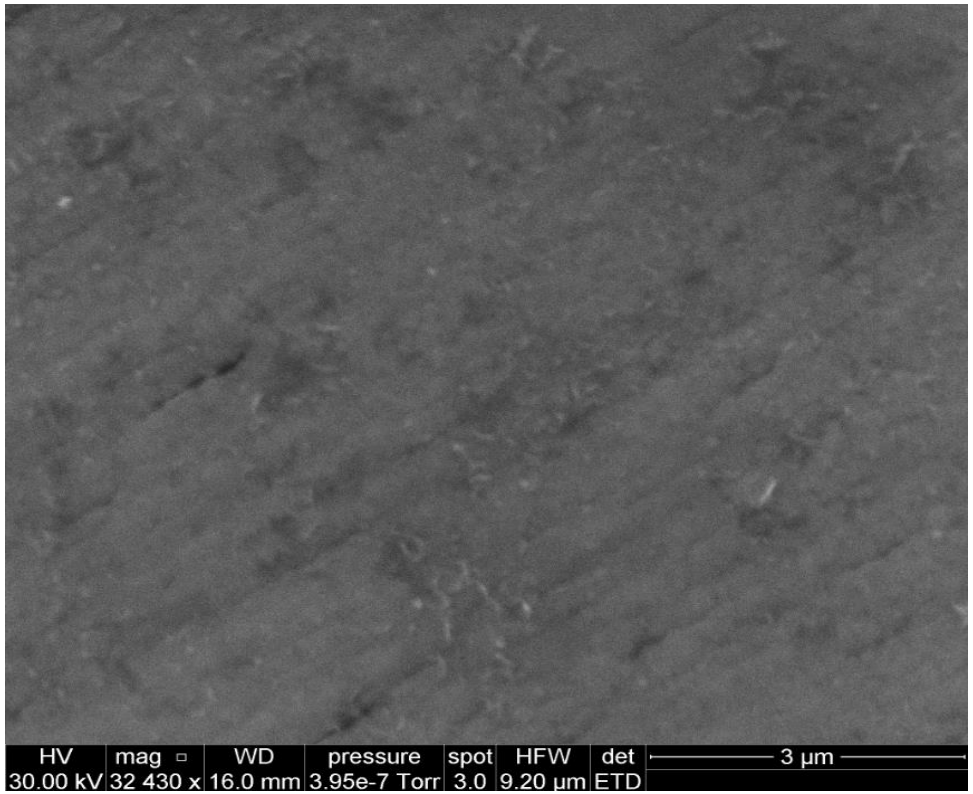
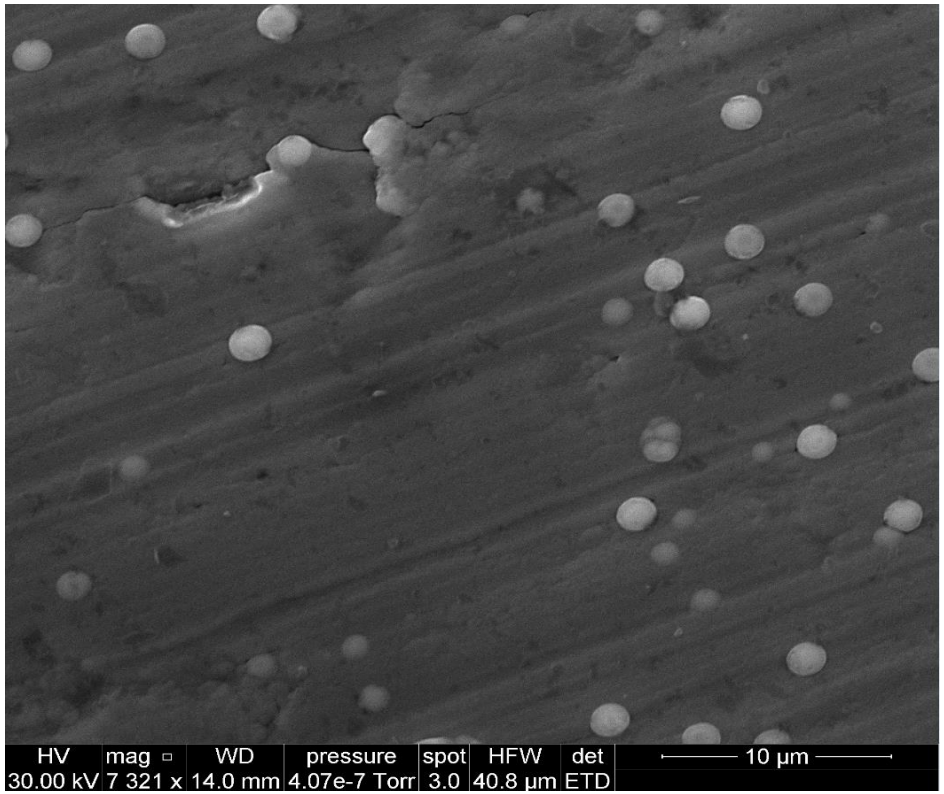
The Samples – Scanning electron Microscope (SEM) images

