

Sustaining Through Innovation

a personnel perspective

Funding and support are vital to enable new innovative companies to take ideas from concept to reality
EPSCoR, as well as UVM & VTSBDC play a vital role and have assisted me in the development of three companies

Sustaining Through Innovation

- EPSCoR ,UVM & VTSBDC provided valuable support & technical expertise



- XC Associates
 - EPSCoR
 - “High thermal conductivity carbon fibers”
 - » Commercialization & Job Creation

THERMAL COMPOSITES

- Thermal Composites
 - EPSCoR
 - “High thermal conductivity heat spreaders using nanotubes embedded in carbon silicon carbide”
 - » Early stage development

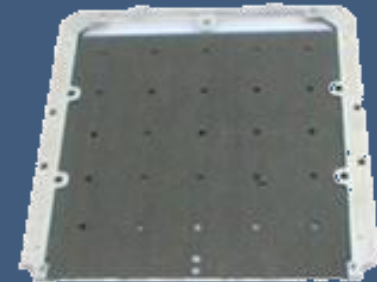
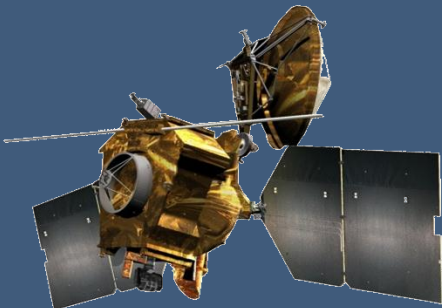
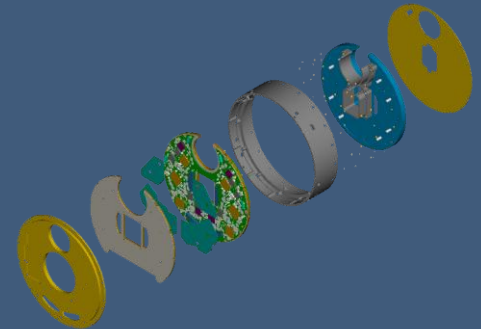


- Renewable Energy Resources
 - Working with VTSBDC, VSJF &
 - expect to work with UVM in future
 - » EPSCoR grants
 - Riparian barriers
 - Solve special combustion issues

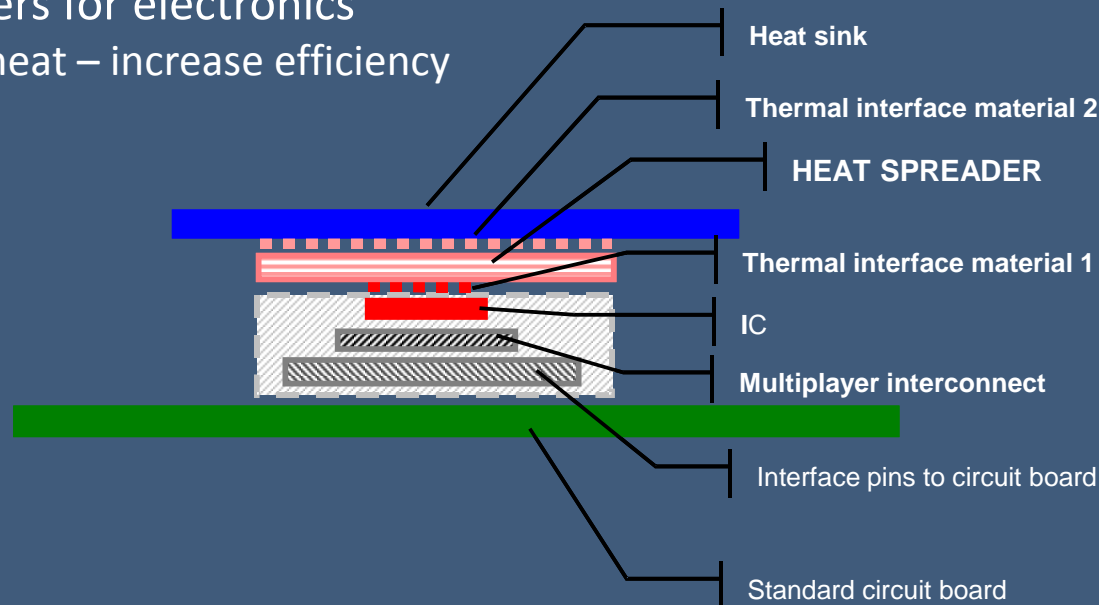
EPSCoR (2001)



- “High thermal conductivity carbon fibers”
 - Elementary modeling to demonstrate concept
- Applications
 - Lightweight high thermal conductivity heat sinks
 - 5xSBIR’s phase I & II
 - Missile Defense Agency, NASA, Navy
- Commercialization & Job Creation



- “High thermal conductivity heat spreaders using nanotubes embedded in carbon silicon carbide”
 - Build a high thermal conductivity material
 - $K > 1000 \text{ w/m/K}$
 - To be achieved by adding carbon nanotubes to silicon carbide matrix
- Application
 - Heat spreaders for electronics
 - Remove heat – increase efficiency



