Glass Body Packaging

Andrey Elagin
on behalf of the LAPPD collaboration

Glass Body Design

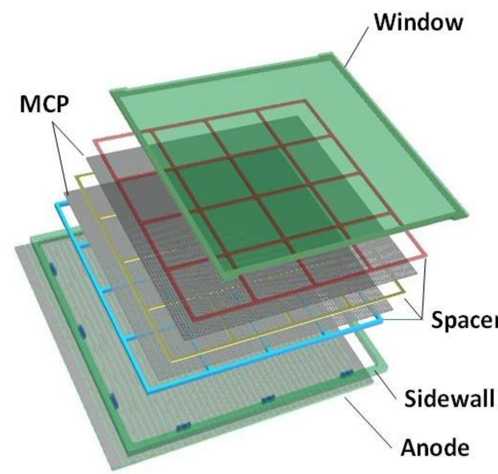
High risk - high reward

Risk:

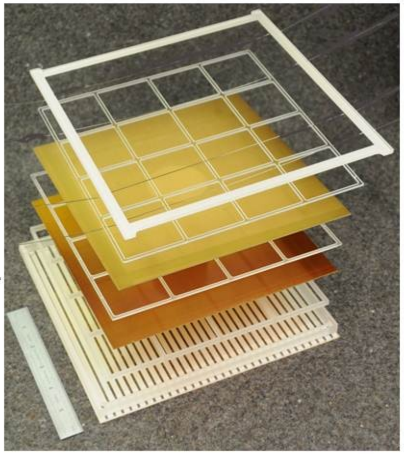
- „Glass is glass“, - J.Gregar
- 3 years ago there were many concerns
  - mechanical properties
  - hermetic packaging
- Most concerns have been addressed

Reward:

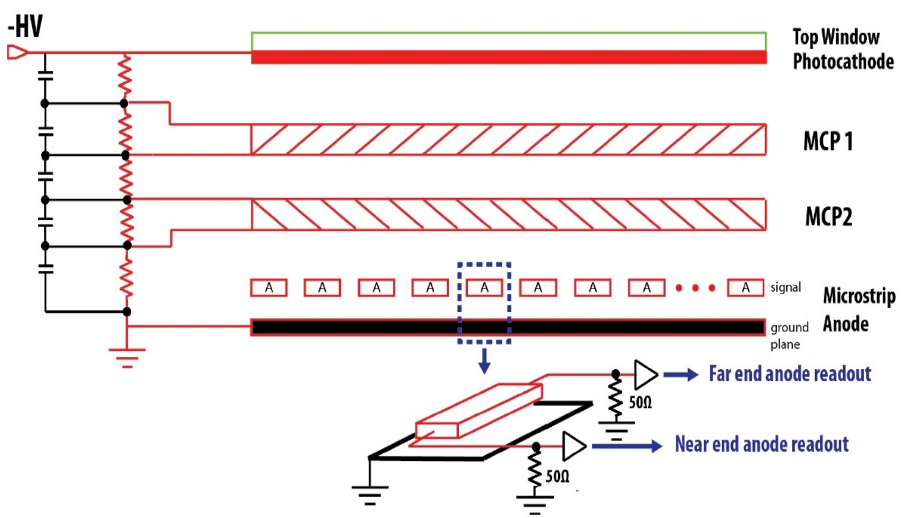
- Cheap, widely available float glass
- Anode is made by silk-screening method (very cheap)
- Flat panel
- No pins, single HV cable
  - high voltage distribution is controlled by the resistance of the internal parts functionalized with ALD
- Modular design
- High bandwidth 50 Ω object
  - designed for fast timing



Design Drawing - September 2010



Actual Glass Parts - April 2012



Collaborative with ceramic packaging effort

Glass Package History

- Many of us knew nothing about glass and we were told it can't be used
- B33 glass is machined well by water-jet cut
- Local supplier (P.Jaynes at Cat-i Glass): parts became available to our specs
- Glass shop at Argonne (J.Gregar's enormous expertise)
- Cheap 50 Ω anode design
- Frit seal of the sidewall over anode silver traces
- Glass body vacuum assembly has been tested in the demountable configuration
- Demonstration of indium top seal scalability to 8x8"

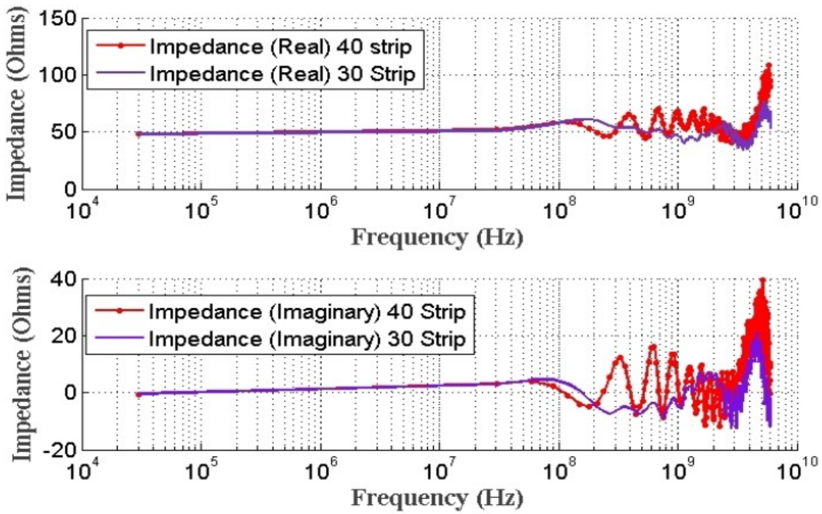
Today we are a few steps away from integration of all individual components into a sealed tube

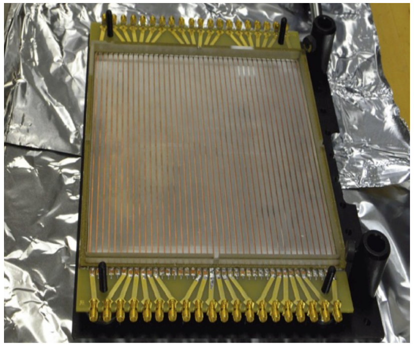
H.Grabas, R.Obaid,
E.Oberla, H.Frisch
J.F.Genat