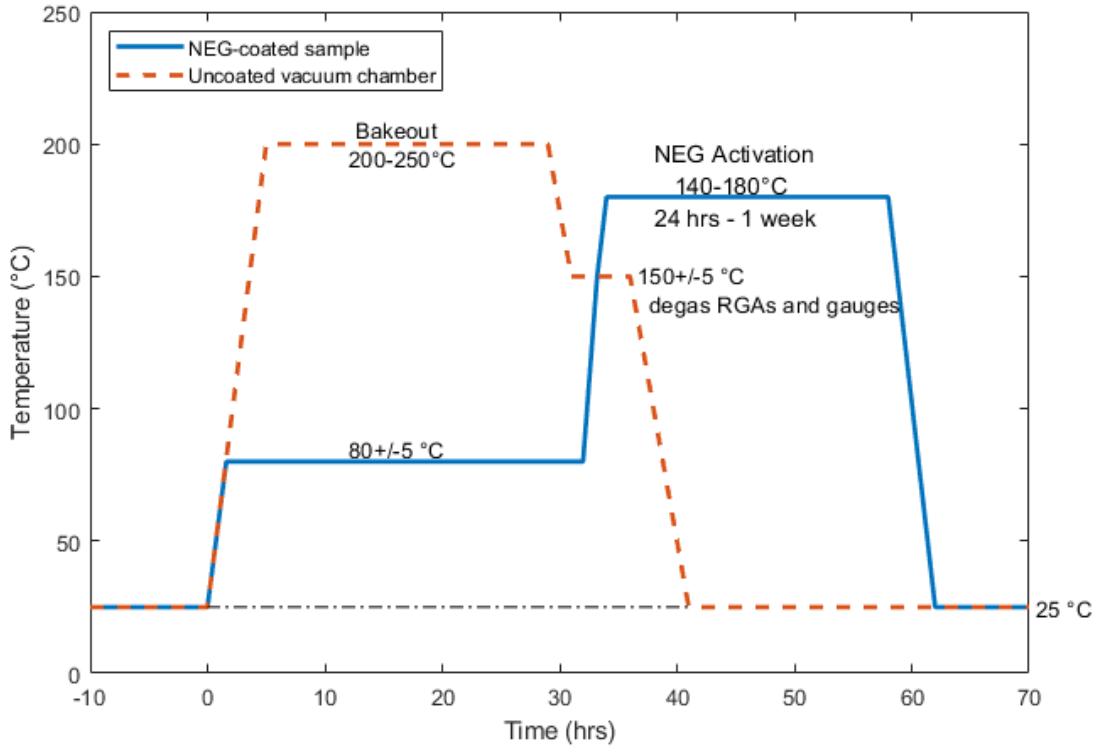


Aluminium Sample – Dense Ti-Zr-V coating

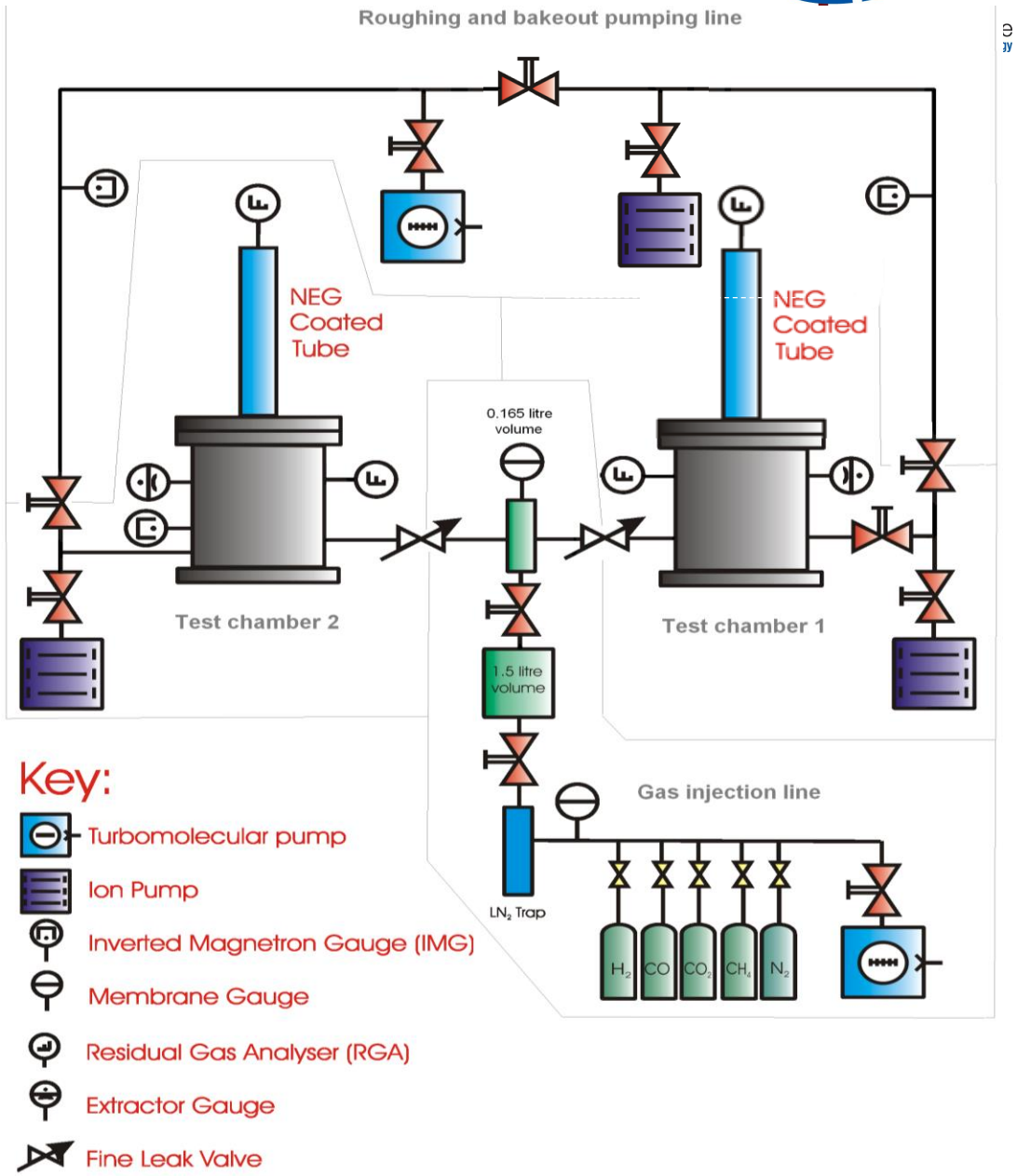


Copper Sample – Dual Layer Dense/Columnar Ti-Zr-V coating

