Mechanical Structures for Vacuum Insulation Panel (VIP) Cores

Alan Feinerman, CTO, Thermal Conservation Technologies (TCT), and UIC, ECE Department

Tomas Juocepis, Ravi Patel, and Prateek Gupta, Scientist, TCT

Tatjana Dankovic, UIC, ECE Department

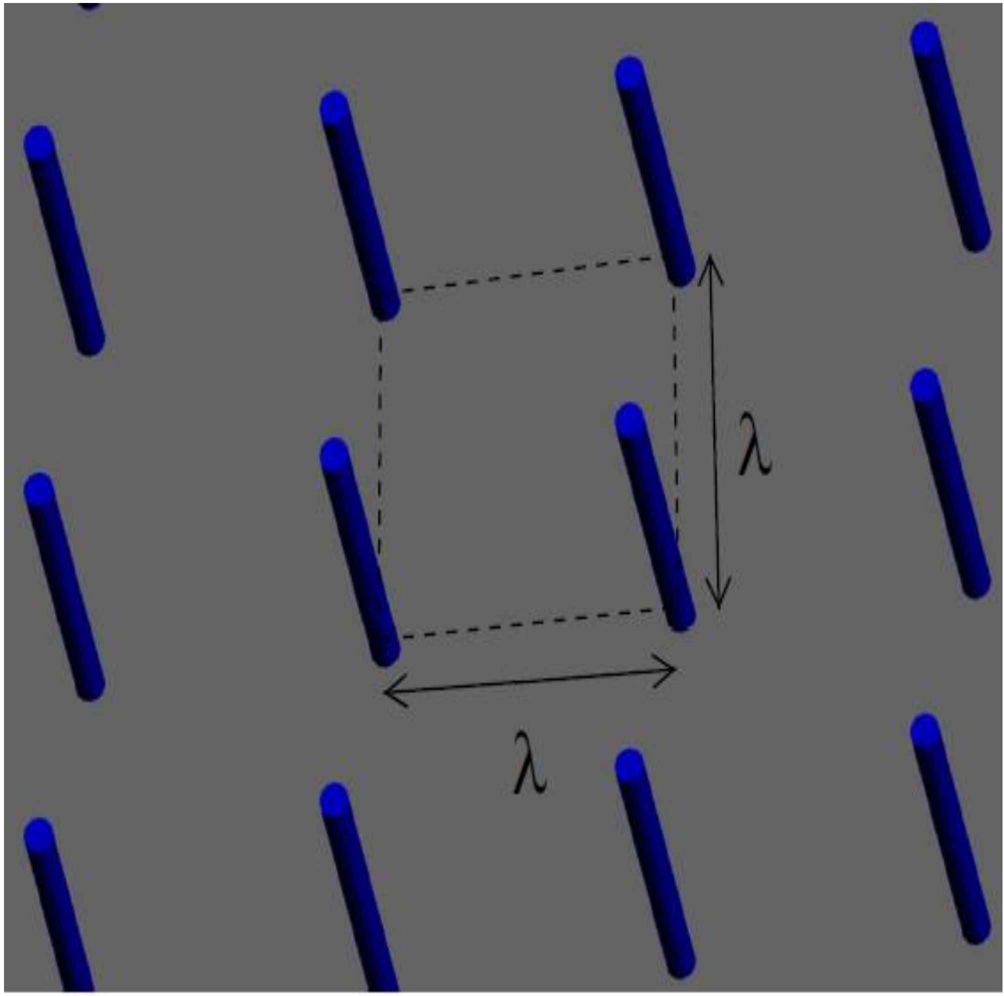
Core Thermal Performance in λ^xλ cell

$$\sigma_{\sup} * A_{\sup} = atm * \lambda^2$$

$$Q_{fs} = \kappa_{fs} * \lambda^2 * \nabla T$$

$$Q_{\sup} = \kappa_{\sup} * A_{\sup} * \nabla T$$

$$\frac{Q_{fs}}{Q_{\sup}} = \left(\frac{\kappa_{fs}}{atm}\right) * \left(\frac{\sigma_{\sup}}{\kappa_{\sup}}\right)$$