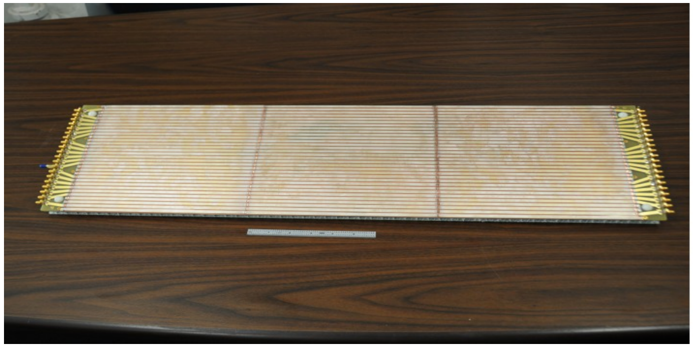
RF Strip-Line Anode

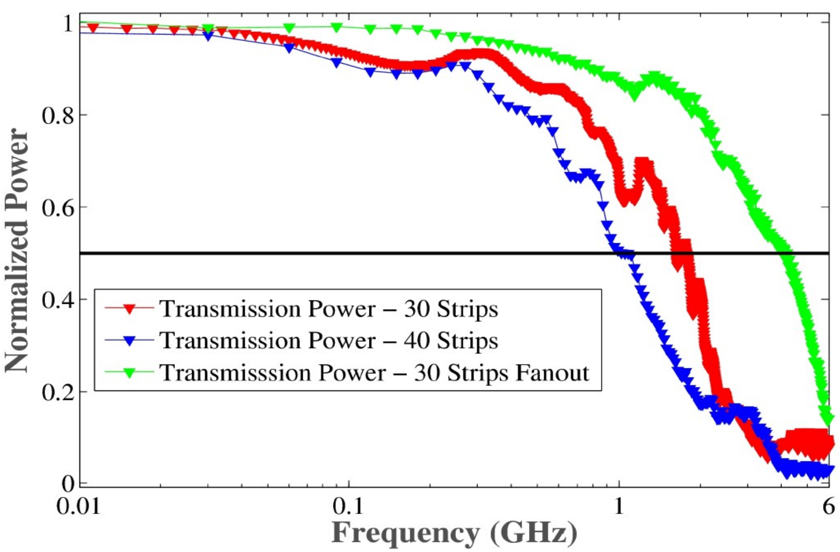
A.Axtell, P.Jaynes

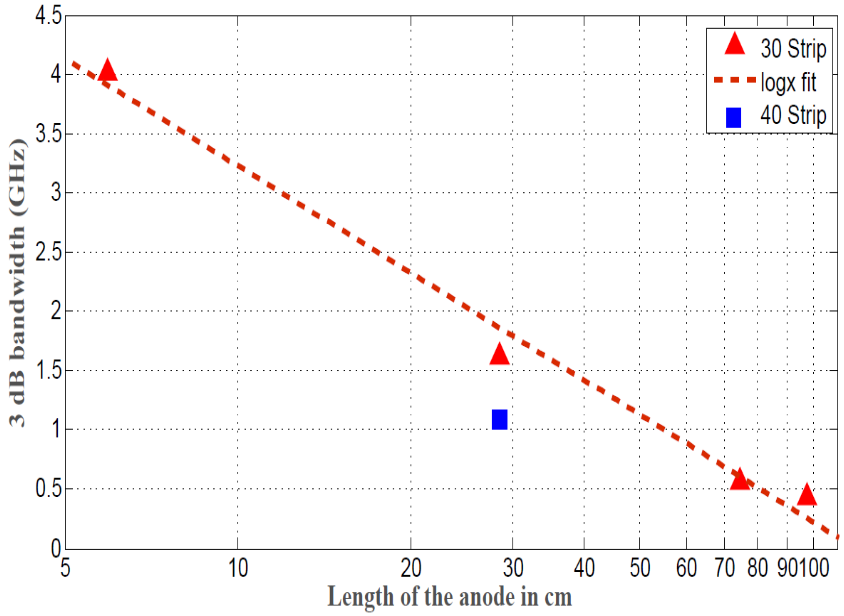
- Silk-screened silver on inexpensive glass
- 50 Ω impedance
- 1.6-0.4GHz bandwidth







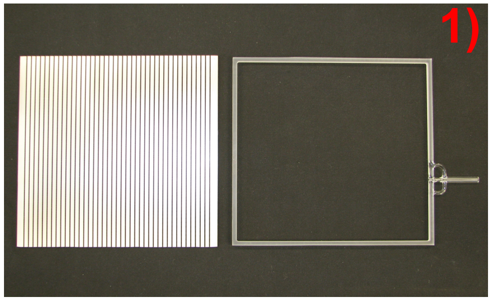


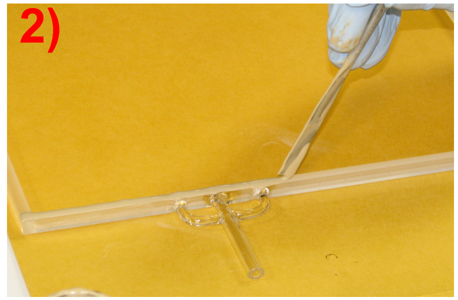


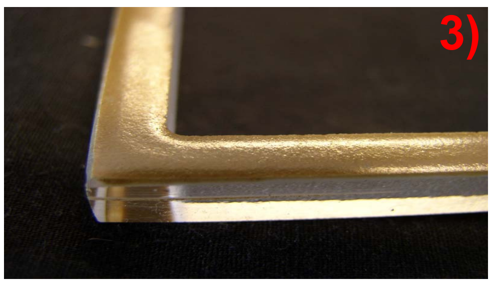
see also Gary Varner's talk

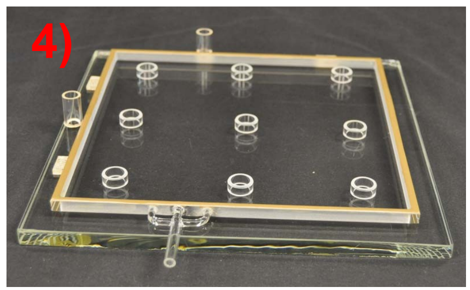
Frit Seal

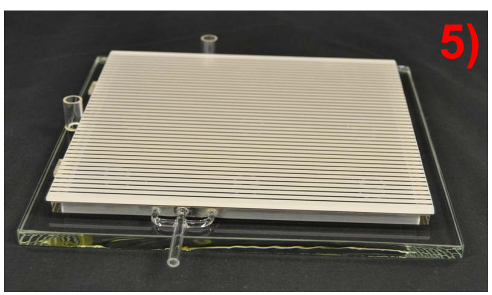
J.Gregar, M.Minot

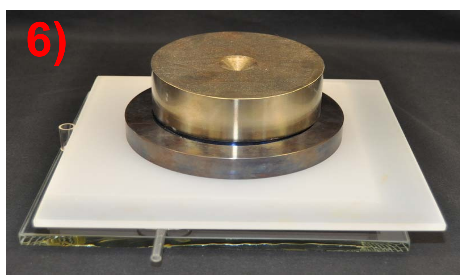












1) Attach pump out tube to 8.66x8.66" frame

2) Apply schott #G018-223 K3 frit paste to frame

3) Fire the frit (many trials to optimize parameters)