Experimental Facility



- The Baking and Activation regime for each sample.
- Equipped with Gas injection system, a calibrated extractor gauge and RGAs



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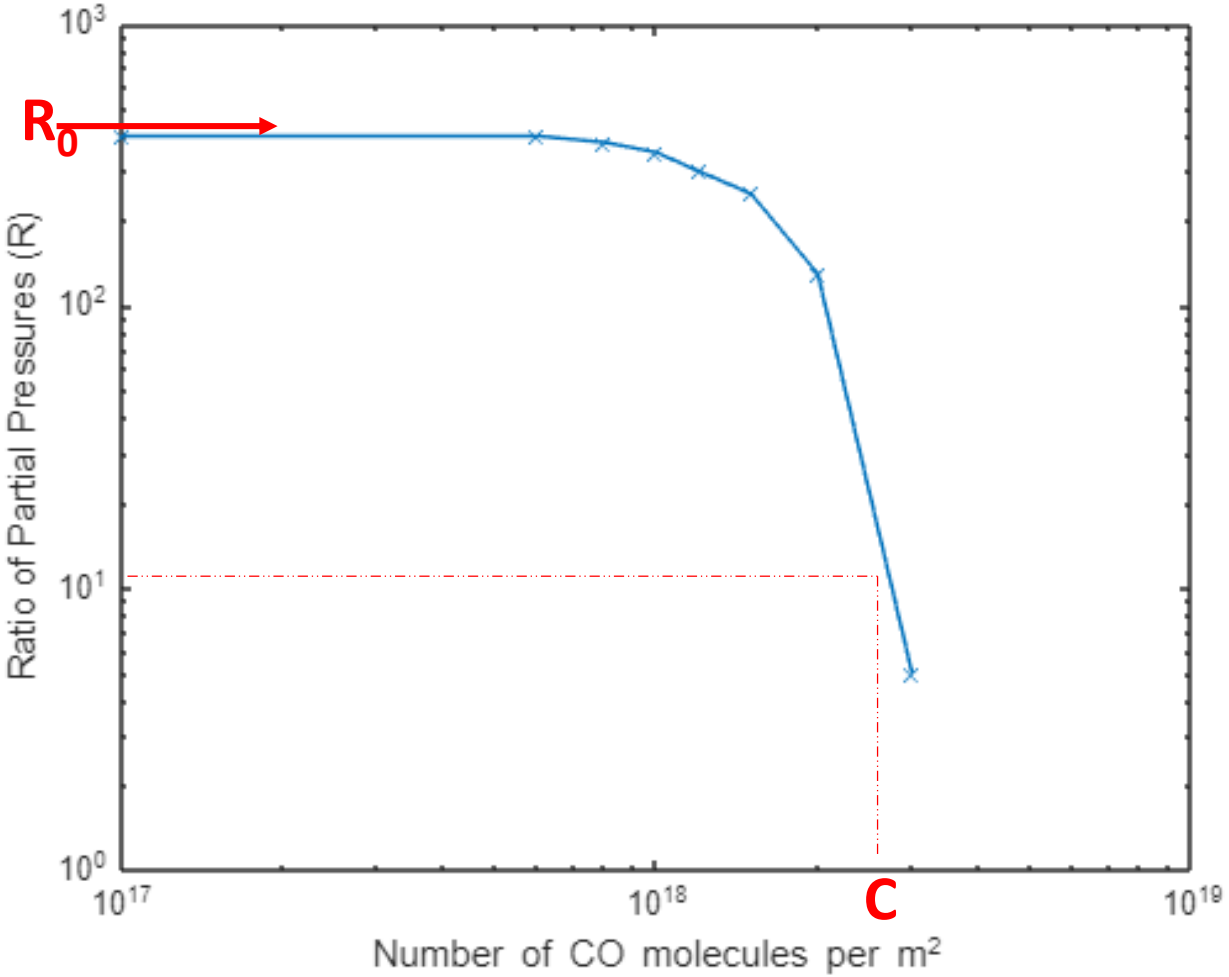
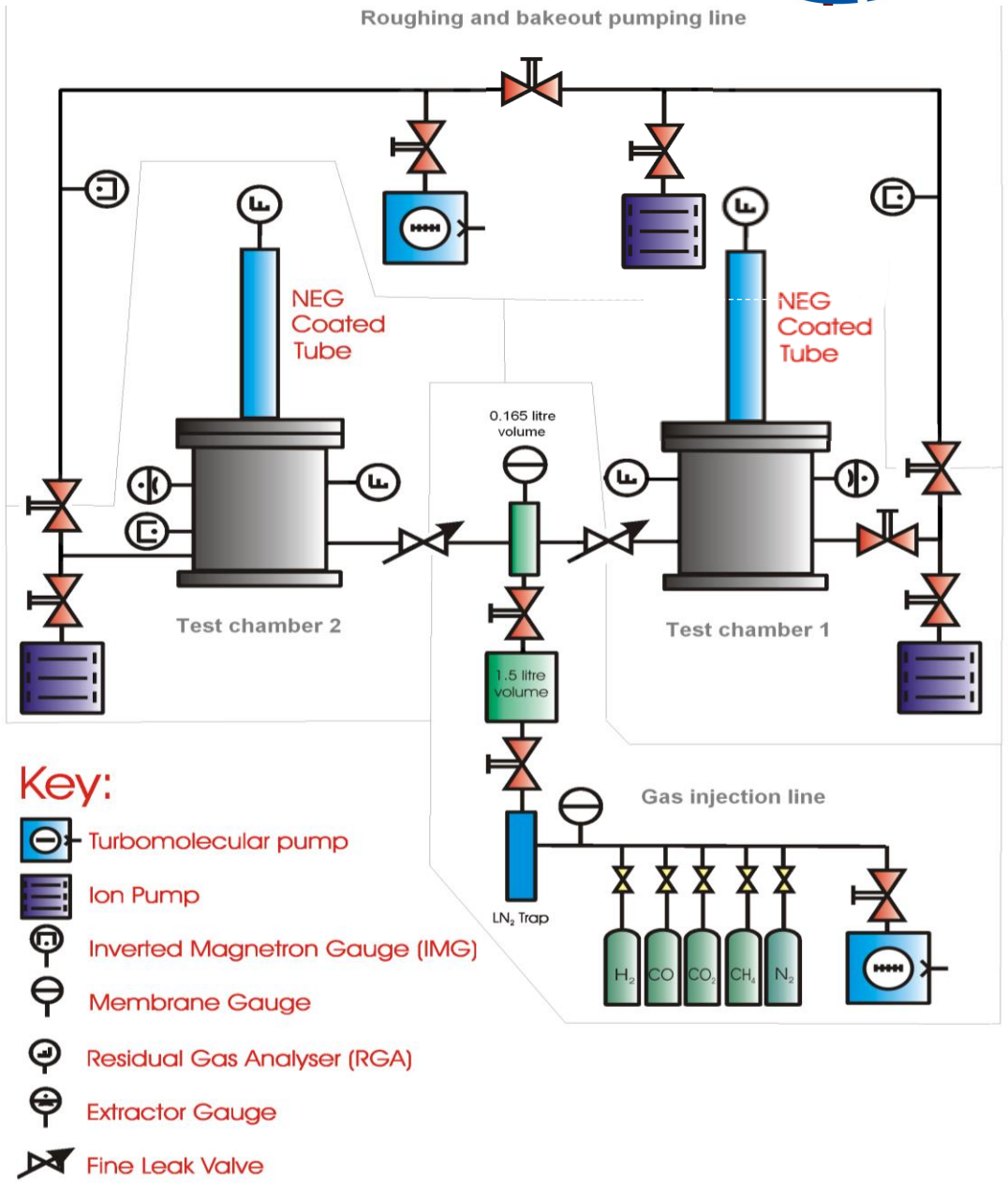
Experimental Facility



