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Capacity of the SAES St707™ Non-Evaporable Getter at Various Temperatures

For use in Tritium Thermoelectric Generators

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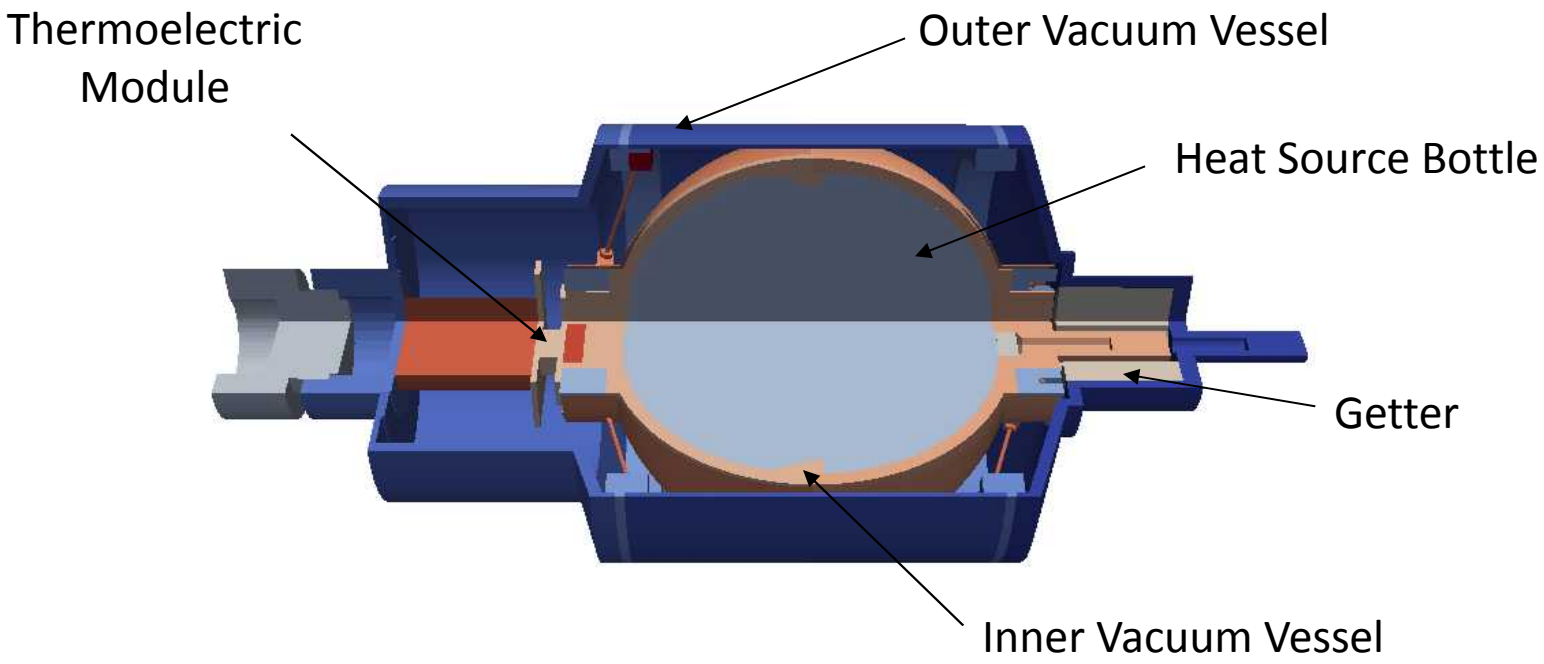
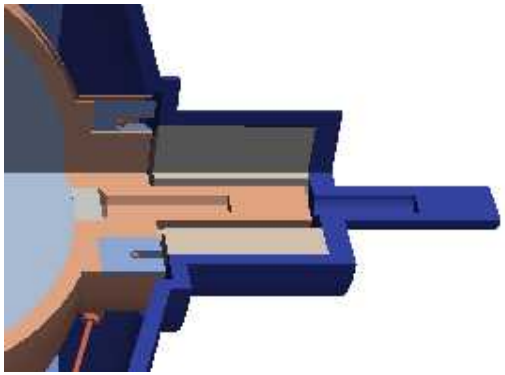
Prototype design of a Tritium Thermoelectric Generator (TTG)



Ideally all the heat goes through the thermoelectric module since there is a vacuum between the vessels.

A non-evaporable getter insures that the vacuum is maintained for life.