4) Prepare for anode plate frit sealing

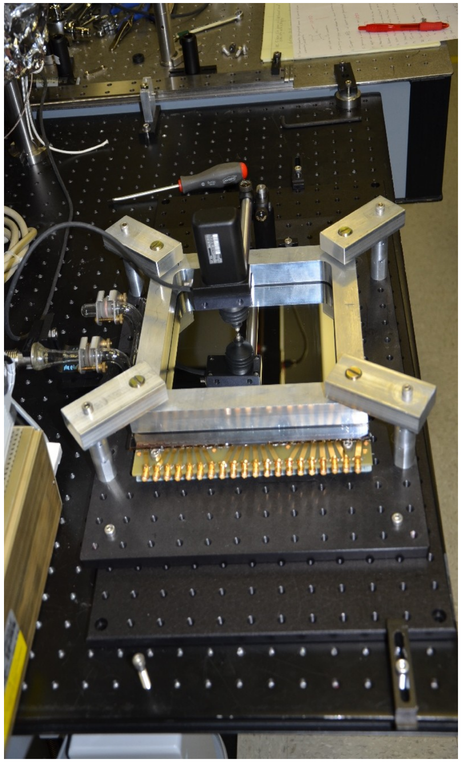
5) Position anode on top of the frame

6) Add weight

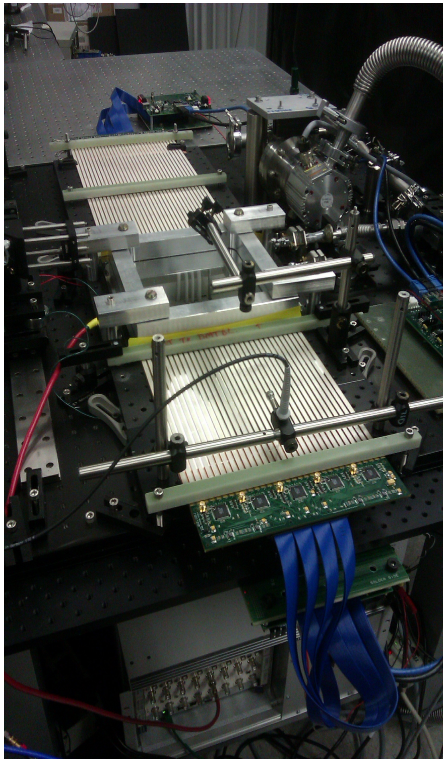
- **Tile bases are reliably reproducible**
- **Mechanical and vacuum properties have been tested**

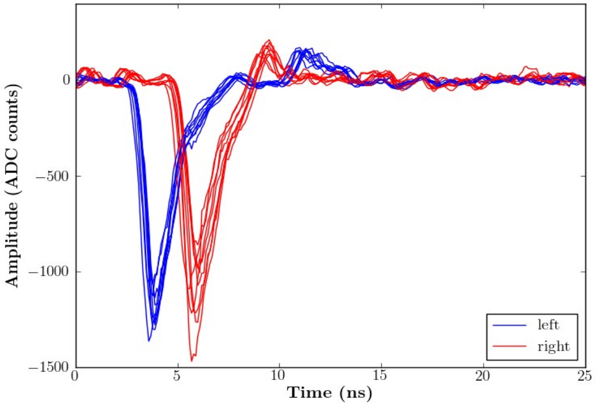
Glass Body Demountable

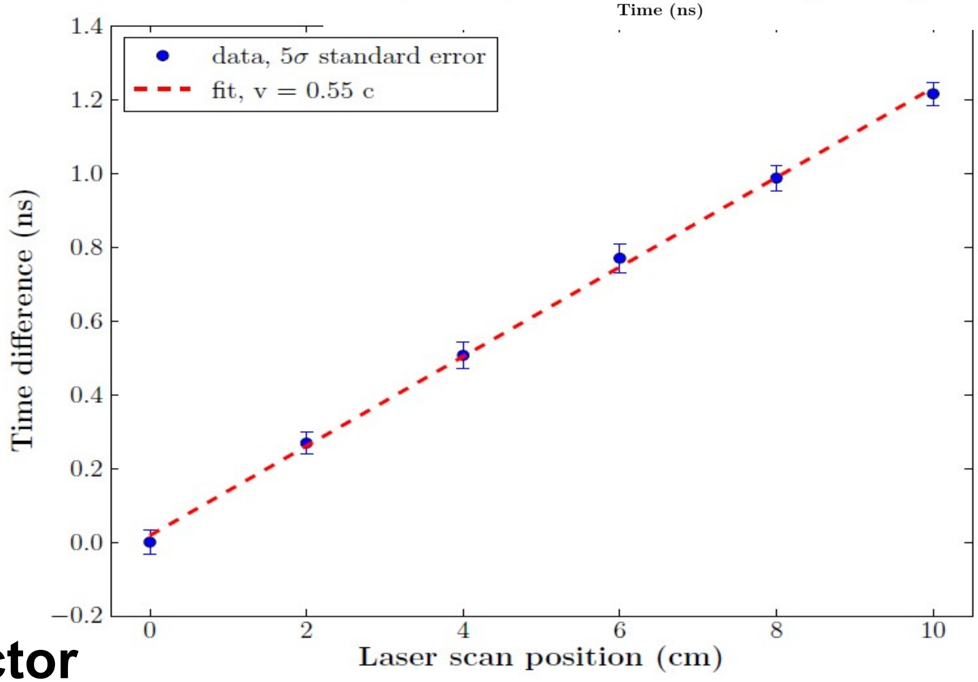
Demountable 1.0 (May 2012)



Demountable 3.0 (Sep-Dec 2012)







- **Prototype of the LAPPD glass body detector (except for aluminum photo-cathode, top seal by compression on a Viton O-ring, active pumping)**
- **Successful tests of the mechanical, electrical, and vacuum properties of a fully sealed tube**

details in Matt Wetstein's talk

Top Seal

How to close frit sealed tile base at the top and stay at moderate temperatures? Top Seal problem

Use indium or indium alloys

- soft metal
- low melting point (157C for pure In)
- essentially zero vapor pressure
- indium-glass seals are successfully used by industry

Top Seal Parallel Paths

- "Cold Seal" effort (**M.Kupfer, D.Walters, J.E.Indacochea**)

  - indium wire is placed in between glass parts and compressed

- "Hot Seal" effort (**A.Elagin, R.Obaid, R.Northrop**)

