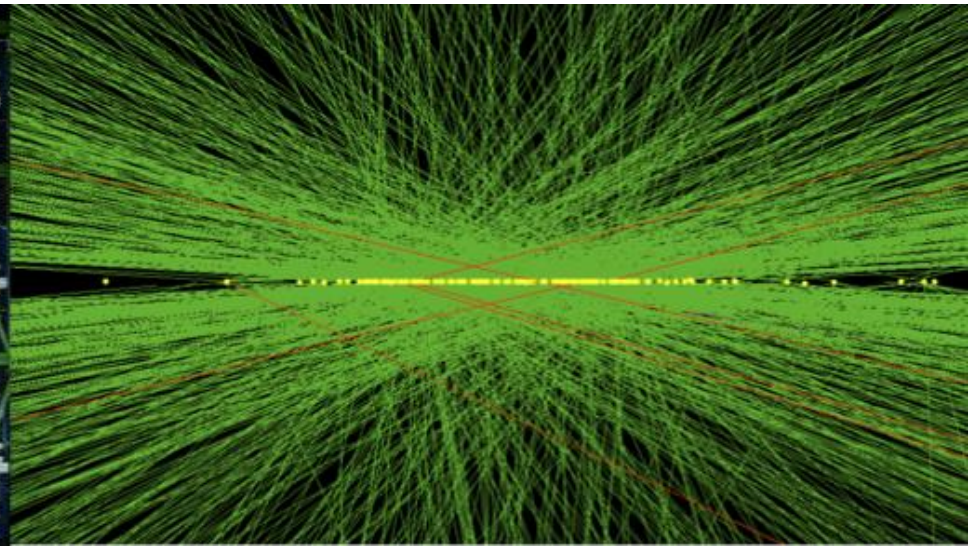
how to attach module to dee: some ideas to explore this summer

Jim Alexander

TFPX Mechanics mtg

2 May 2019

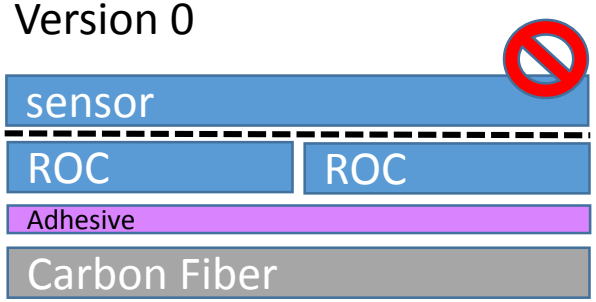


Summer Projects at Cornell

- Address "macro" thermal problem comprehensively. Define macro thermal problem: "*performance of thermal pathway from ROCs and Sensors actually on a Dee*" (conductance, resistance)
- Distinguish from micro thermal studies, defined by "*measurements of intrinsic thermal conductivities in materials*" – ie, Purdue. (conductivity, resistivity)
- Must demonstrate control of this critical problem by time of Final Design Review in September
- Resources for macro studies:
  - Postdoc (Jose), Grad Student (Sam), +5 undergrads
  - CO_2 cooling plant and associated infrastructure
  - RTDs, thermal camera, LabView, etc etc
  - 2 dees, plus miscellaneous scraps
  - ANSYS + smart students + Yadira's expertise
  - Tech support, shop support, 3D printing, etc etc

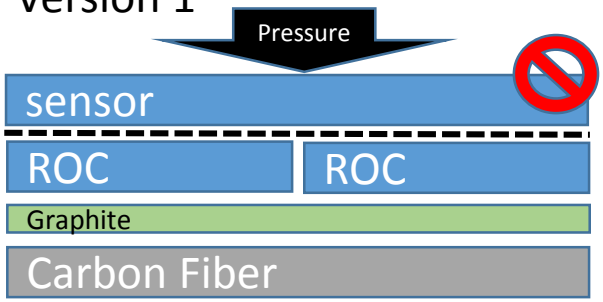
Basic issue: How to Attach Module to Dee: (1)