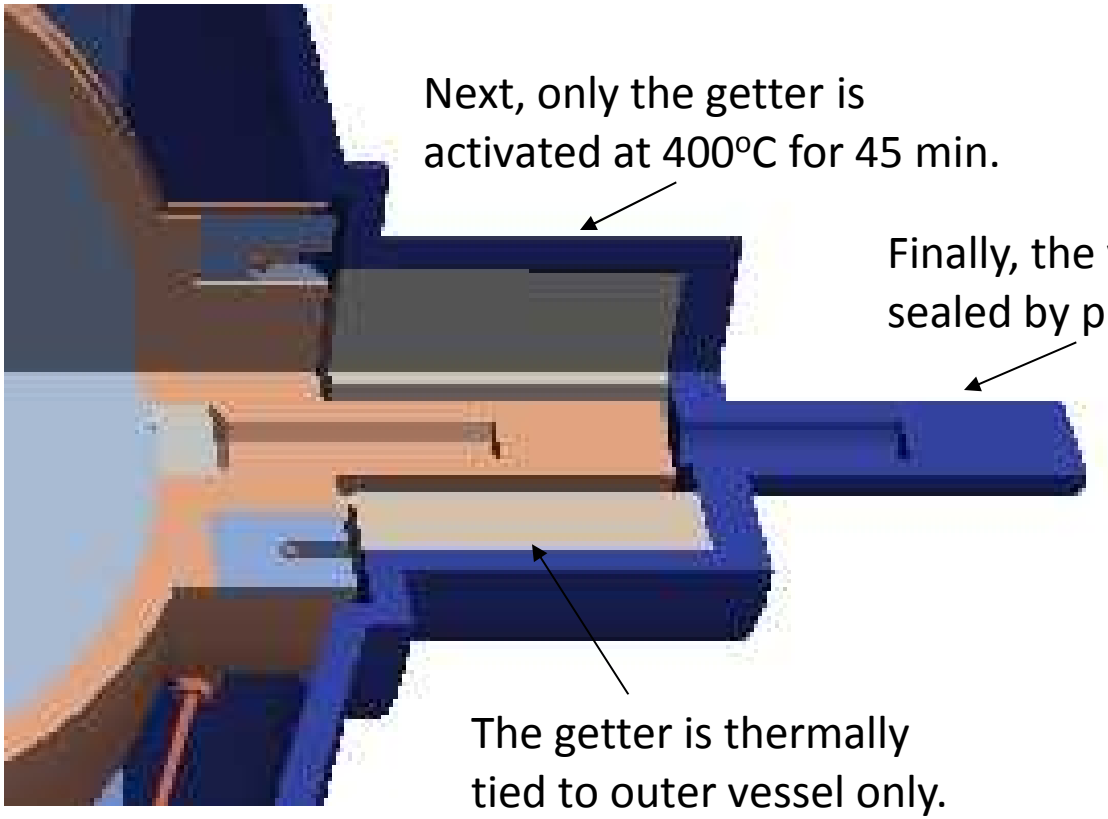


The getter:

- is unpowered (thus non-evaporable).
- must be activated *in situ*.
- must maintain 4 x 10^{-5} torr without regeneration or auxiliary pumping for 15 years.
- must operate over a range of temperatures, e.g. -55 to +60^{o}C.
- must not degenerate to the degree that it shorts the thermal path of the system or it will have to be contained by a component such as a frit.

SAES St707™ can be activated at low temperature.

First, the entire vessel is pumped and baked at 200°C for 2-3 days.



Next, only the getter is activated at 400°C for 45 min.

Finally, the vessel is sealed by pinch welding.

The getter is thermally tied to outer vessel only.

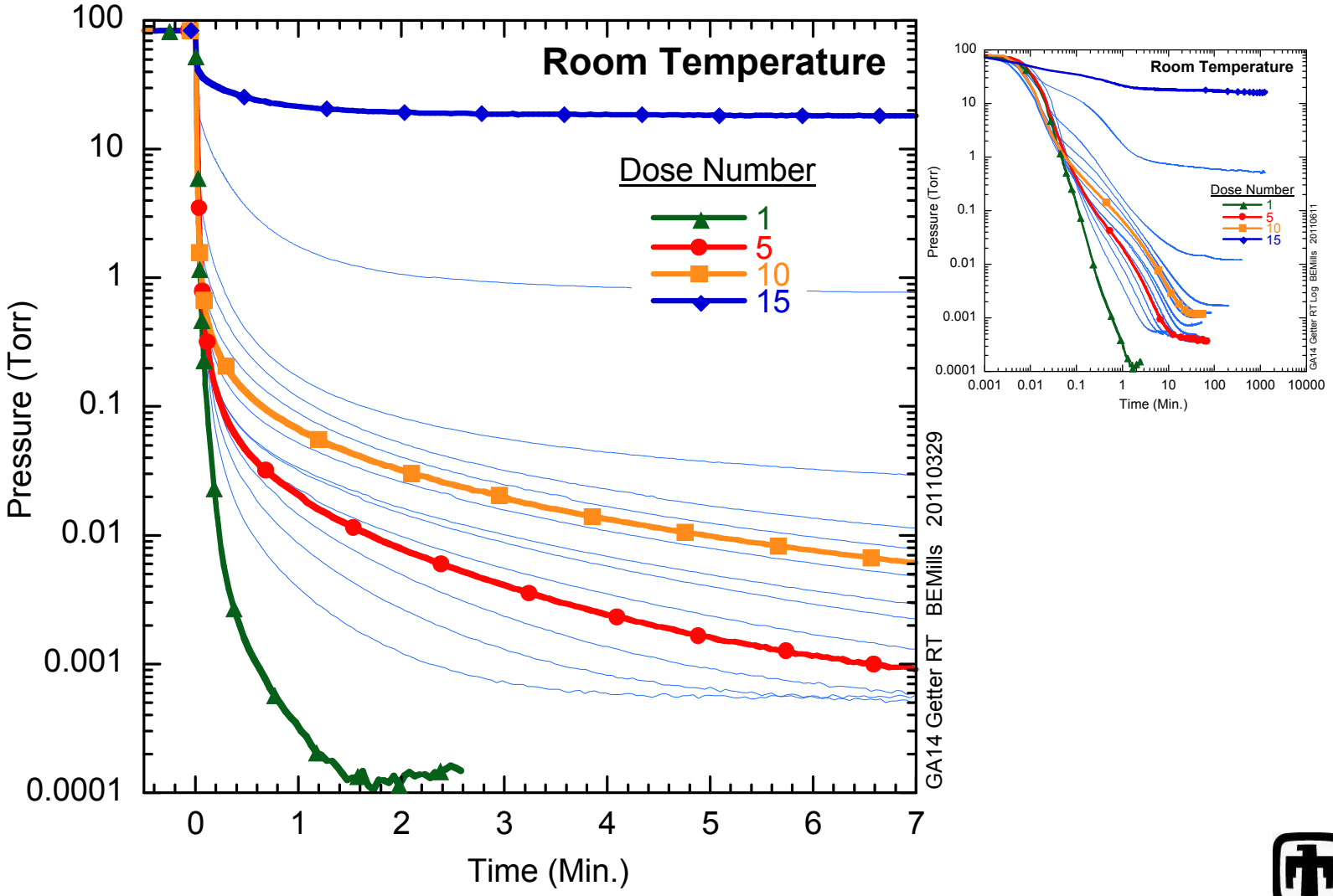
Extensive efforts were made to minimize the load on the getter.

- All materials internal to the vacuum were vacuum baked at a suitable temperature before assembly.
  - E.g. steel was pre-baked at 500°C.
  - Gold plated steel was further baked at 300°C.
  - Other components were baked at temperatures that did not cause degradation.
- The major gas evolved from the materials at temperatures above the system bake of 200°C is hydrogen.