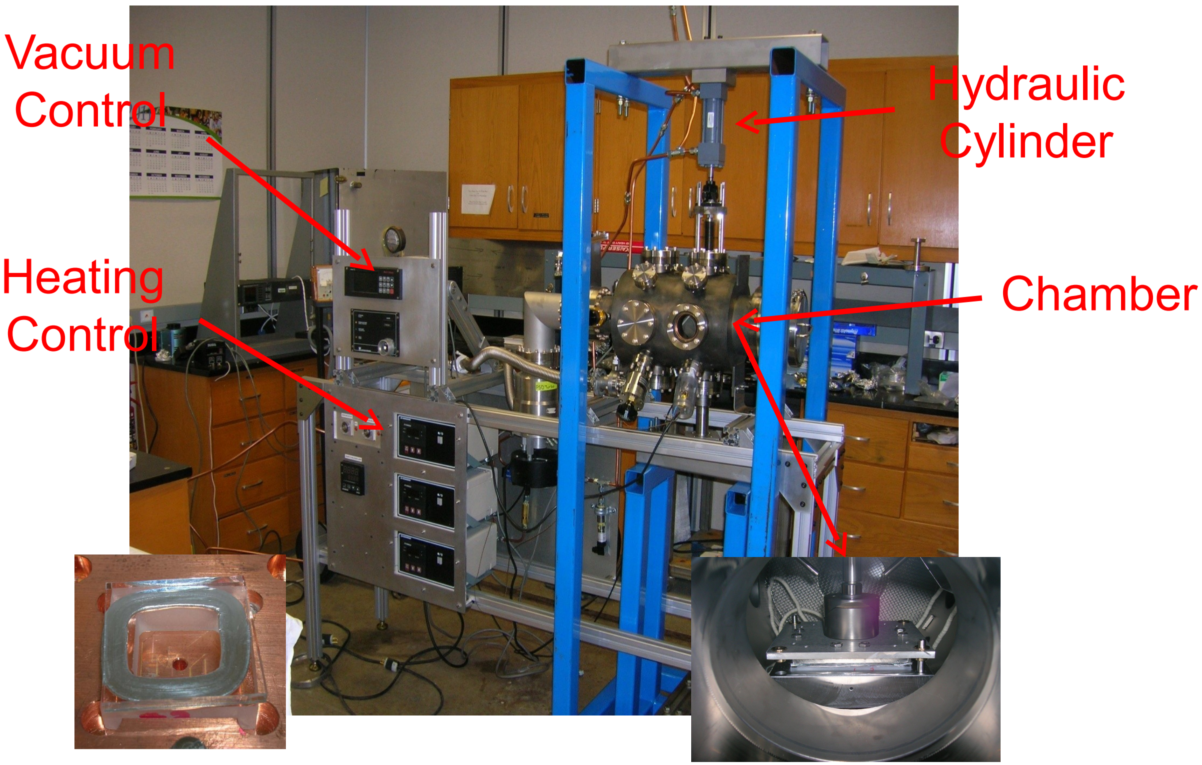
  - indium is melted and glass parts are tinned with indium prior to assembly

- "Groove" effort (**J.McPhate, O.Siegmund, R.Northrop, R.Metz**)

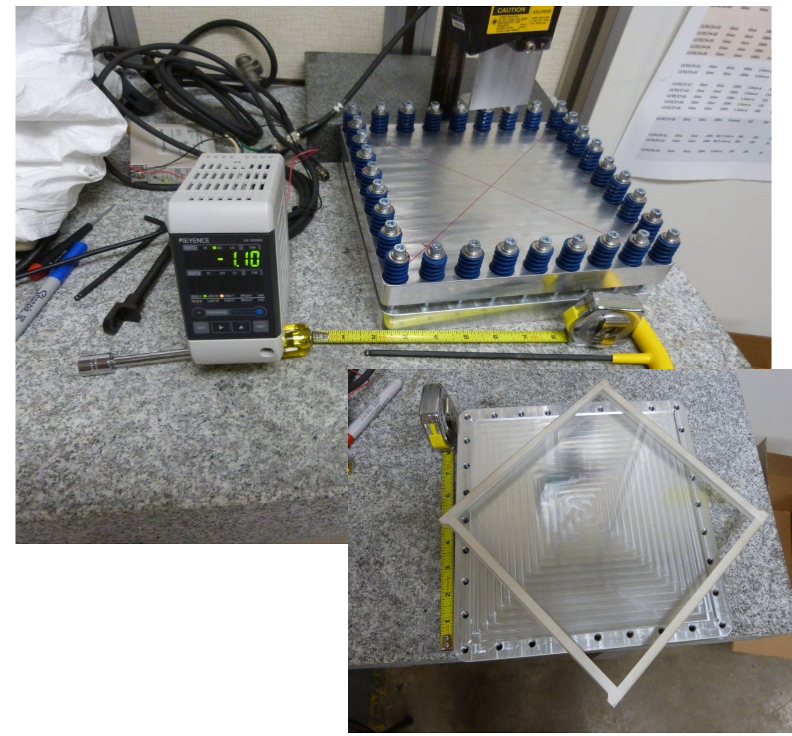
  - a groove in a sidewall is made and filled with indium forming a well

"Cold Seal"

Hydraulic system



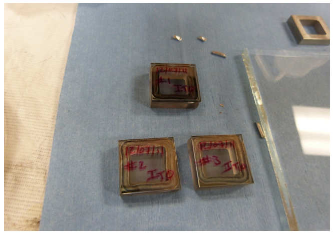
Spring compression



- **Tests with 1x1" and 4x4" glass parts**
- **Detailed studies on the compression force and time needed to make a seal**
- **Test in vacuum or in air**

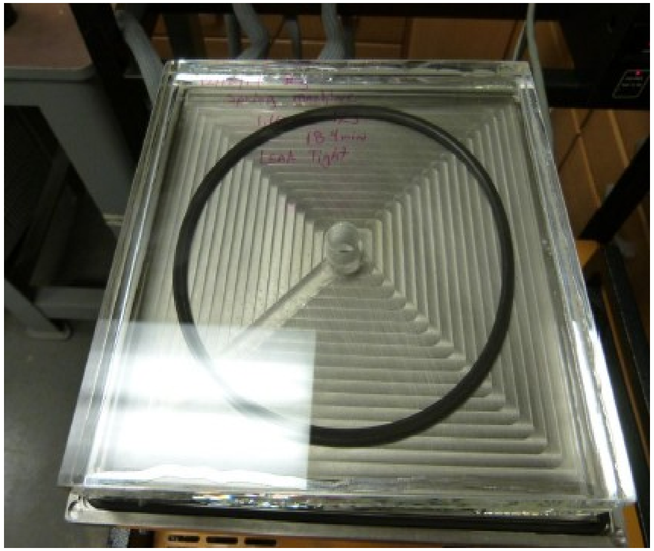
- **Very high compression force possible**
- **No limits on the compression time**

"Cold Seal"



Proof of principle using 1x1" test samples:
- interface
- environment
- compression force and time
- aging tests
- many successful reproducible leak tight* samples

Technique scalability using 4x4" test samples
- compression force and time
- mechanical properties
- six completely leak tight parts made

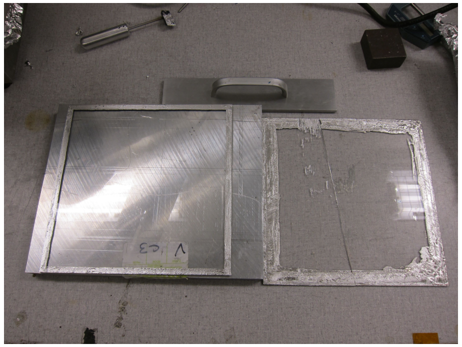


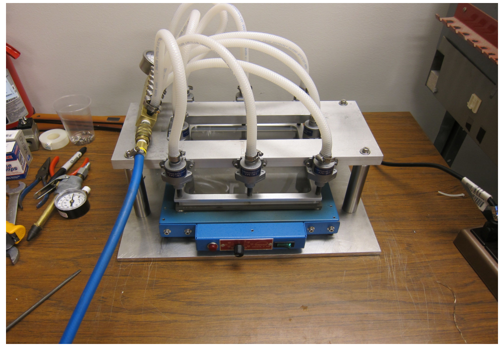
Work on 8x8" seal:
- longer compression time
- mechanical properties
- several parts leaking only at the corners
- demonstration of 8x8" indium seal capability:
  0.8mm gap in between two 16mm windows