Version 0



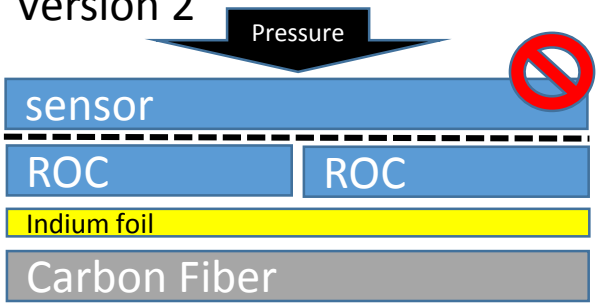
not removable

Version 1



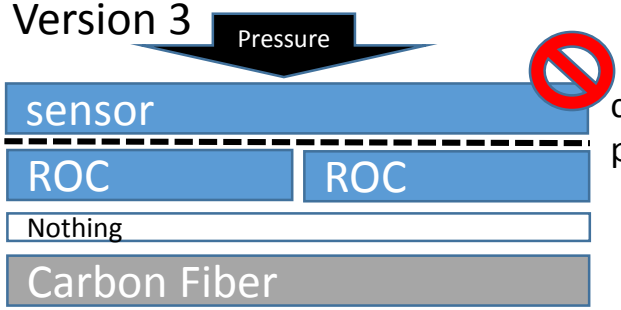
conductive

Version 2



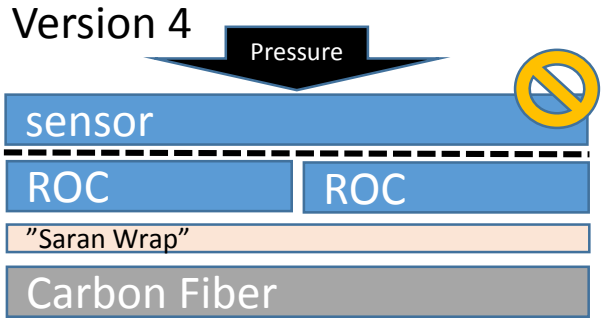
conductive

Version 3



conductive, poor contact

Version 4

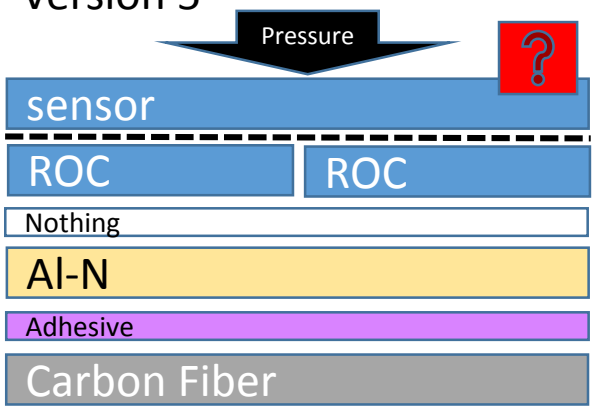


must be rad-hard material

NASA: polyvinyl dichloride dies ~ 10MRad

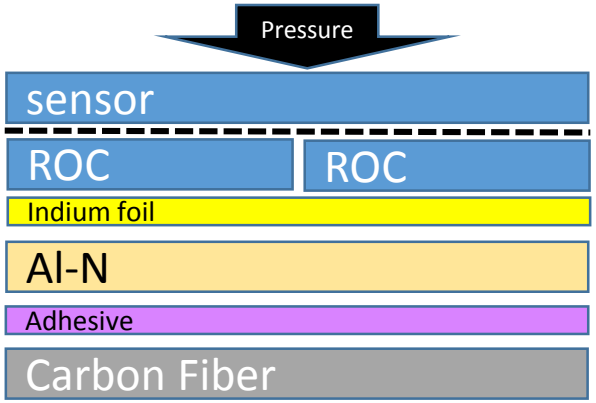
Basic issue: How to Attach Module to Dee: (2)