Laboratory experiments replicated the prototype time-temperature process.

- A steel vessel fitted with an internal thermocouple by the getter pellet was used to calibrate a tube furnace for baking and activating.
- The thermocouple was replaced by a valve so that the pellet could be transferred to the getter measurement station *in vacuo*.
- Measured aliquots of gas were introduced and left till the pressure appeared to no longer decrease.

The getter rate is fast at room temperature.



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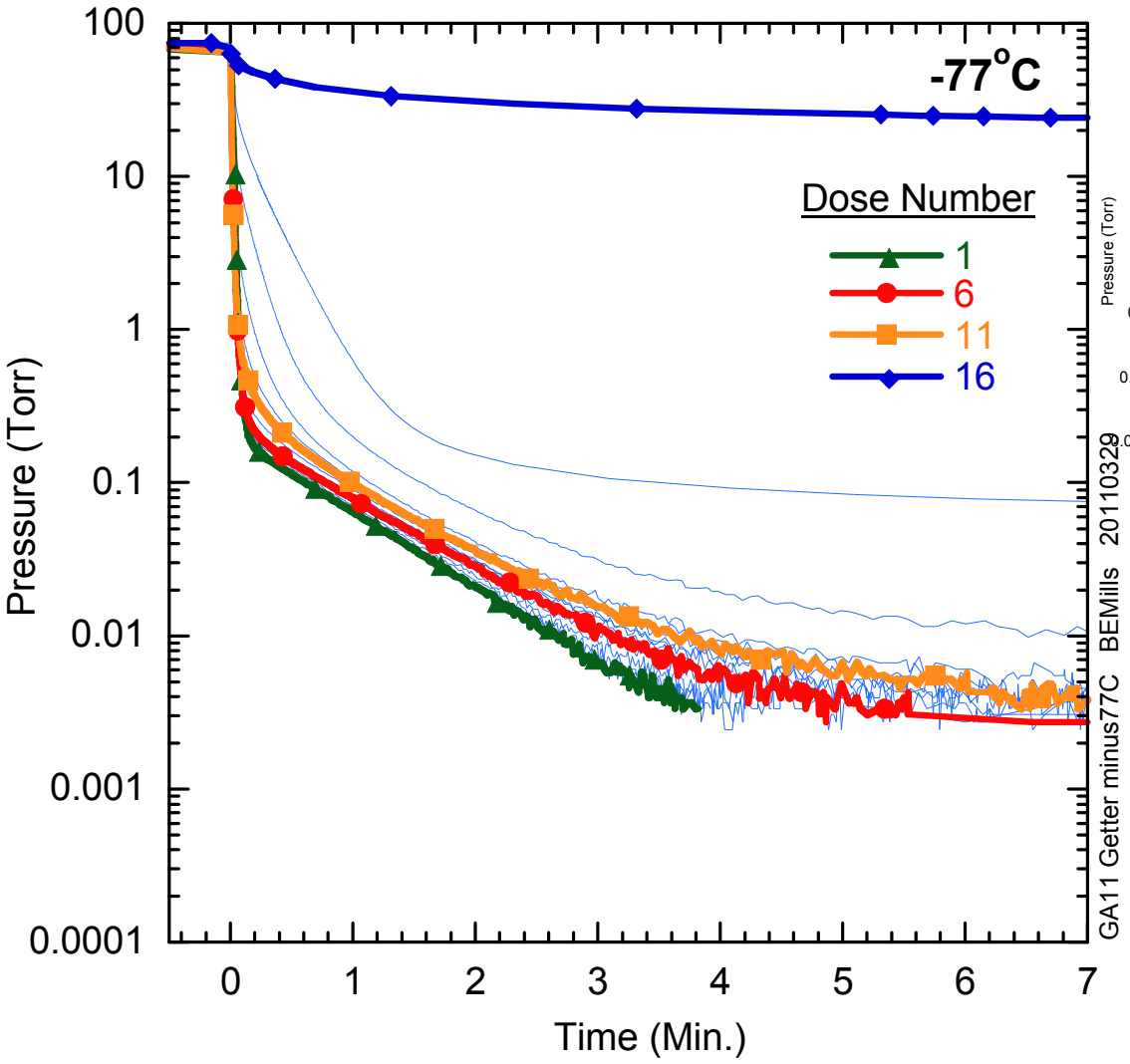
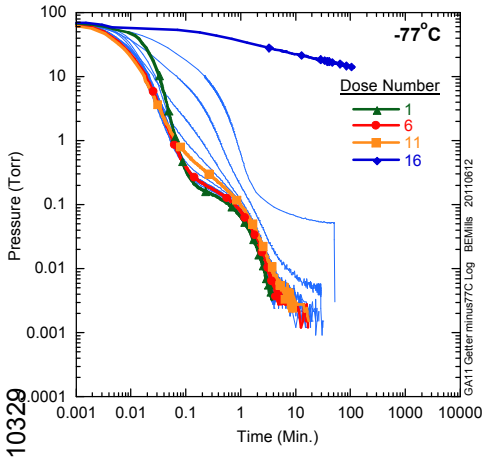
For lower temperatures several options were tried.

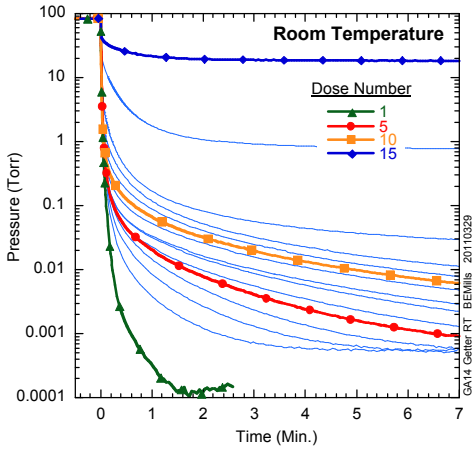
- The goal was to measure at -55°C.
- It is possible to obtain -55°C with a mixed xylene/dry ice slush bath.
  - Maintaining a steady temperature for hours with this bath proved difficult.
  - Our measurements are very temperature sensitive.
- A dry ice/acetone bath* was much more tractable.
  - AND the getter remained active in that bath.
- The getter was inactive at liquid nitrogen temperature** in the time allotted.