Example Plot of Results



TPMC Simulations

α= sticking probability

Low Pressure High

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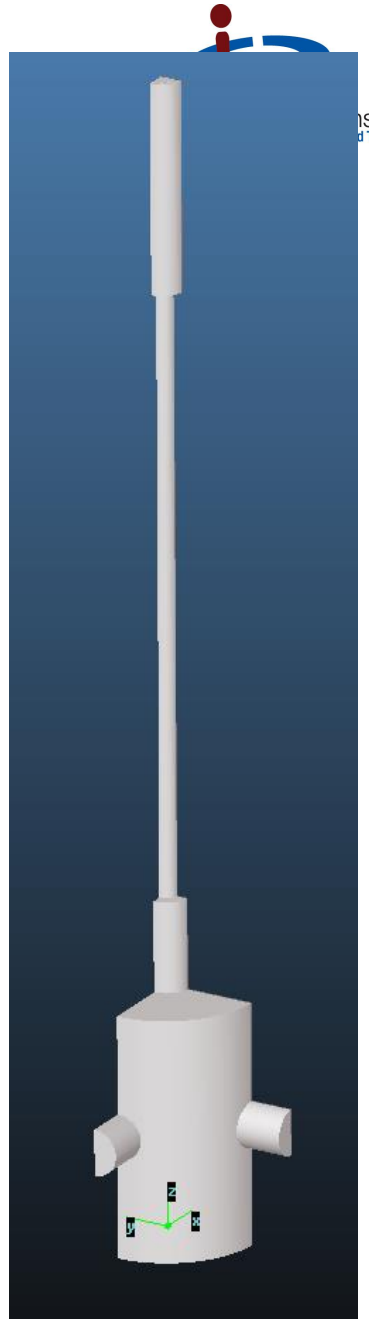
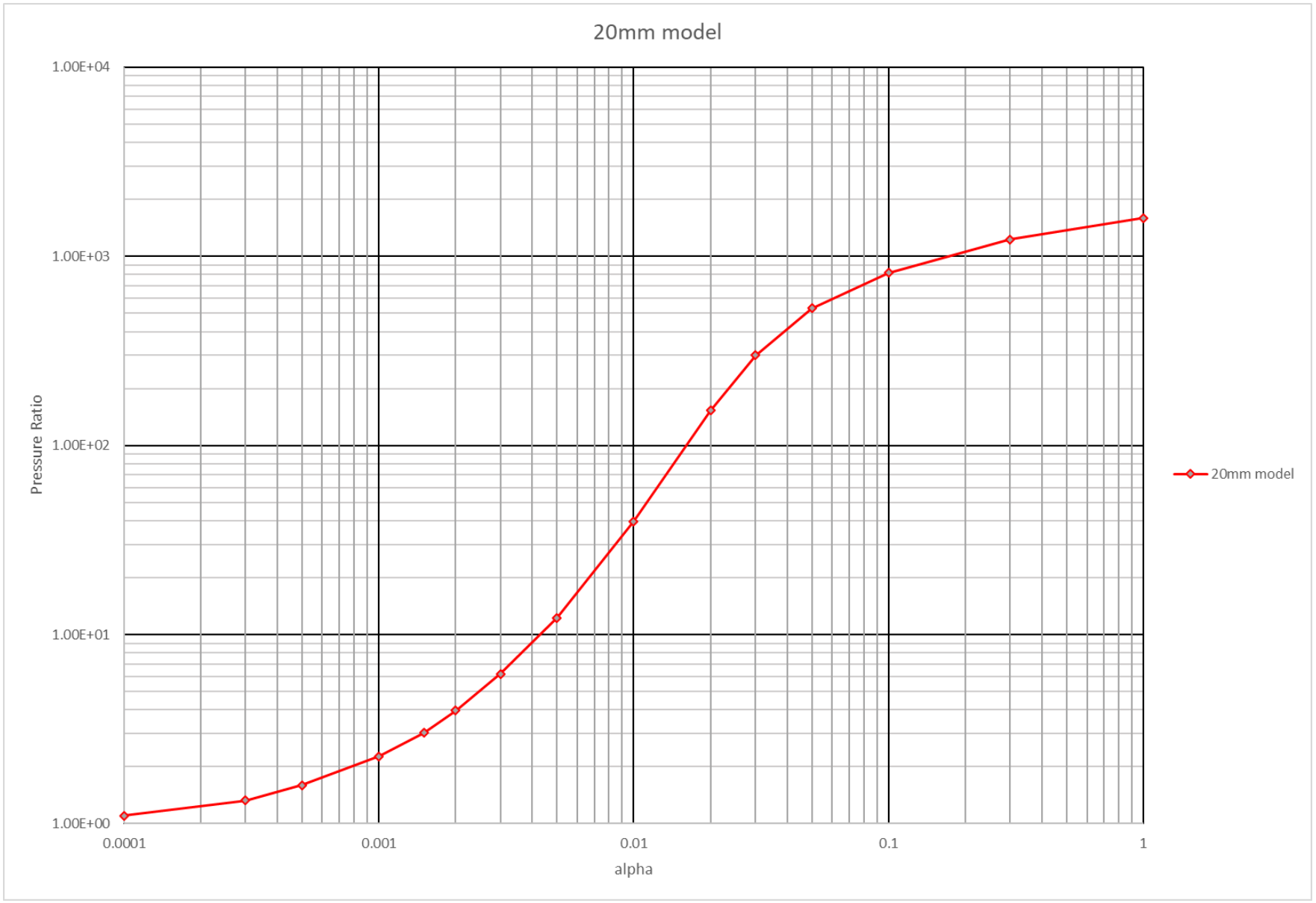
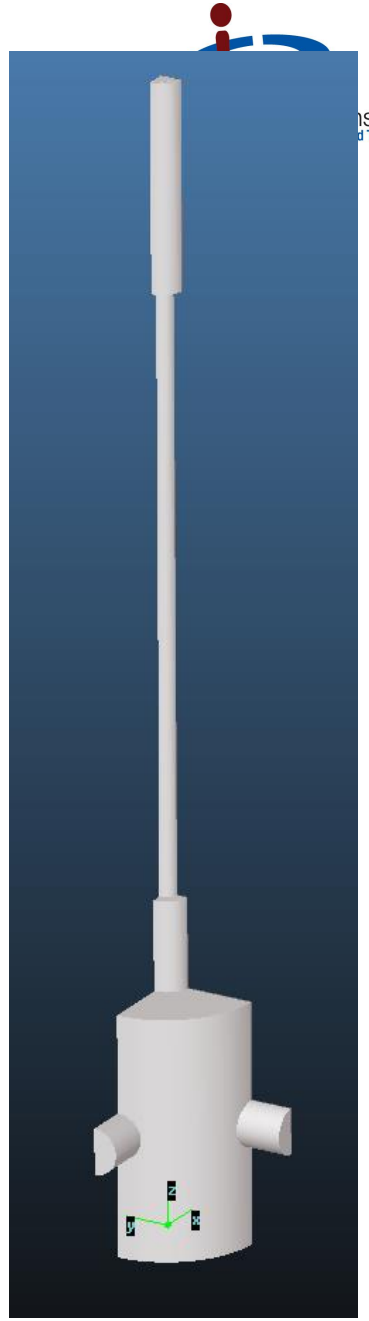
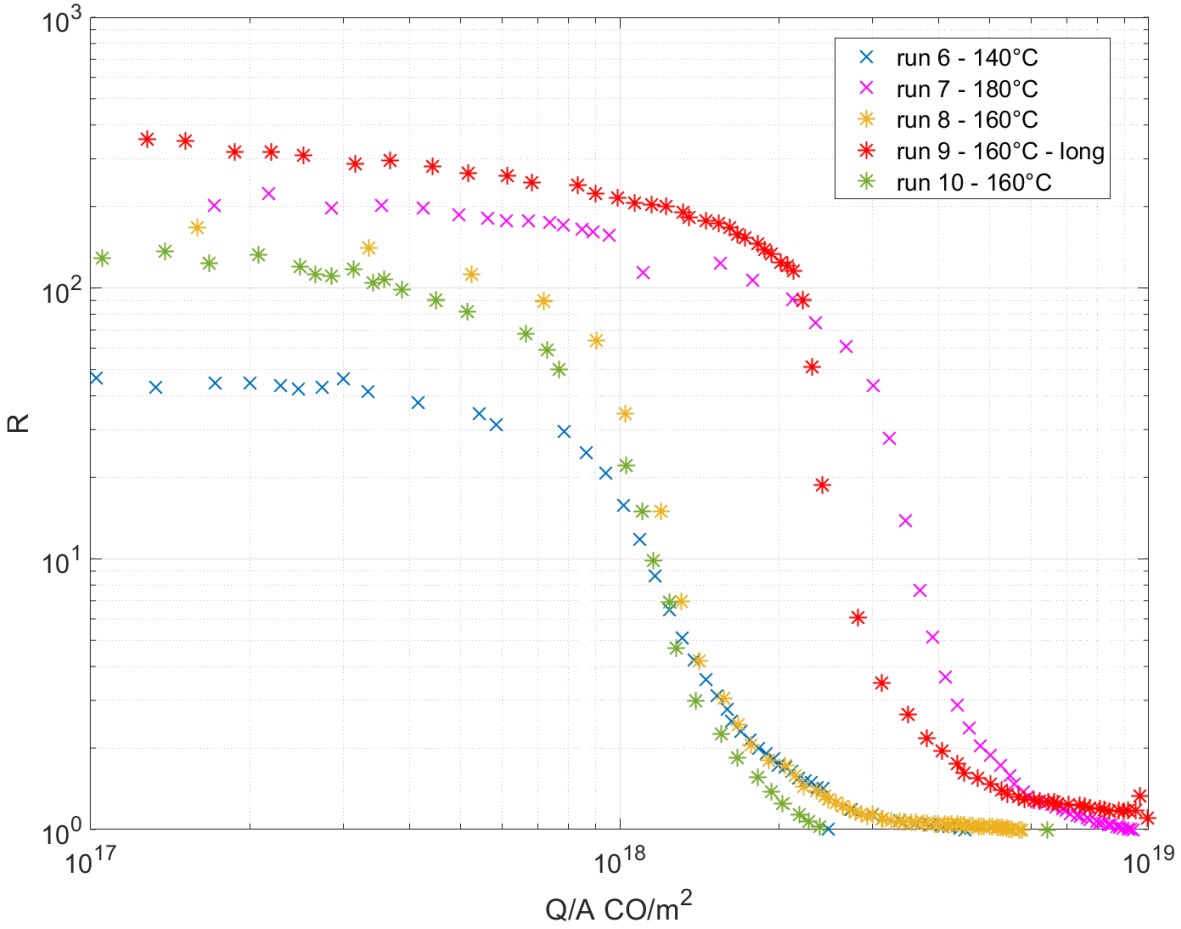