* *Leak tight definition: not visible with helium leak checker which has limit of 10^{-10} cc/s*

"Hot Seal"

Phase I (in air)





• Indium seal fundamentals
 - interface
 - oxide formation

• Proof of principle using 1x1" test samples
 - little oxidation
 - many successful reproducible leak tight samples

• Several attempts to make 8x8" seal
 - oxide formation becomes limiting factor
 - best result is a part with 10^{-6}cc/s leak at a single pinpoint

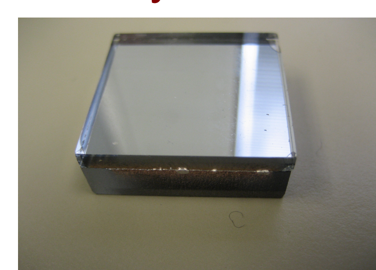
Phase II (in inert atmosphere)

Advantage: no indium oxide formation

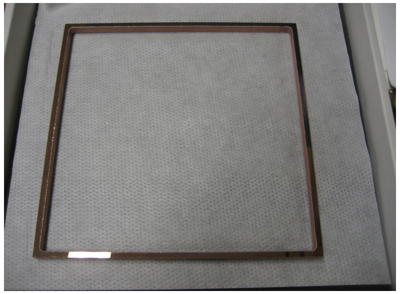
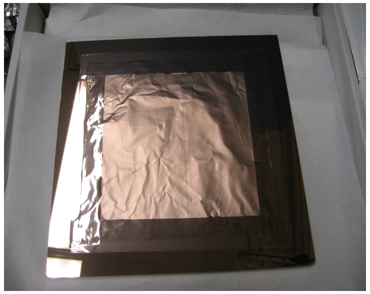
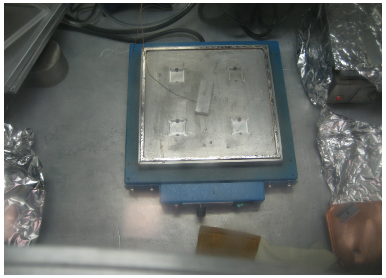
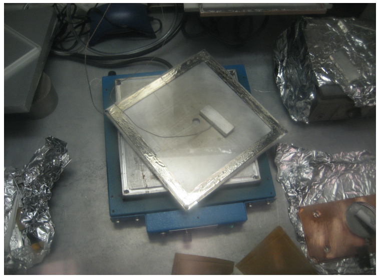
New complication: no adhesion of the melted indium to the glass surface

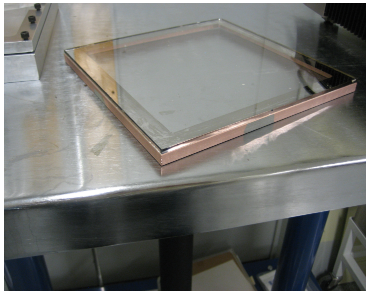
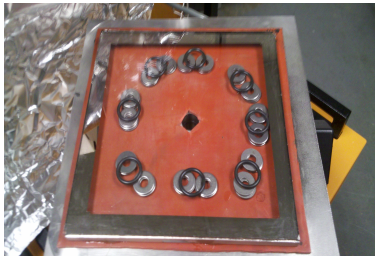
Solution: glass-NiCr-Cu-In inteface

• Controlled process
• Achieved good reproducibility of 1x1" seals



"Hot Seal"

Status:

One attempt to make 8" seal in the glove box
- parts coated in sputtering system

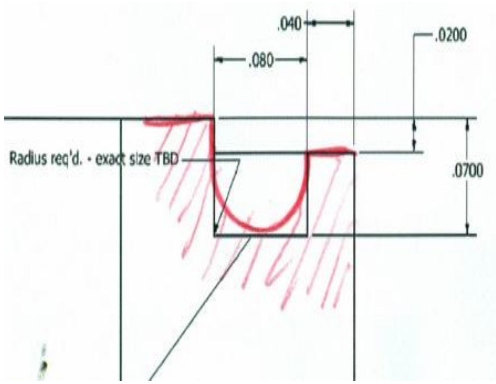
Promising, but there were leaks at all 4 corners

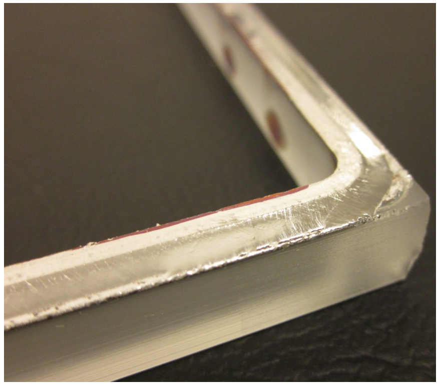
Major problems identified and being addressed
- copper oxidation
- parts time spent in air between sputtering system and glove box

Plans:

Improve thin film deposition capabilities for 8x8" parts
- plasma cleaning
- electroding

"Groove Seal"



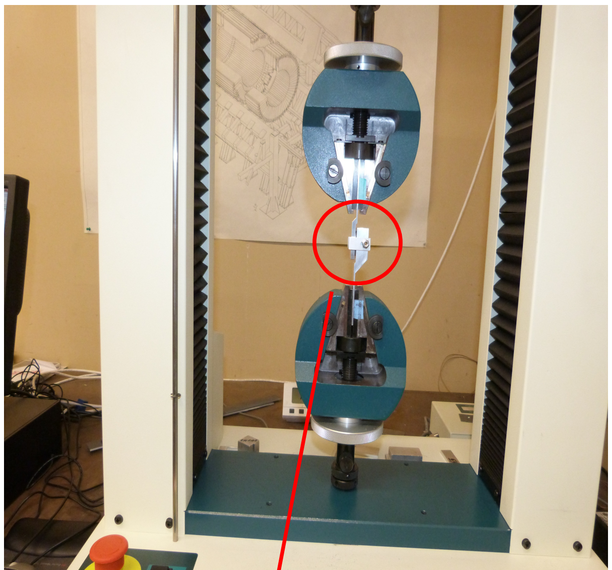


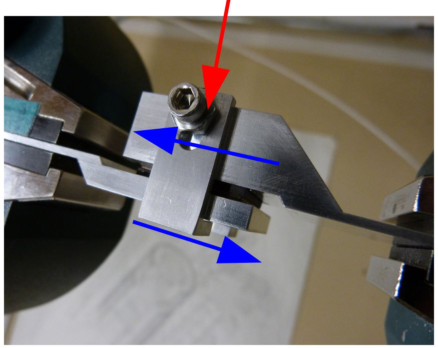
- Dimensions copied from SSL copper well brazed to ceramic body
- B33 glass machines nicely
- Could be molded in quantity production to reduce cost
- Ongoing at SSL

Indium Seal Reliability Tests

Shear testing setup

M.Kupfer, D.Walters





Seal strength by shear testing

- Limit for the indium bulk strength is 600-760psi
  - tested on 1x1" parts made of copper
  - indium bonds with copper very well
  - the failure is always in the indium bulk and not in the interface
- Measured strength for the glass parts is up to 400psi
- Measured strength for the Cu coated parts is 500-600psi
- The failure is in the interface in the most cases

Aging tests:

- Sealed parts are heated to 80C and 130C for extended period of time
- Most samples remain leak tight
- Some develop $O(10^{-10})$ cc/s leaks

Summary

- Glass parts to our specs are cheap and widely available

  - industry partners

  - Argonne glass shop

  - gained expertise on machining the glass parts at UChicago

- All individual components of the glass package are successfully tested

  - 50 Ω, 1.6GHz anode (scalable and very cheap)

  - frit seal over the anode striplines

  - demountable glass package tested in a complete system configuration:
  high voltage distribution between internal components, *mechanical reliability*, *vacuum hermicity*, *MCP pulses readout*

  - indium seal technique scalability demonstrated on 8x8" glass parts

- With proper integration of all individual components

  a working sealed tube is a few steps away

Backups

How strong and reliable the seal is?