* Measured at -77°C. **LN temperature is -196°C.

Initially slower at low temperature, the rate declines less with capacity.







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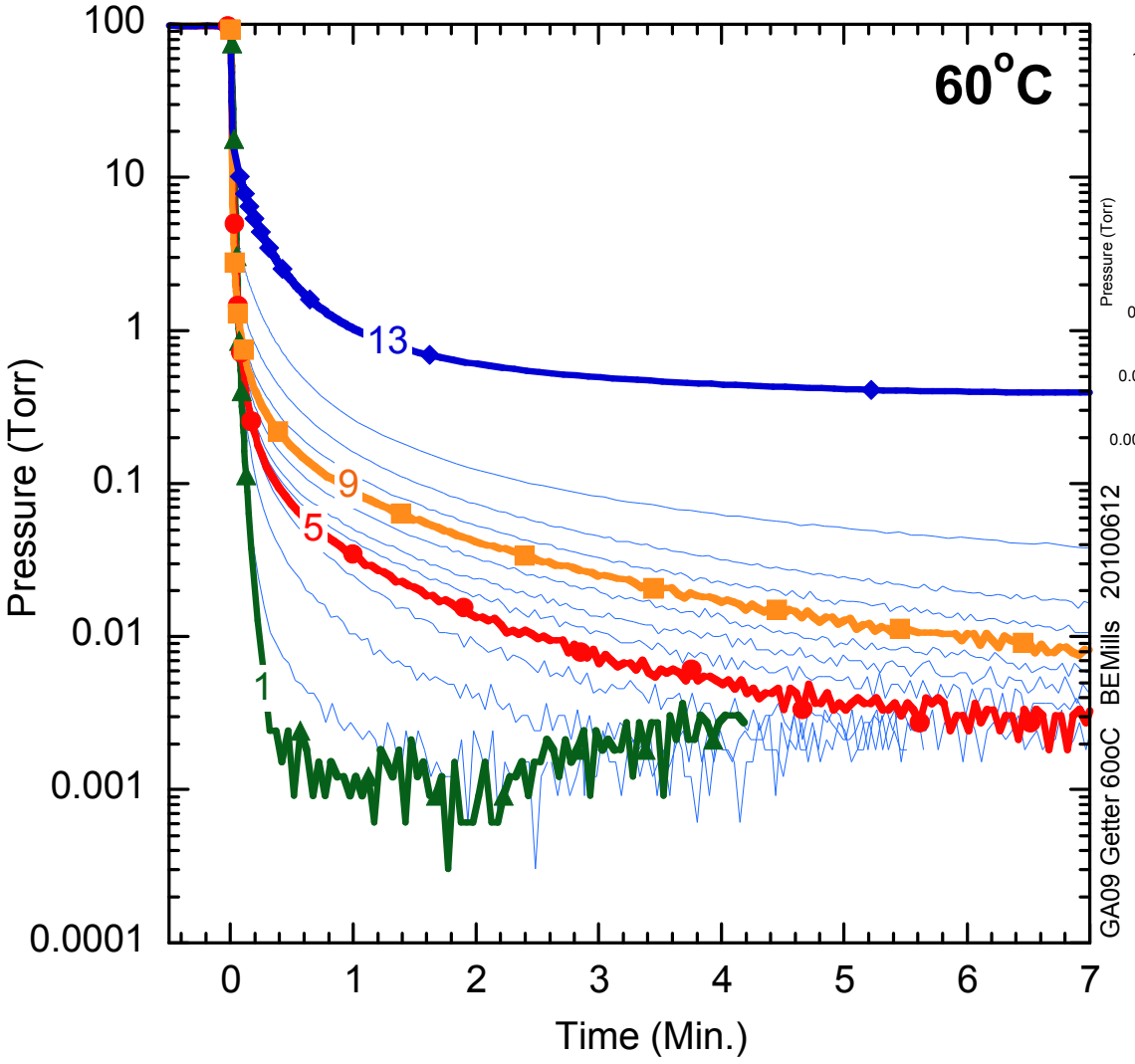
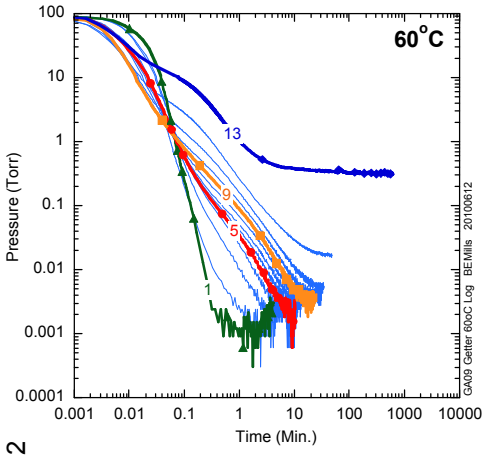
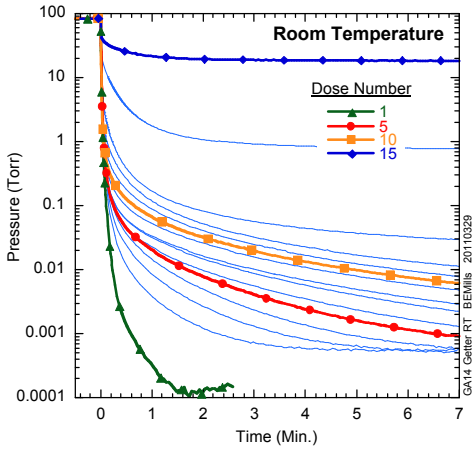
High temperature is more like room temperature with reduced capacity.