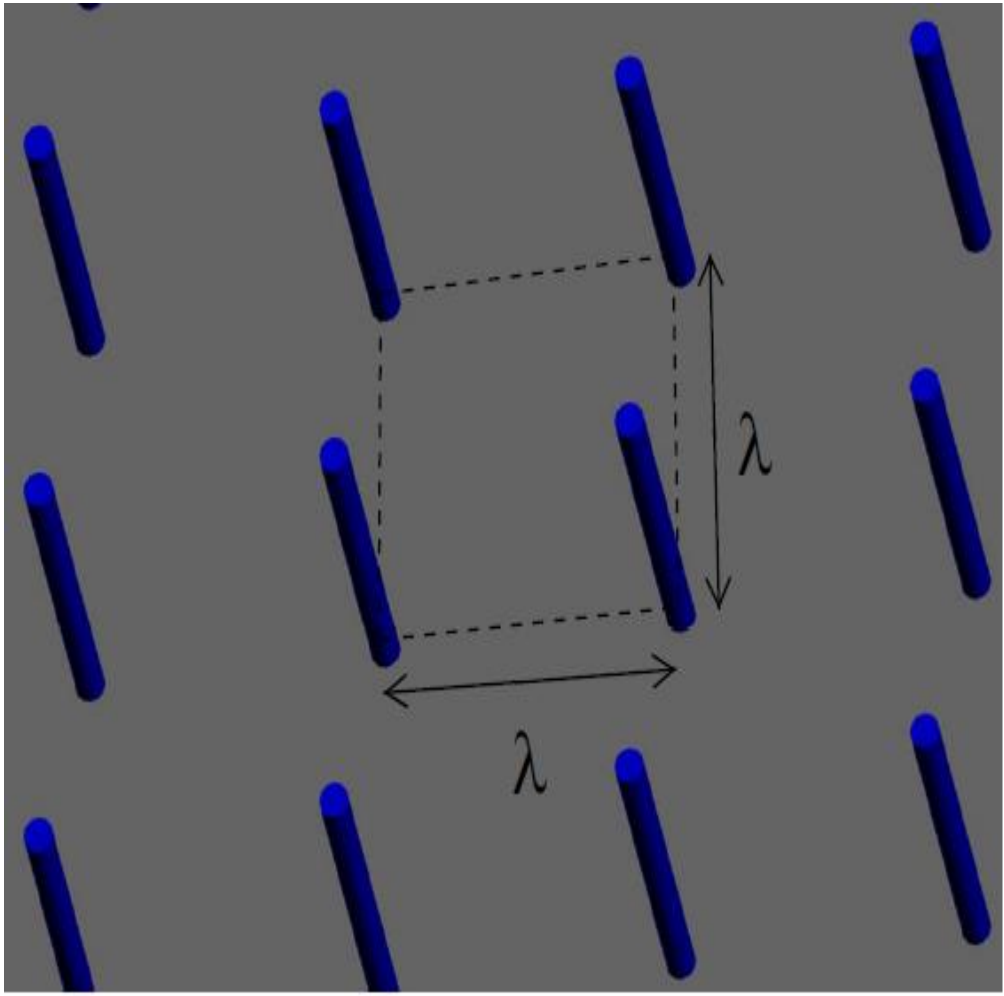


Core Mass in λxλ cell

$$M_{fs} = \rho_{fs} * t_{VIP} * \lambda^2$$

$$M_{\sup} = \rho_{\sup} * A_{\sup} * t_{VIP}$$

$$\frac{M_{fs}}{M_{\sup}} = \left(\frac{\rho_{fs}}{atm}\right) * \left(\frac{\sigma_{\sup}}{\rho_{\sup}}\right)$$