Version 5



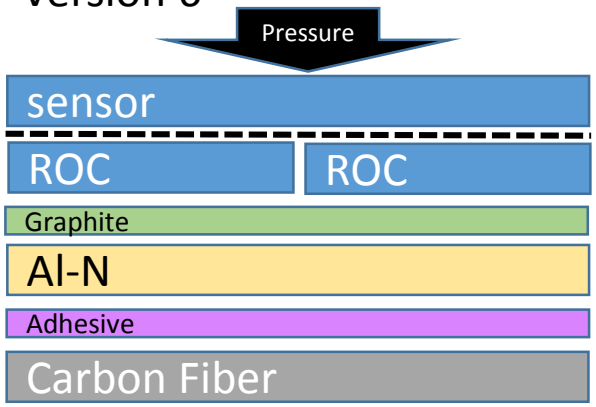
ROCs not even?

Version 7



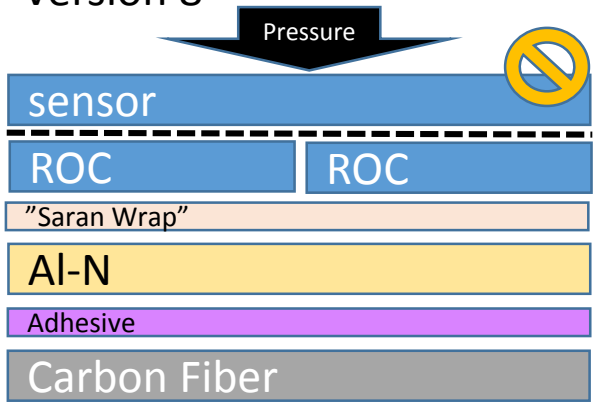
cost? mass?
X_0=12mm
X_0(Si)=94mm

Version 6



is graphite soft enough?

Version 8

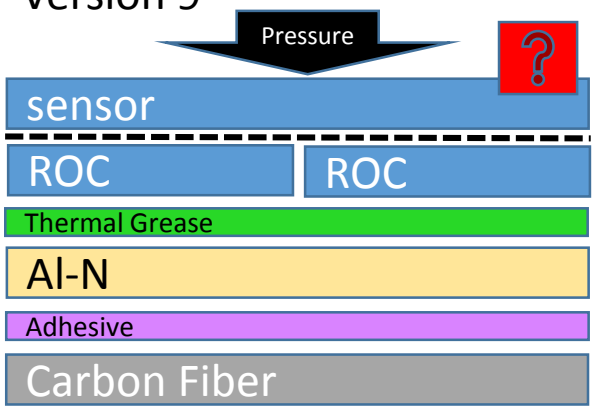


must be rad-hard material.

Alum Nitride layer eliminates conductivity issue and provide high-quality surface

Basic issue: How to Attach Module to Dee: (2a)

Version 9



What happens to thermal grease after irradiation?

Alum Nitride layer eliminates conductivity issue and provide high-quality surface

Thermal score cards

Version 0

TFPX-0						@253K			
Material	thickness (mm)	circumf erence	width (mm)	L (mm)	Area (mm^2)	k (W/m.K)	symmetry	kA/t (W/C)	R (C/W)
Sensor- Si	0.075		4.65	43.45	202	191	4	2058.140	0.0005
Bumpbonds	0.010		0.010		25	36	4	365.607	0.0027
ROC - Si	0.150		4.65	43.45	202	191	4	1029.070	0.0010
adhesive	0.100		4.65	43.45	202	2.00	4	16.163	0.0619
carbon Fiber thru	0.240		4.65	43.45	202	1.08	4	3.637	0.2750
Carbon Foam	2.000		2.33	43.45	87	20	4	2.990	0.3344
adhesive	0.100	0.25	1.41	43.45	61	2.00	4	4.914	0.2035
SS	0.125	0.25	1.41	43.45	61	12.5	4	24.570	0.0407
boundary layer	n/a	0.25	1.41	43.45	61	12000	4	2.948	0.3392
								total R	1.26