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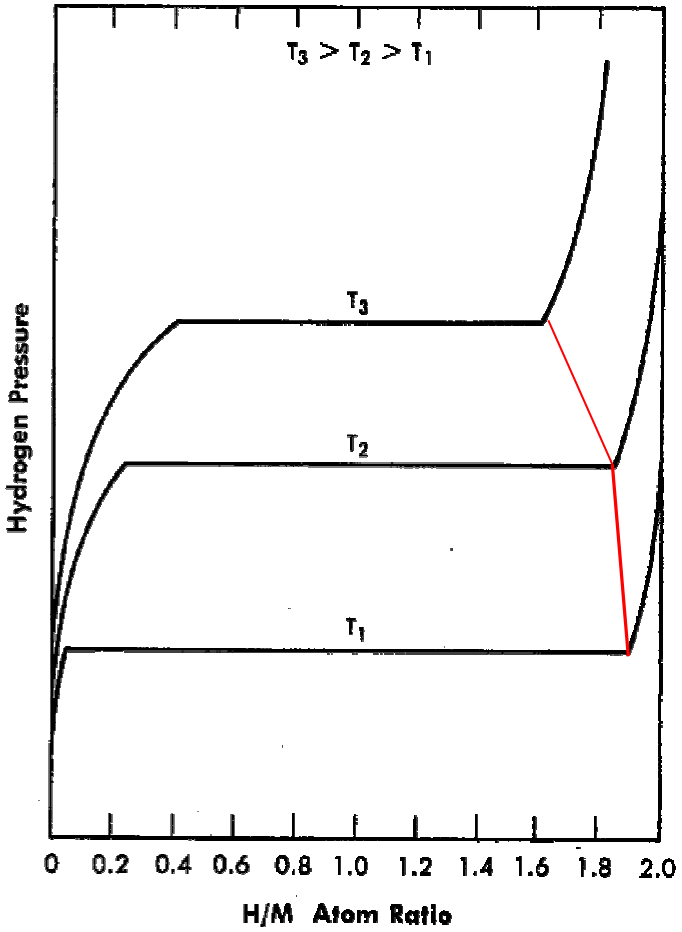
Hydrogen capacity declines with increasing temperature.

Temperature	Quantity H_2 Absorbed (mol/g)	Capacity (std cm^3/g)	H_2 to Zr Mole Ratio
-77ºC	9.9×10^{-3}	238	1.29
20ºC	9.3×10^{-3}	225	1.22
60ºC	8.1×10^{-3}	196	1.06

Lower capacity at higher temperature is typical of PCT*s at these temperatures.



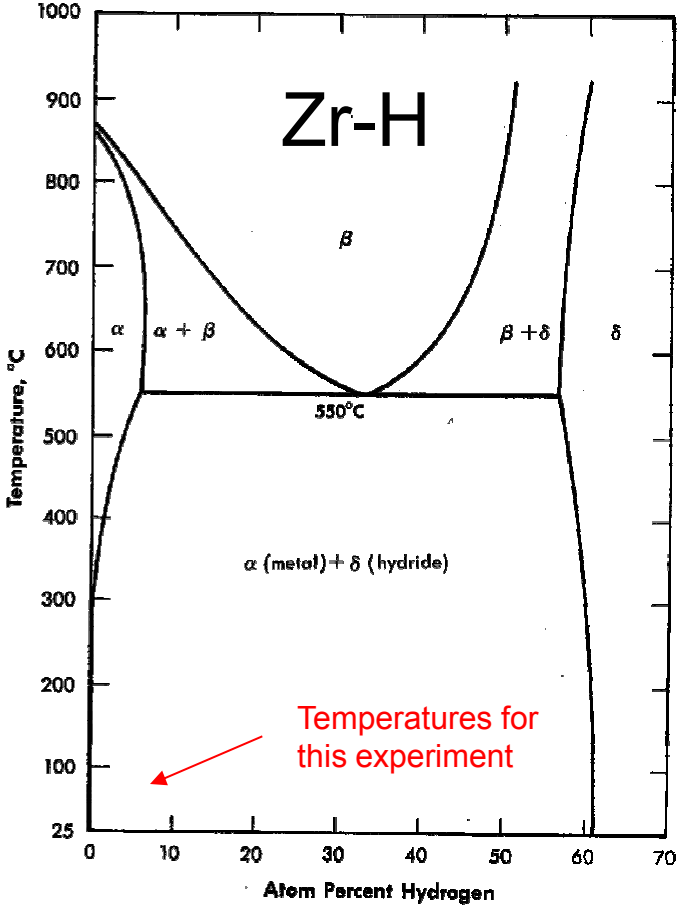


FIG. 3.6 Zirconium–hydrogen phase diagram.

* Pressure-composition-temperature diagram.

R.L. Beck and W.M. Mueller in *Metal Hydrides*, W.M. Mueller, J.P. Blackledge and G.G. Libowitz, Eds., Academic Press, New York, 1968.