Hot seal

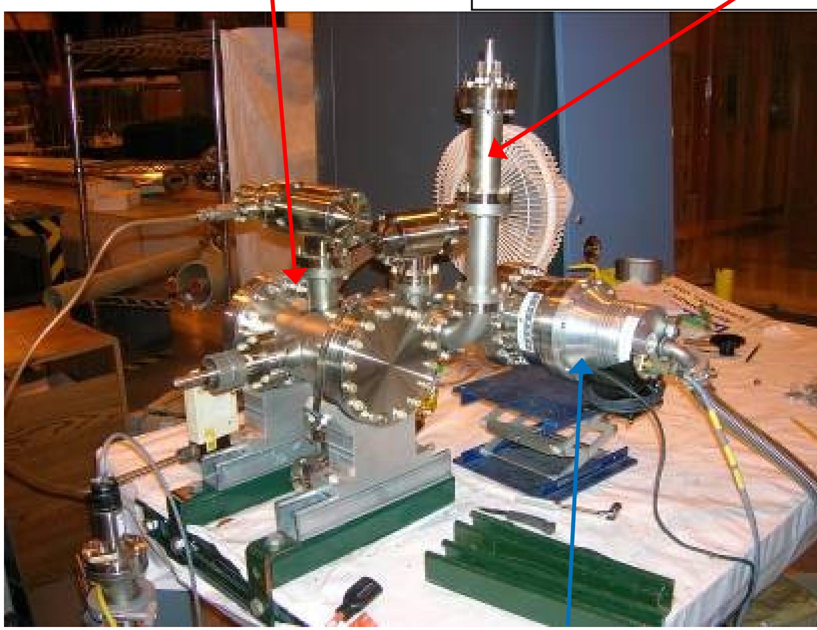
Leak tight samples:	
Bare glass #1	**190 lb**
Bare glass #2	**278 lb**
Bare glass with groove	**268 lb**
Cu coated glass #3	**390 lb**
Cu coated glass #4	**345 lb**
Samples with a leak	
Bare glass #4	**47 lb**
Cu coated glass #1	**213 lb**
Cu coated glass #2	**221 lb**

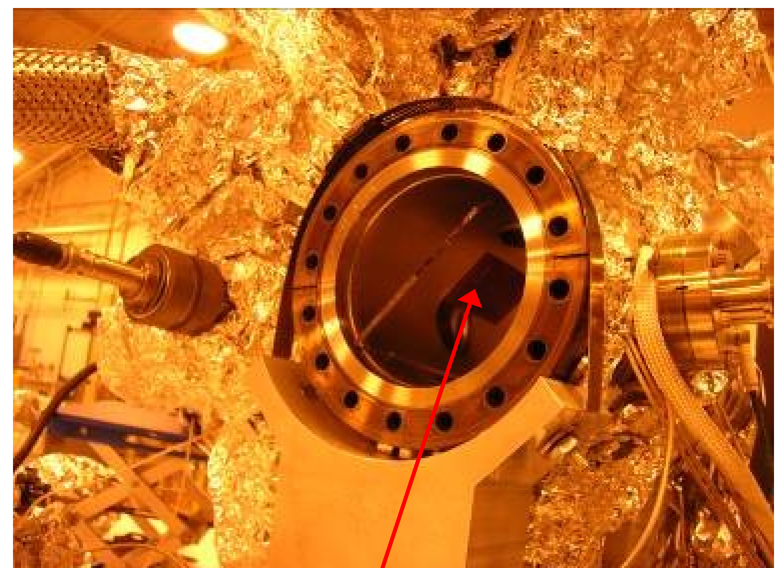
Cold seal

Aging Matrix

Coating	80 ºC 68 Hours	80 ºC 172 Hours	130 ºC 42 hours	130 ºC 213 Hours	Shearing Force (lbs)
Silver (52In/48Sn Solder)	Leak (10^{-10})	Leak (10^{-10})	Leak (10^{-10})	Leak Tight	N/A
Titanium	Leak Tight	Leak Tight	Leak Tight	Leak (10^{-10})	138.24
Chromium	Leak Tight	Leak Tight	Leak Tight	Leak (10^{-10})	173.73
Bare Glass	Leak Tight	Leak Tight	Leak Tight	Leak (10^{-10})	186.21
Nichrome	Leak Tight	Leak Tight	Leak Tight	Leak Tight	218.32
ITO	Leak Tight	Leak Tight	Leak Tight	Leak Tight	191.76