Background

THERMAL COMPOSITES

- Carbon nanotubes have very high thermal conductivities
 - 3000 w/m/K for multi wall (MWNT) and
 - 6600 w/m/K for single wall (SWNT)
 - » Stainless steel \approx 25, Aluminum 180, Copper \approx 350
- Prior work
 - Adding nanotubes to typical epoxy or polyimide matrixes has resulted in disappointing improvement to thermal conductivity
 - $K \approx 0.5\text{-}2.0$ w/m/K
 - this is well below expectations
- Goal
 - Thermal conductivity ≈ 1000 w/m/K

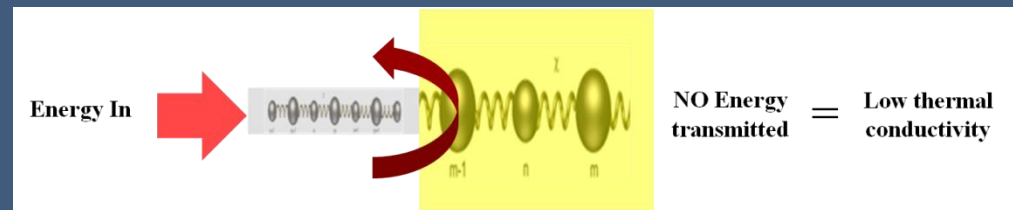
Hypothesis

THERMAL COMPOSITES

- Thermal energy in nanotubes is transmitted by phonons (vibrations)
 - In order to transmit thermal energy through a matrix loaded with nanotubes, the stiffness of matrix must be similar to the nanotube



Stiffness mismatch = No energy transmitted



Stiffness match = energy transmitted



Thermal Results

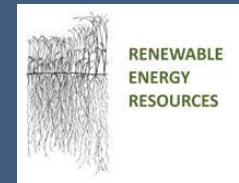
THERMAL COMPOSITES

- Initial measurements indicate thermal conductivity in order of 150 w/m/K
 - Much lower than expected due to excessive porosity of matrix
 - Small sample.
- Ongoing
 - Re-measuring and confirm measurements
 - Modify matrix cure to reduce porosity
 - Build new samples based on very slow cure
- Conclusion
 - Based on the level of porosity observed we are greatly encouraged by the high thermal conductivity we measured and believe that with ongoing efforts we achieve the target thermal conductivity

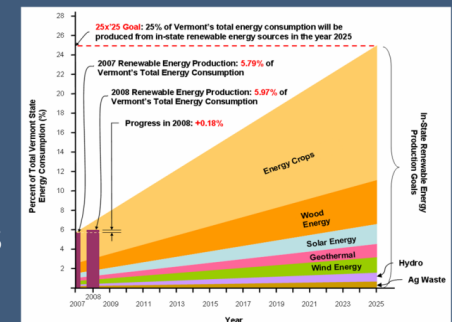
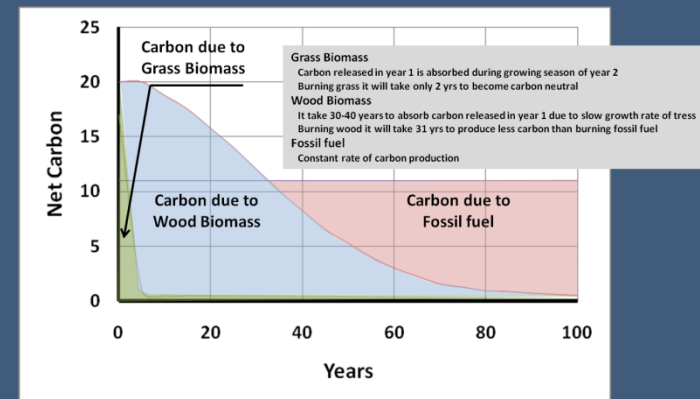
Next Steps

- EPSCoR funding is relatively small only allows one approach to be explored
 - Initial work indicates that the approach described has the potential to develop a high thermal conductivity material
- SBIR phase I submitted to NSF funding
 - Proposal rated as “good” but not funded
 - “Need more basic mathematical analysis to substantiate hypothesis”
 - Valuable help from VTSBDC
- Future
 - Looking for additional funding
 - Some additional work is being carried out Surrey University, UK
 - Blue Sky Nano
 - Early stage negotiations with US & UK companies to continue work

Renewable Energy Resources



- To provide crop biomass for heating applications
- Work with customers to provide long term fuel plans
 - In-house expertise
 - Strategic alliances
 - Growers/harvesters
 - Boiler manufacturers
- Business Plan
 - Market development
 - Operate mobile briquetting
 - Service several towns
 - Travel to local area
 - Operate many mobile machines
 - Mature market
 - Once demand exceeds 8,000 tons/yr within 30 mile radius
 - Set up fixed base processing plant
 - Set up many fixed based plants



Business Development



- Raising capital
 - Investors
 - Grants
 - VSJF
 - EPSCoR, SBIR, USDA, etc.
- Developing relationships
 - VTSBDC, UVM,.....
- Received first orders
 - Benton school,
 - Hospital, College Campus, Electrical Generation
- Future
 - Looks good
 - Growth
 - Jobs



Concluding Remarks

Vermont is fortunate to have organizations that help
entrepreneurs and innovators bring ideas from
concept to reality

My thanks to
EPSCoR, UVM, VTSBDC, VSJF

- Something to think about
 - Innovation is great!
 - Company growth and retention in Vermont is important
 - Particularly in Southern Vermont