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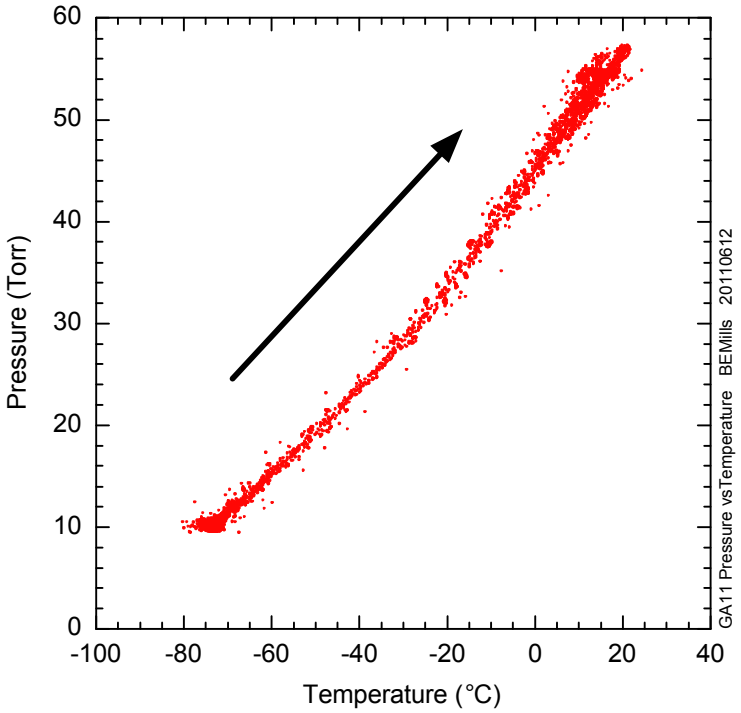
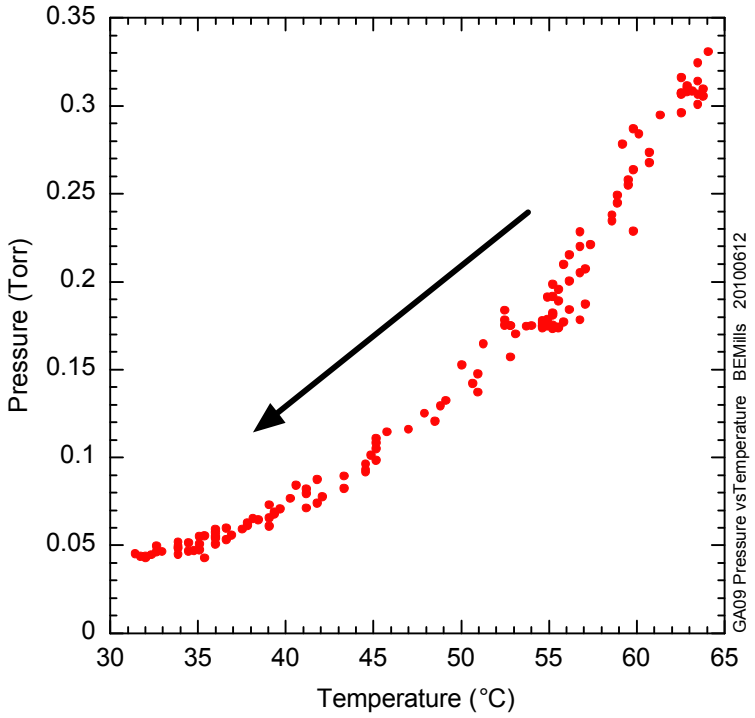
Pressure readjusts with temperature, as expected from PCT.

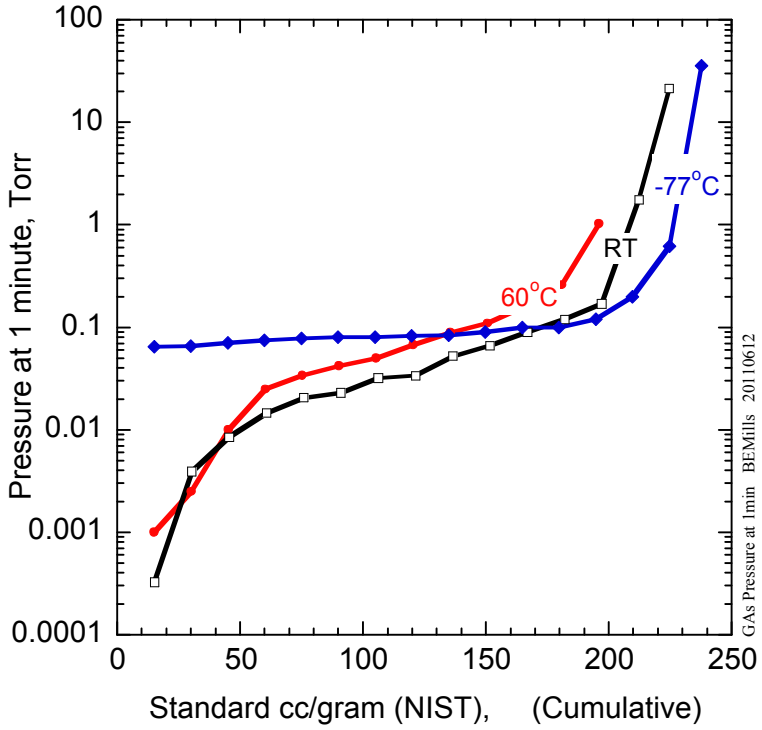


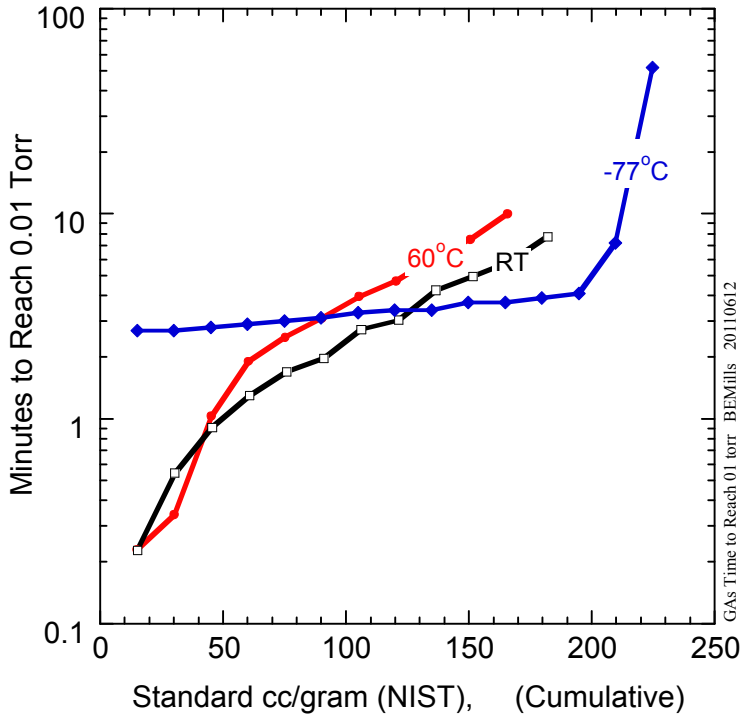
-77ºC to Room Temperature



60ºC to Room Temperature

-77ºC starts faster, but finishes with a slower rate than other temperatures.