VIP Mass in λxλ cell

$$M_{fs} = \left(\rho_{fs} * t_{VIP} + 2 * \rho_{env} * t_{env}\right) * \lambda^2$$

$$M_{\sup} = \rho_{\sup} * A_{\sup} * t_{VIP} + 2 * \rho_{env} * t_{env} * \lambda^2$$

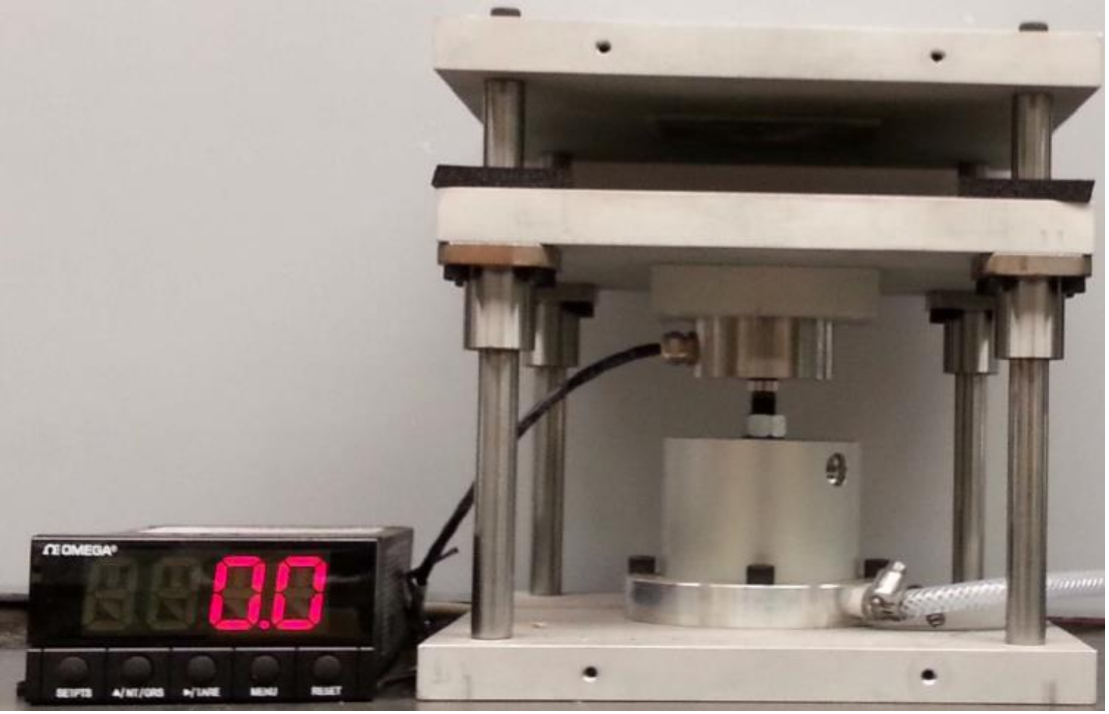
$$\frac{M_{fs}}{M_{\sup}} = \frac{\left(\rho_{fs} * t_{VIP} + 2 * \rho_{env} * t_{env}\right) * \lambda^2}{\rho_{\sup} * A_{\sup} * t_{VIP} + 2 * \rho_{env} * t_{env} * \lambda^2}$$