Version 5

TFPX-1						@253K			
Material	thickness (mm)	circumf erence	width (mm)	L (mm)	Area (mm^2)	k (W/m.K)	symmetry	kA/t (W/C)	R (C/W)
Sensor- Si	0.075		4.65	43.45	202	191	4	2058.140	0.0005
Bumpbonds	0.010		0.010		25	36	4	365.607	0.0027
ROC - Si	0.150		4.65	43.45	202	191	4	1029.070	0.0010
contact layer	n/a		4.65	43.45	202	5000	2	2.02043	0.4949
Al-N plate	0.100		4.65	43.45	202	200	2	808.17000	0.0012
adhesive	0.100		4.65	43.45	202	2.00	4	16.163	0.0619
carbon Fiber thru	0.240		4.65	43.45	202	1.08	4	3.637	0.2750
Carbon Foam	2.000		2.33	43.45	87	20	4	2.990	0.3344
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SS	0.125	0.25	1.41	43.45	61	12.5	4	24.570	0.0407
boundary layer	n/a	0.25	1.41	43.45	61	12000	4	2.948	0.3392
								total R	1.76

Assumes contact conductance h=5000 W/m^{2}K… may be impossible

Miscellaneous materials data

graphite sheets, 17um – 100um

Product Name		Test Method	Tgon 9017	Tgon 9025	Tgon 9040	Tgon 9070	Tgon 9100
Thickness (mm)		ASTM D374	0.017+/-0.005	0.025+/-0.005	0.04+/-0.005	0.07+/-0.01	0.1+/-0.01
Thermal conductivity (W/mK)	X,Y direction	ASTM E1461	1650~1900	1500~1700	1150~1400	700~1000	500~700
	Z direction		15	15	15	15	15
Thermal diffusivity (cm^2/s)		ASTM E1461	9	9	8	7	7
Density (g/cm^3)		ASTM D792	2.05~2.25	2.05~2.25	1.65~1.85	1.0~1.3	0.7~1.0

Indium foil, 2um – 100um

IN000040 Indium Foil
Thickness : 0.002mm, Purity : 99.8%, Support : Temporary Acrylic

IN000050 Indium Foil
Thickness : 0.0025mm, Purity : 99.8%, Support : Temporary Acrylic

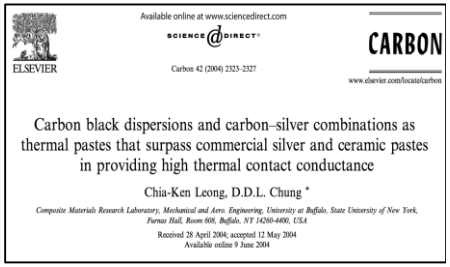
IN000060 Indium Foil
Thickness : 0.003mm, Purity : 99.8%, Support : Temporary Acrylic

IN000070 Indium Foil
Thickness : 0.004mm, Purity : 99.8%, Support : Temporary Acrylic

IN000080 Indium Foil
Thickness : 0.005mm, Purity : 99.8%, Support : Temporary Acrylic

IN000090 Indium Foil
Thickness : 0.006mm, Purity : 99.8%, Support : Temporary Acrylic

slightly weird…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Carbon black dispersions and carbon–silver combinations as thermal pastes that surpass commercial silver and ceramic pastes in providing high thermal contact conductance