The -77ºC rate is very temperature-independent until nearly “full”.

60ºC starts similar to room temperature (RT), but speeds up slightly compared with room temperature (RT).

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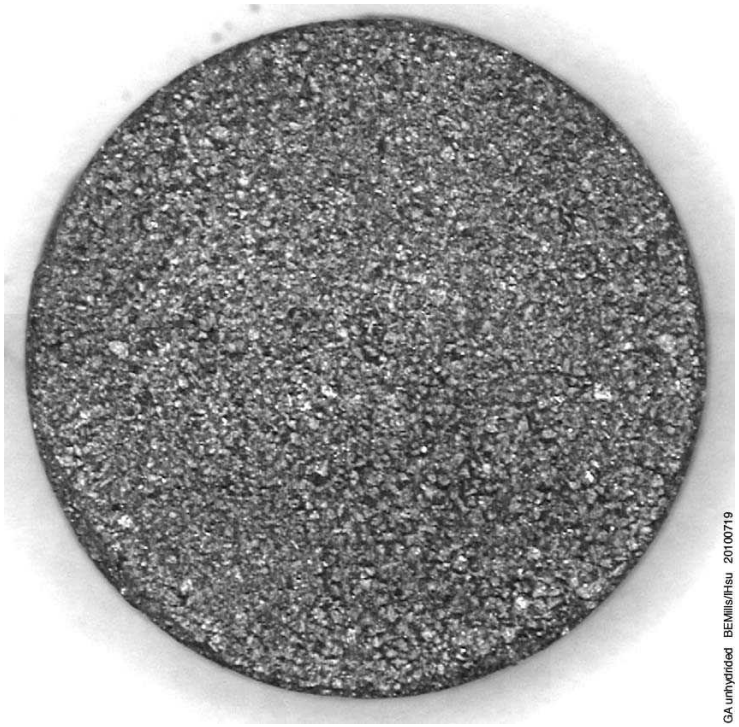
As the getter hydrides it loses its physical integrety.

Before Hydriding



After Hydriding

All other getters were in chunks & dust after hydriding.
These could be expected to cause a thermal shortcircuit.

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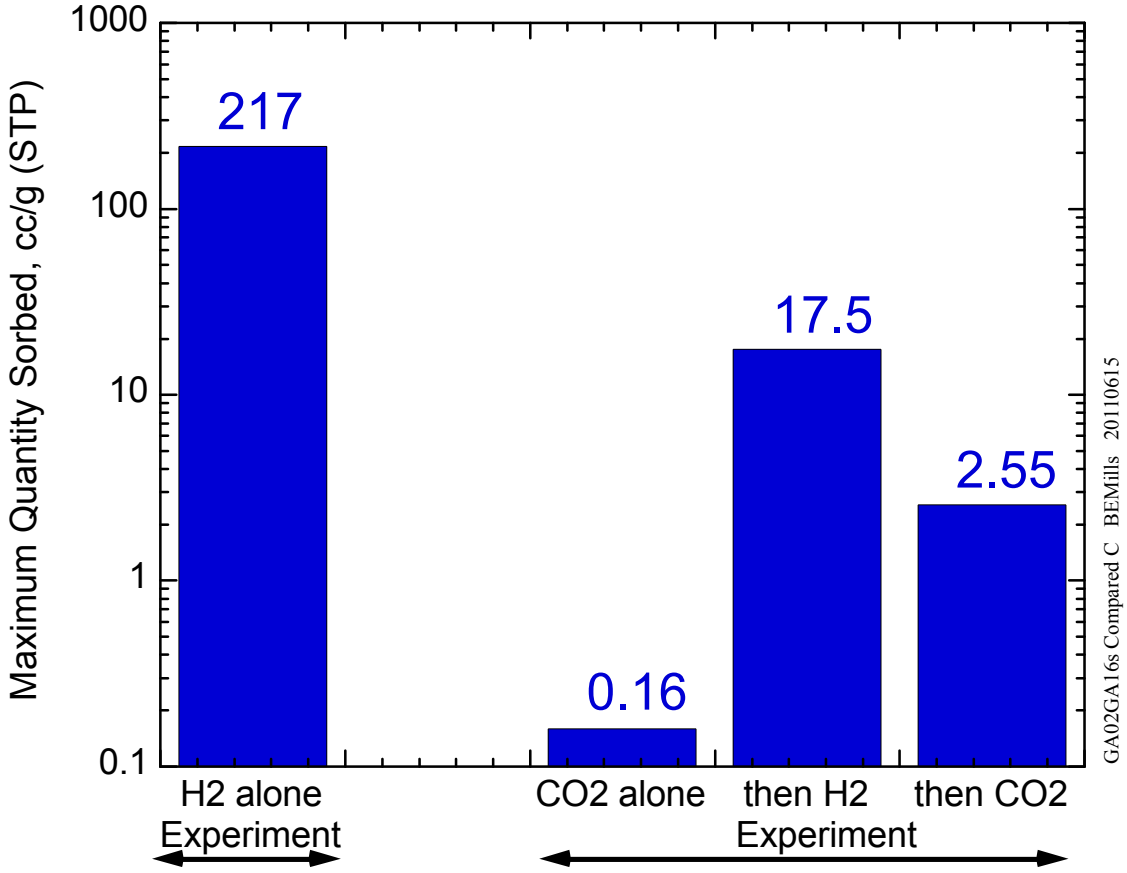
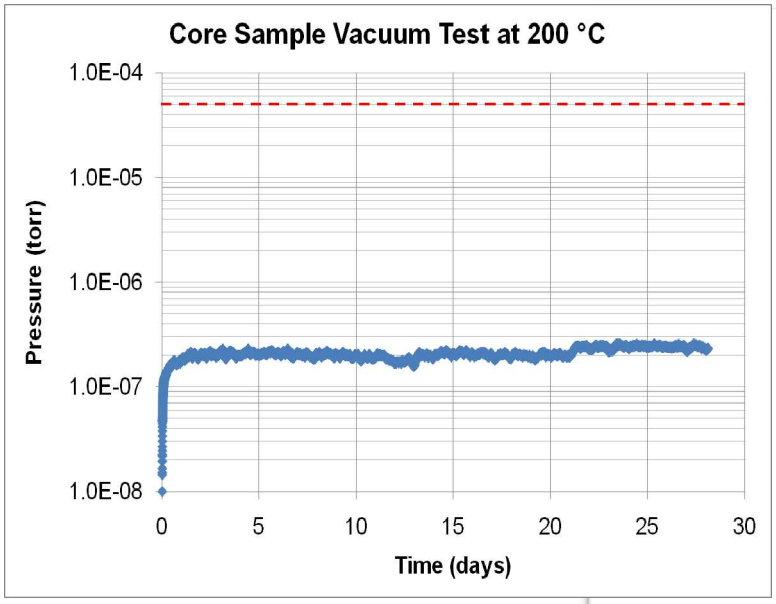
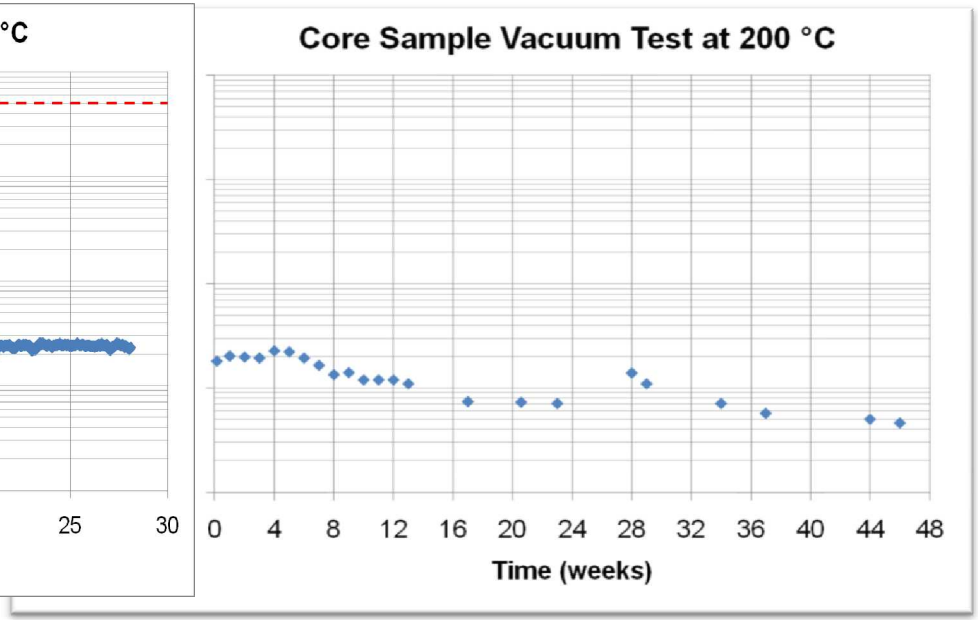
Carbon dioxide is gettered better after some hydrogen has been gettered.



