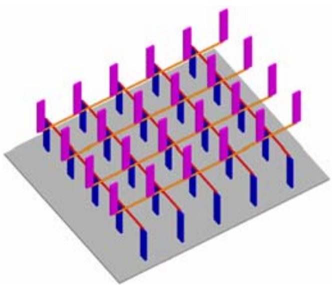
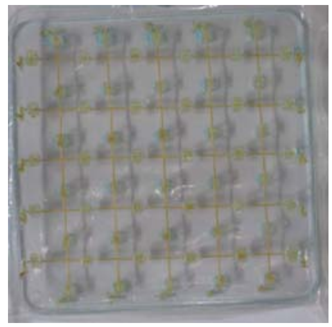
Ultra-low thermal conductivity insulation

Research is underway on designing, fabricating, and testing vacuum insulation panels (VIP) with supporting elements under tension instead of compression. Thermal analysis has indicated that the reduction in thermal conduction through a VIP is given by $\frac{\kappa_{air} * \sigma_{\max}}{\kappa_{filament} * P_o}$ or $\frac{\kappa_{air} * C_{\max}}{\kappa_{column} * P_o}$ with periodic tensile or compressive elements respectively, where κ_{air}, κ_{filament}, κ_{column}, are the thermal conductivity of air, filament, or column, and P_o, σ_{max}, and C_{max}, are the atmospheric load (10^5 Pa), maximum tensile stress, or maximum compressive stress. Tensile structures are predicted to



3D view of a tensile VIP. The structure consists of an upper and lower support plate separated by an array of vertical supports. Between the supports are thermally insulating filaments.



VIP prototype made from acrylic with Kevlar filaments. Structure was placed inside a bag and evacuated. Corners are rounded on plates to minimize stress on bag.

have a much greater reduction in thermal conductivity since they have fewer failure mechanisms than compressive elements (e.g. can't buckle or wrinkle), and some materials have exceptionally high breaking strength and low thermal conductivity.[37-38] As an example Kevlar filaments break at 3 GPa and have a thermal conductivity of 0.04 W/(m*^{o}K)[39] compared to GE Plastics Ultem with a maximum compressive strength of 150 MPa and a thermal conductivity of 0.12 W/(m*^{o}K).[40] A conceptual design and a prototype of the structure are shown above. Specific tasks of the REU fellows include fabricating transparent VIP structures using tensile supports in acrylic and glass, as well as modeling and measuring their thermal performance.

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37. A. Feinerman,,"Thermal Conductivity Insulation," University of Illinois at Chicago patent filed 3/15/07.
38. A.D. Feinerman, R. Lajos, V. Sood, and R.J. Carlton, Vacuum Insulation Panels with Supporting Elements in Tension, Proceedings of the 29th International Thermal Conductivity Conference and the 17th International Thermal Expansion Symposium, Birmingham, Alabama, June 24-27, 2007 (under review).
39. http://www.matweb.com/search/SpecificMaterial.asp?bassnum=PDUKEV29
40. http://www.matweb.com/search/SpecificMaterial.asp?bassnum=P1SM50