TPMC Simulations

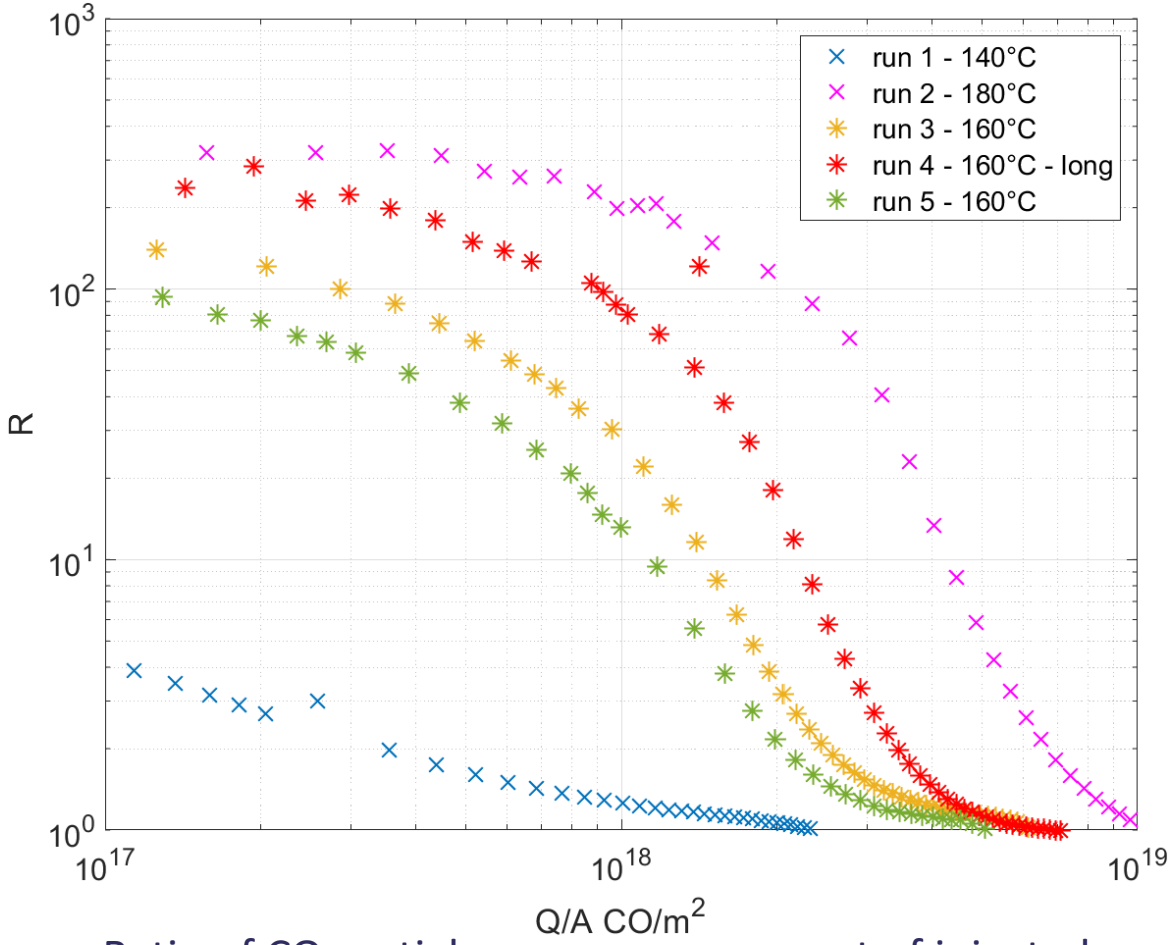




Results



Ratio of CO partial pressures vs amount of injected for Aluminium Sample



Ratio of CO partial pressures vs amount of injected for Copper Sample

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Results

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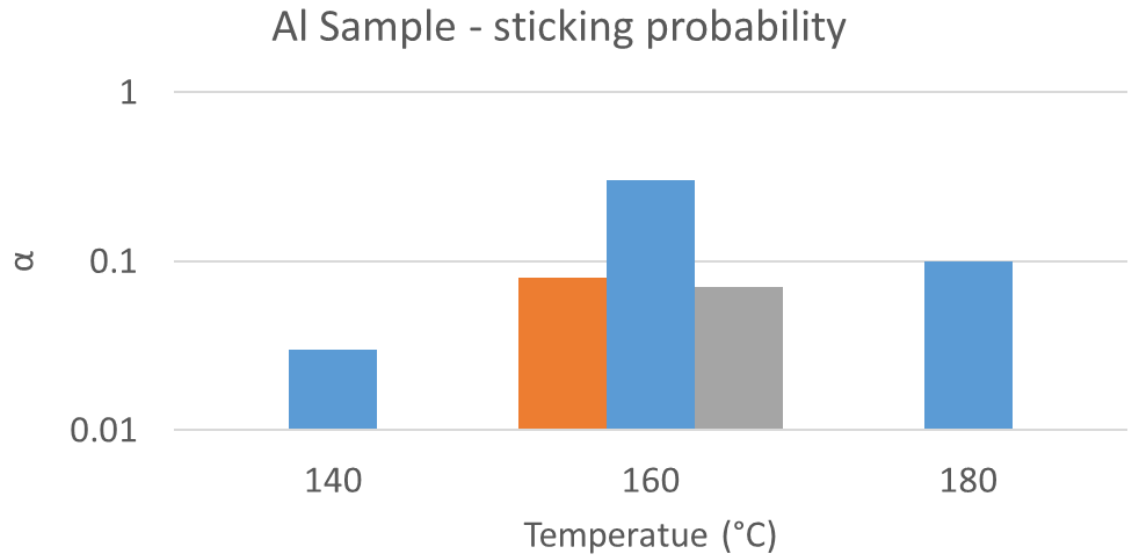