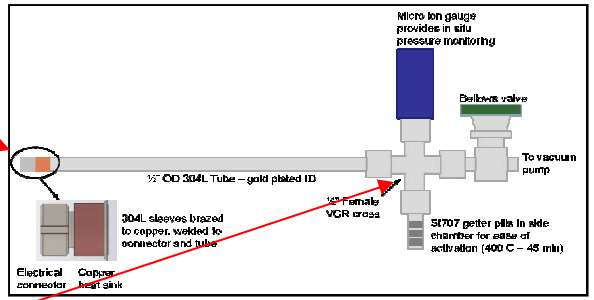
The other most common degas species: CO and N_2 are know to be sorbed; water is known to react with Zr.

In an instrumented laboratory test the getter has exceeded expectations.





A 200°C section contains materials with the proper surface area, volume and treatments.



The getter and ion gauge sections are unheated.

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Conclusions

- **A COTS getter can be used to maintain a vacuum at all STS temperatures.**
- **The capacity decreases with elevated temperature.**
- **The getter can sorb CO_2 better after some exposure to hydrogen.**

Caveats

The materials in the vacuum must be properly prepared to minimize the load on the getter.

The getter must either be contained by a frit or not allowed to reach full capacity and fracture.

Questions?

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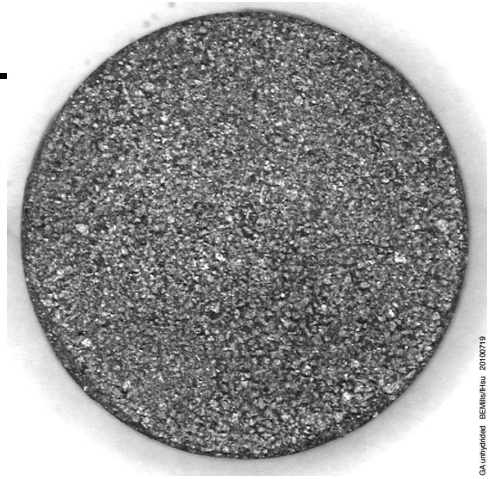
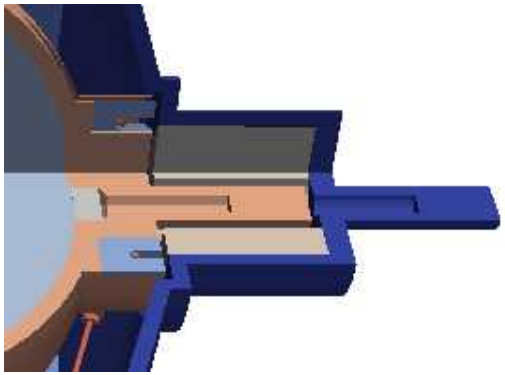
SAES St707™ Non-Evaporable Getter



- **Composition:**
  - **70% zircomium**
  - **24.6%vanadium**
  - **5.4% iron**
- **Samples used in these experiments were ~1.2g at 10mm diameter by 3mm thick.**
- **They are sintered and can be obtained in shapes and sizes, e.g. rings.**



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