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NASA rad hardness table

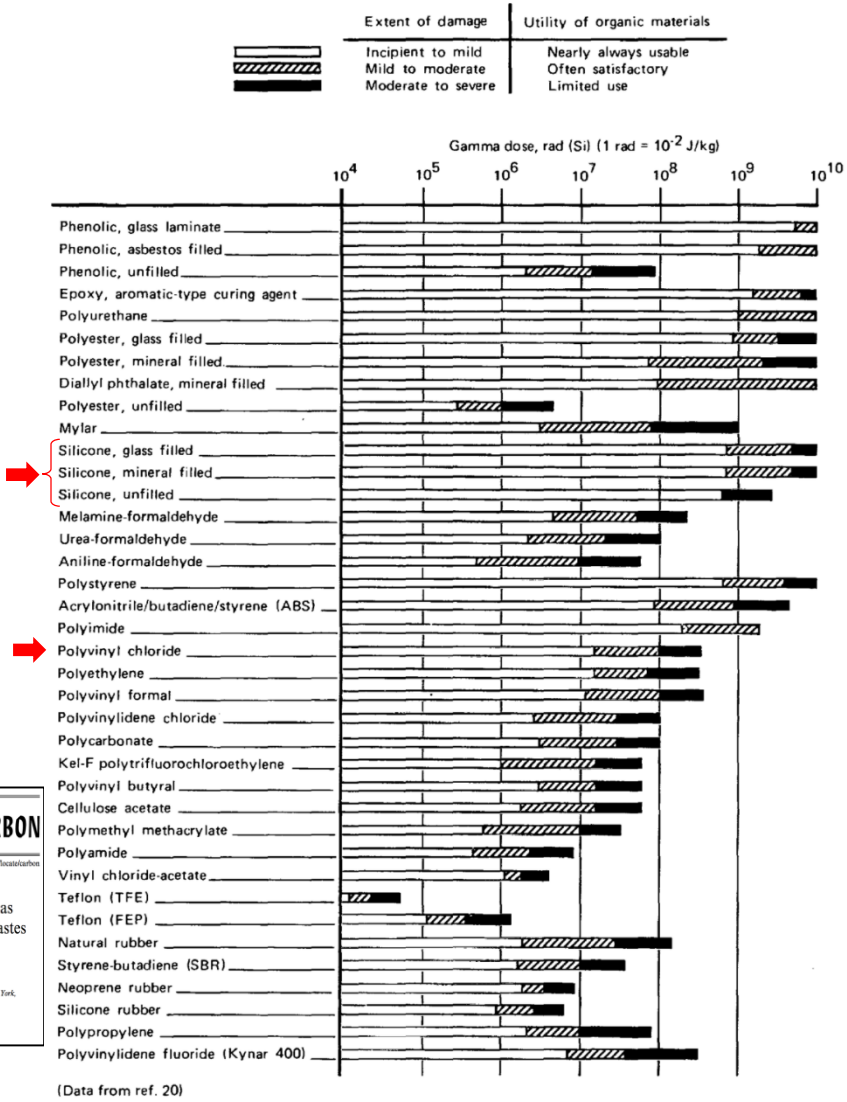


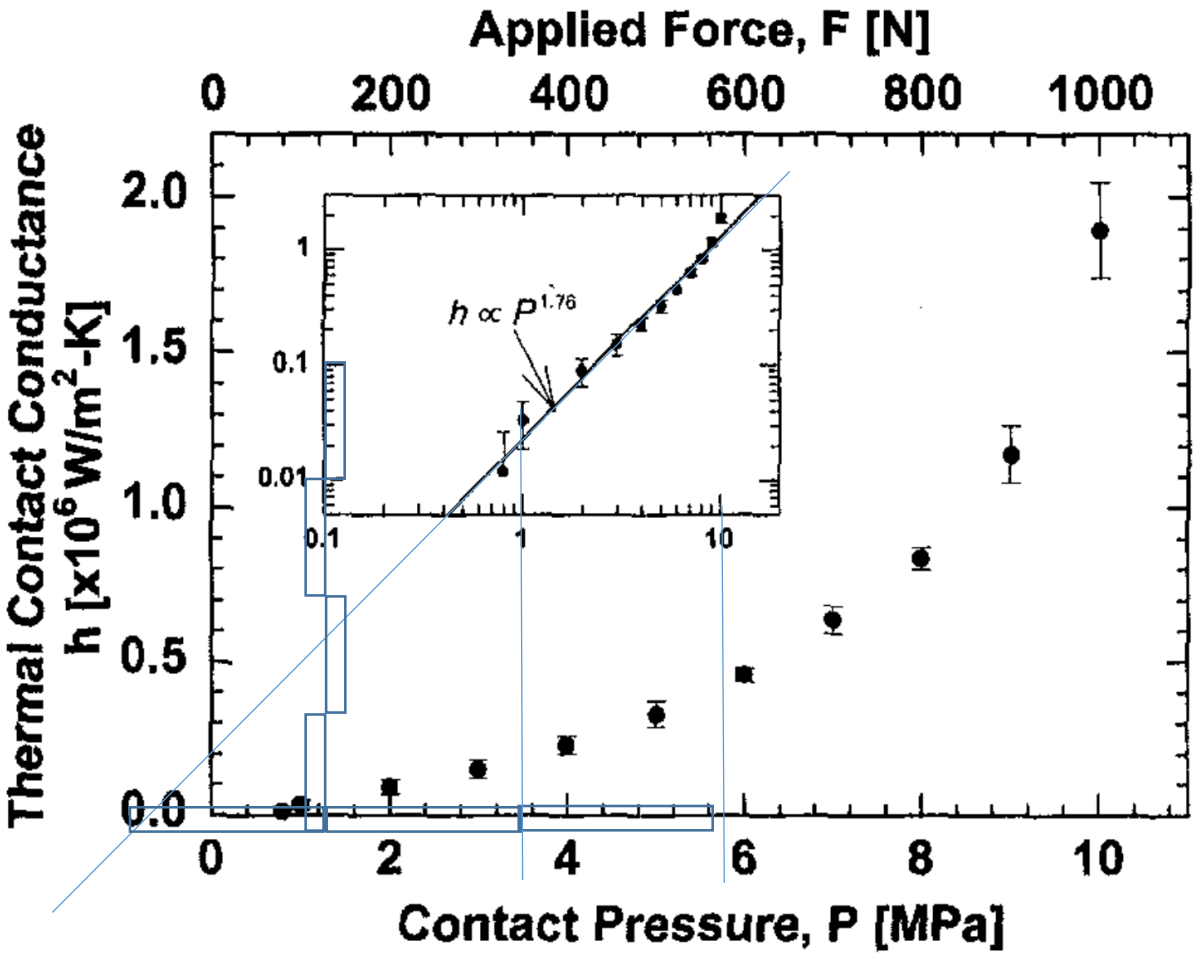
Figure 3. – Relative radiation resistance of organic materials based upon changes in physical properties.

Basic issue: How to Attach Module to Dee: (3)

- What is Pressure ?
  - How much do we need?
  - How do we impose it?
  - How does thermal performance correlate with it?
- What is Adhesive ?
  - many options (Laird, Hysol, Araldite, loaded, what loading material, etc.) We will take guidance from Purdue
  - How do we achieve thin, uniform, performant* layers?
- What is Nothing ?
  - more specifically, what do we need to know about surface quality to achieve decent thermal performance in a dry contact?

* CERN-glish for “high performing”

Contact conductance (1)



Source: Ohsone et al,
J. Heat Transfer
Vol 121, p961, 1999

These data suggest
h ~ 10 W/m²K
at
P=0.01MPa=1.5psi

WAY TOO SMALL

Fig. 7 Plot of thermal contact conductance estimated from the phase lag measurements as a function of compressive load for the Al-Si interface

Contact Conductance (2)