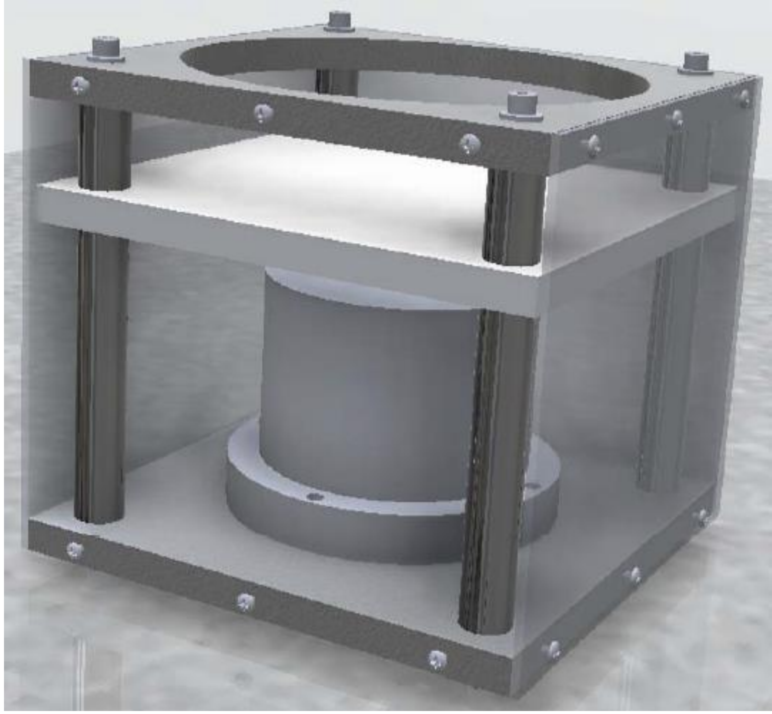
Measure σ_{sup}

Thermal Conservation Technologies

UIC

Measure σ_{sup}






OMEGA
0.3
SETPTS
▲/NT/GRS
▶/TARE
MENU
RESET

Results

	FS	Glass	SS	Ti 3-2.5
σ_{sup}, Pa	$1.0*10^5$	$50*10^6$	$965*10^6$	$965*10^6$
κ_{sup}, W/(m*K)	0.0025	1.1	16	7.8
ρ_{sup}, kg/m^3	150	2230	8000	4510
$\sigma_{sup}/\kappa_{sup}$	$4.0*10^7$	$4.5*10^7$	$6.0*10^7$	$1.2*10^8$
σ_{sup}/ρ_{sup}	$6.7*10^2$	$2.2*10^4$	$1.2*10^5$	$2.1*10^5$

Problem: thermal insulation is either cheap but wastes space, or expensive and doesn't last. heat flow/area = ΔT/(R value)

1" of Insulation	R value	lb/ft²	$/ft²	Lifetime	Exterior
Basotect UL	4	0.03	~$3	>25 years	Unfaced
VIP fumed silica core	50	0.83	$3.00	5 years	Metallized polymer
VIP fumed silica core	**50**	**0.96**	**$3.50**	**50 years**	**Stainless steel**
VIP mechanical core	**86**	**0.18**	**$1.75**	**50 years**	**Stainless steel**
VIP mechanical core	**175**	**0.10**	**$22.50**	**50 years**	**Titanium alloy**

- VIP is a Vacuum Insulation Panel, i.e. thermos
- VIP with solid core improves R value by $\kappa_{\text{fumed silica}} / \kappa_{\text{core}}$
- UIC mechanical core, additional improvement by $\sigma_{\text{core}} / P_{\text{atmosphere}}$
- US patents #7,968,159 & 8,475,893 issued to UIC on 6/2011, and 7/2013
- NSF SBIR I & IB for 2011, phase II, fellowship, IIC, & REU for 2012-14

Conclusions

- Mechanical support can improve thermal performance and lower mass of VIP core.
- We developed a compact instrument to measure large loads to evaluate maximum stress structure can support.
- A mechanical support requires a metal envelope that can increase VIP weight over a metallized polymer film unless using a 0.025mm thick Titanium alloy.

Acknowledgements

This study was sponsored by Thermal Conservation Technologies with support from NSF Phase II SBIR #1230294 and Clean Energy Trust "2011 Business Concept Award." Dr. Alan Feinerman is the majority owner of Thermal Conservation Technologies.

www.nsf.gov/awardsearch/showAward.do?AwardNumber=1230294