Can we keep good vacuum? outgasing studies

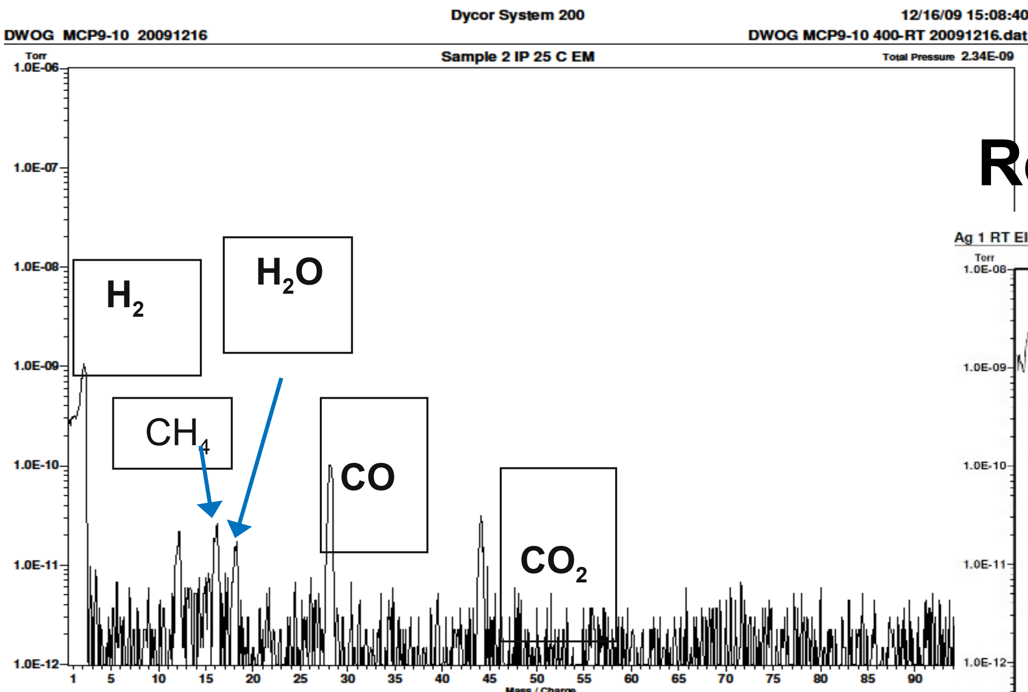




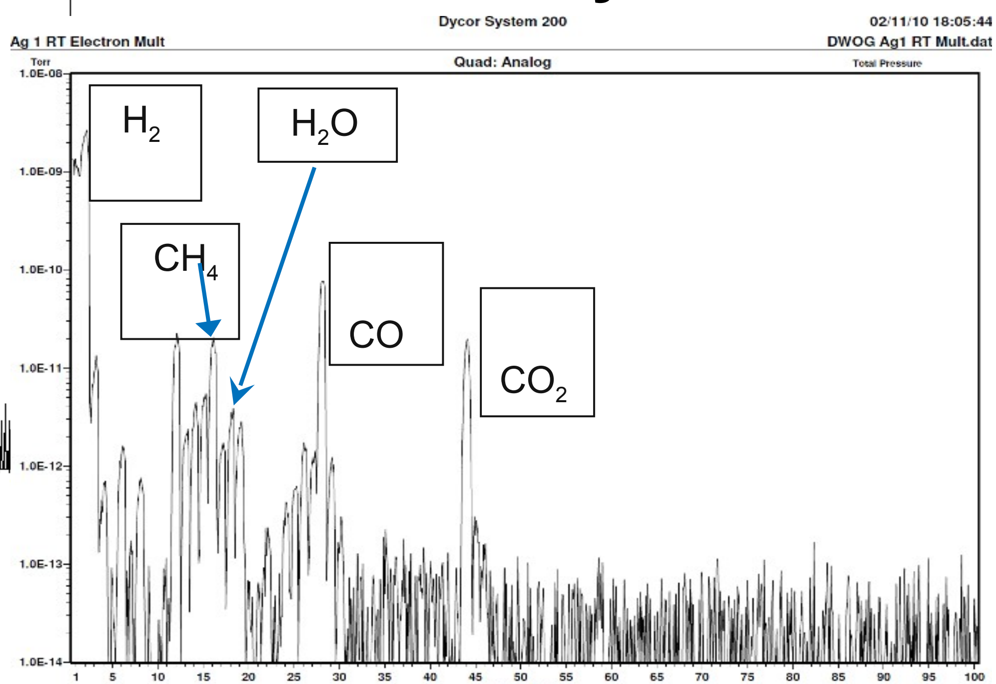
Outgasing studies

D.Walters, Argonne

Residual Gas Analysis MCP

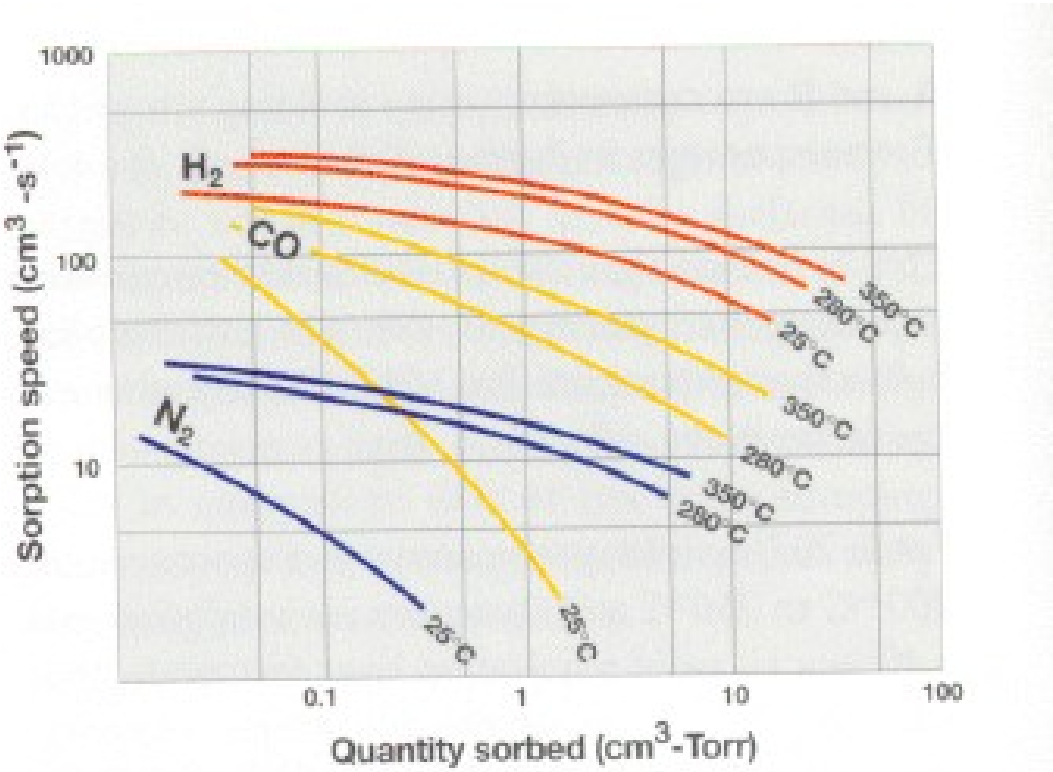


Residual Gas Analysis Silver Paste



Outgasing tests are being continued at SSL

Saes ST-707 Getter Strips



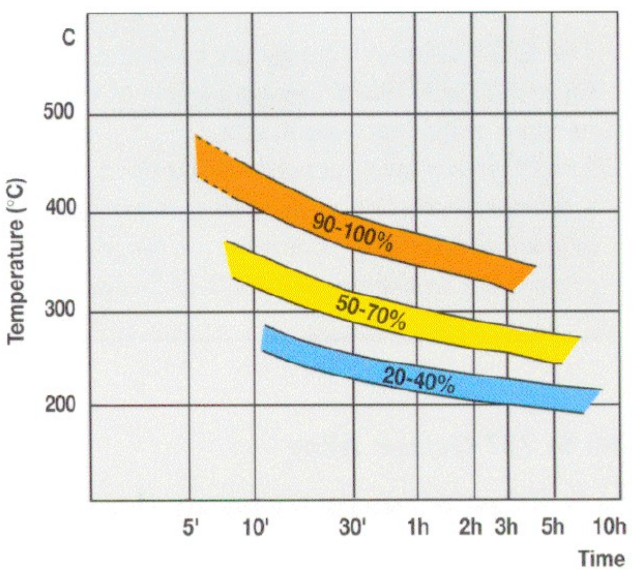