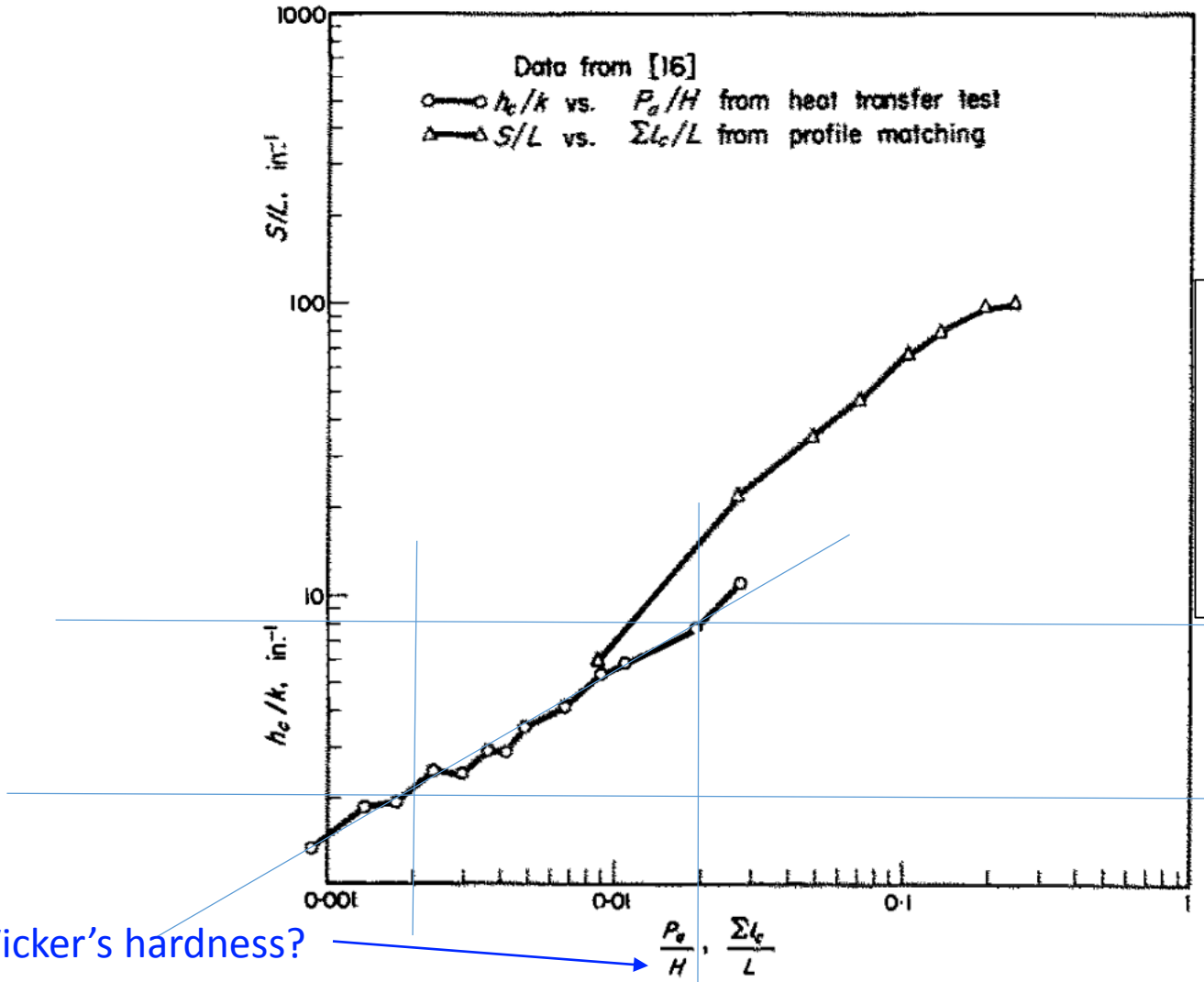


FIG. 8. Comparisons of regions where heat transfer and profile matching data are available.