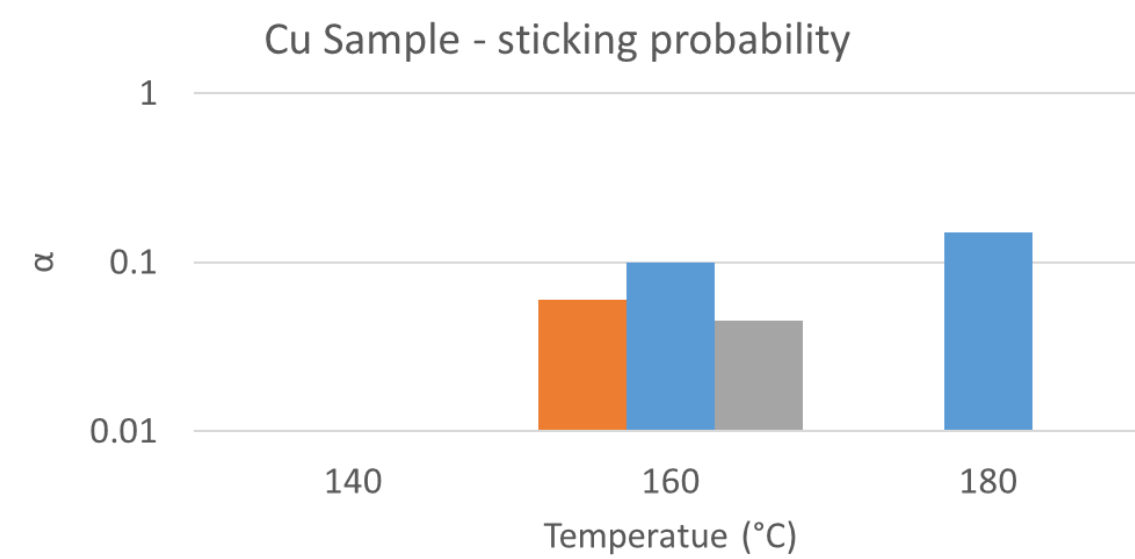

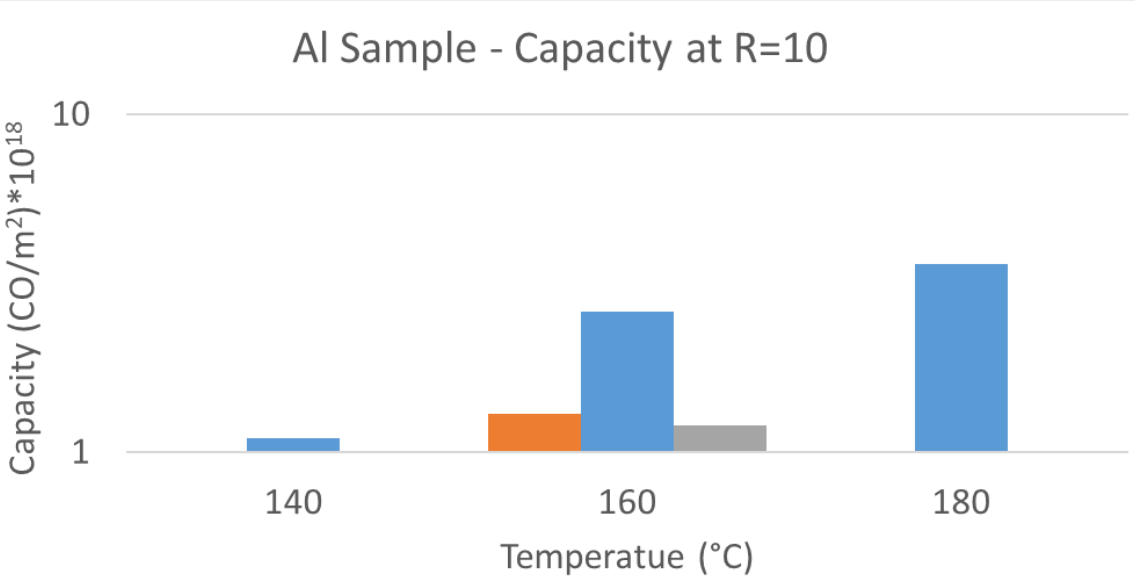

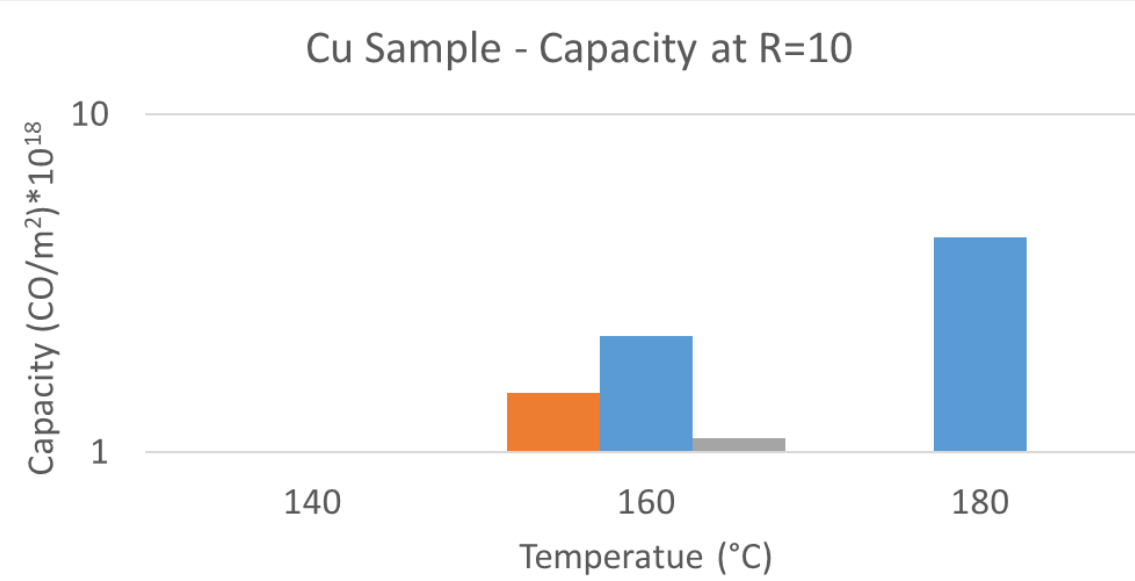

Conclusions

- Desire to reduce the required activation temperature of NEG
- Dense and dual-layer coatings were investigated

- Both samples saw an increase of pumping properties with a longer activation time.
- Better reaction from the dual-layer coating
- There is potential for reaching the same pumping efficiency as 24 hour activation at 180 °C.

What Next?

- Different lengths of time- different temperatures – different compositions.
- Perform a similar study with different injected gasses (i.e H_2 and CO_2)
- Perform ESD yield measurements on samples after different activation durations, to see if these properties are also improved.

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Thank you

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