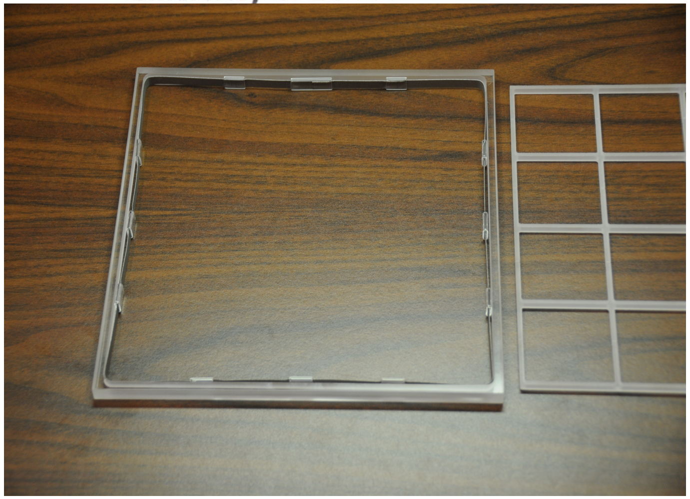
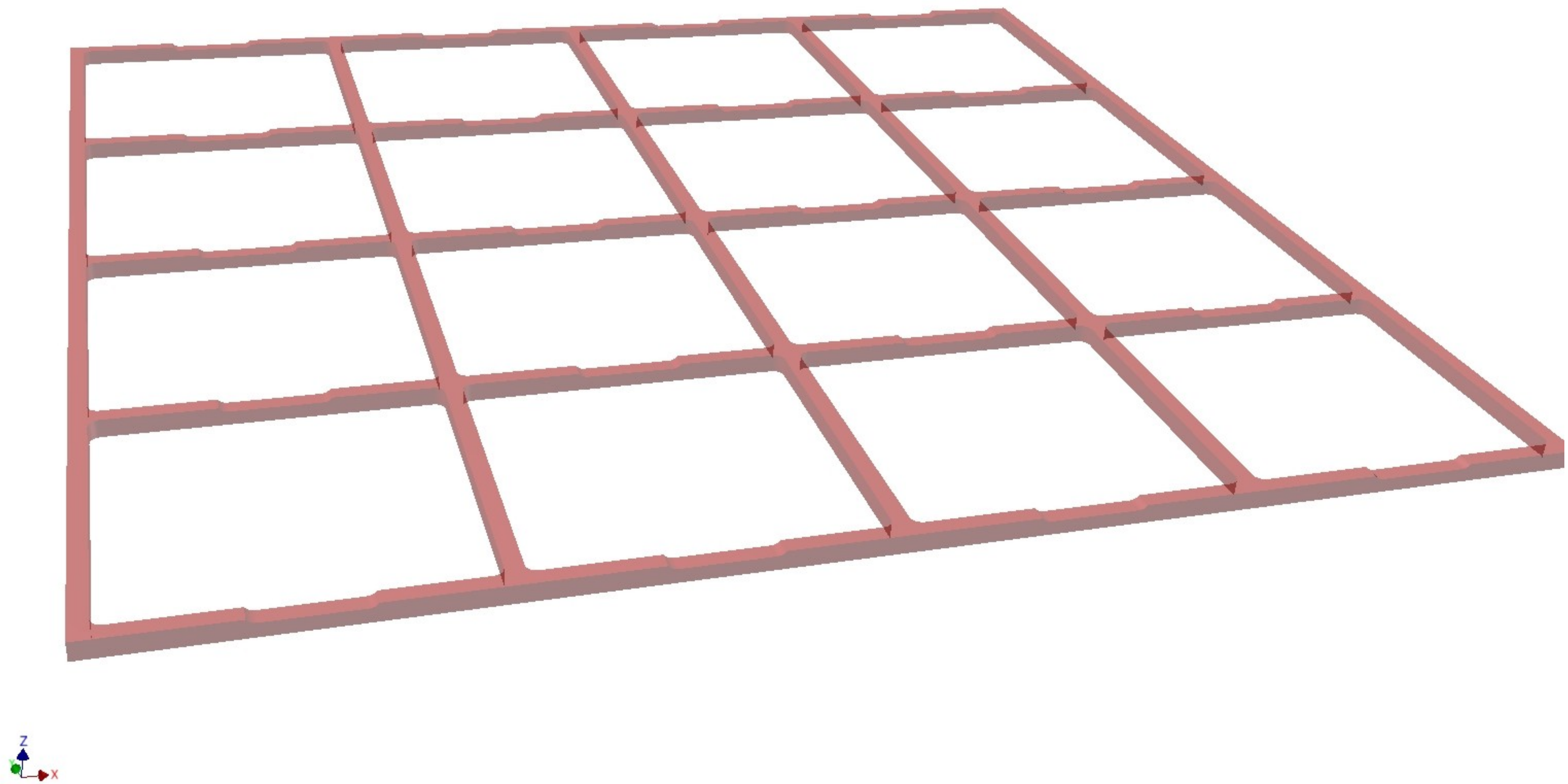


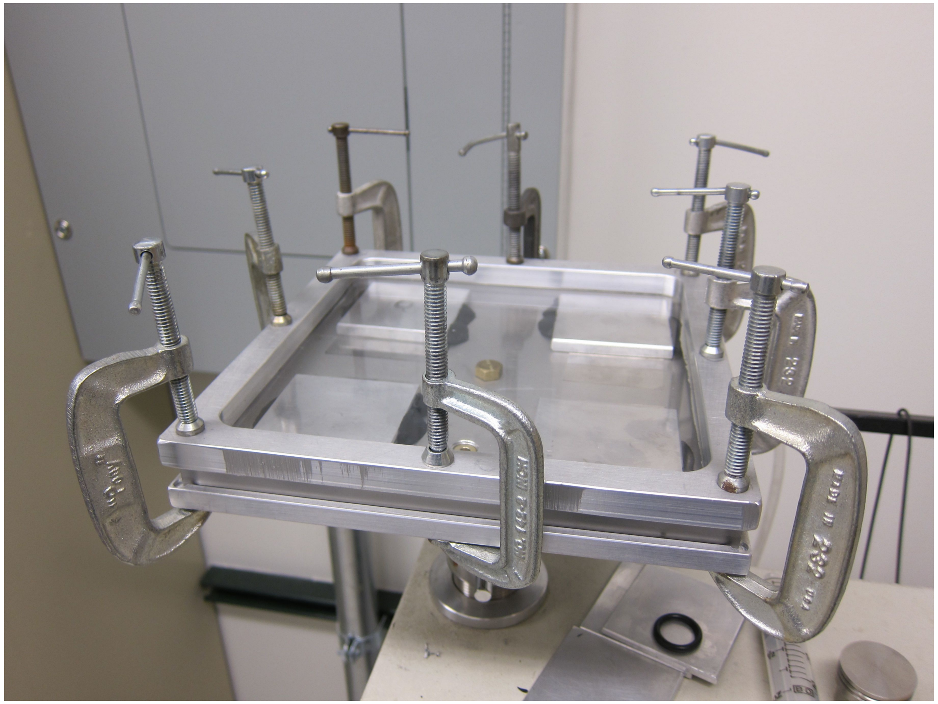
Fig. 1. Activation conditions and gettering efficiency of St 707



- Data is for 50 sq mm
- This material can be activated at 350 C (2 hrs).
- From this the area of the getter is 8.8 sq inches

Does it breaks when pumped? No, we have grid spacers



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