Source: Cooper et al, Int. J. Heat Mass Transfer Vol 12, p279-300, 1969

These data suggest
h ~ 8 W/m^{2}K
at
P=0.01MPa=1.5psi

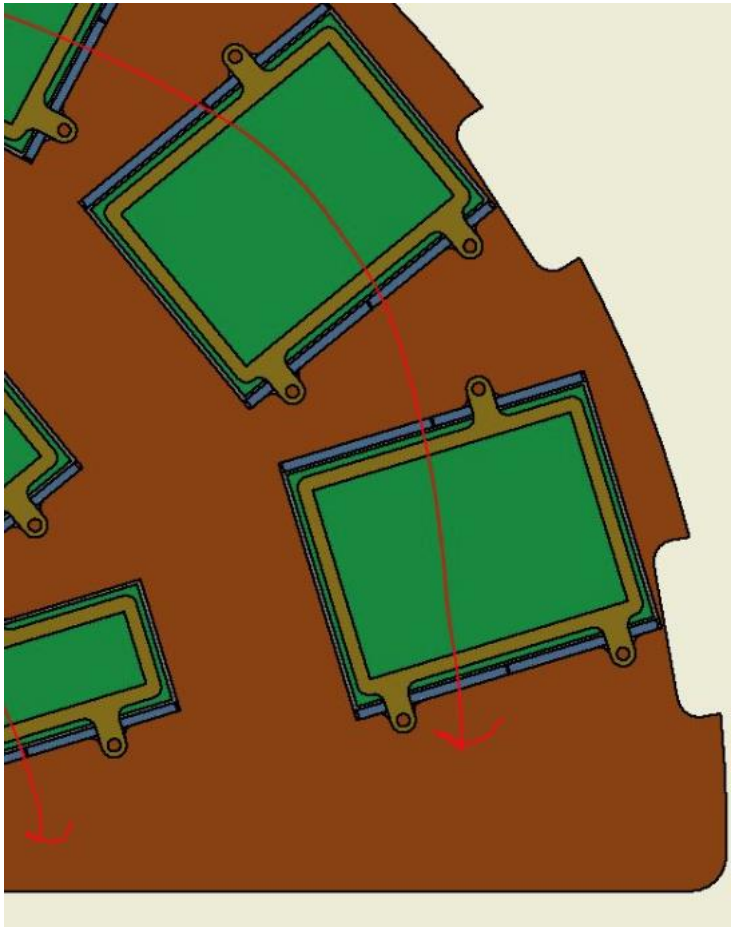
WAY TOO SMALL

H=Vicker's hardness?
for Si: ~ 1GPa

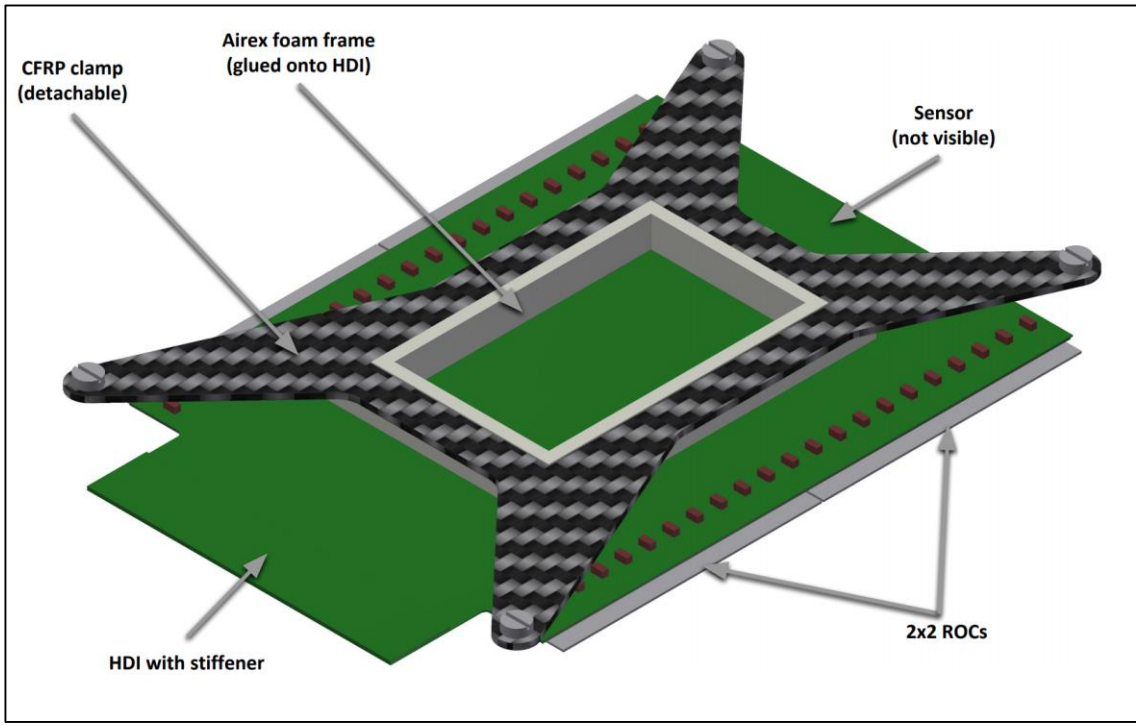
How to push?

Pressure

Yadira's picture frame



TEPX spider



Elephant