COE CST First Annual Technical Meeting:

FCAAP Overview

F. S. Alvi (FSU)
J. Kapat (UCF)
N. Fitz-Coy (UF)

Outline

- **FCAAP Overview**
  - Background
  - Capabilities, Resources, Facilities
- **Projects & Research**
  - Current
  - Potential
- **Lunch**

FCAAP Background

- **Established through a competitive program in late 2008**
  - **Florida Legislature: "The 21st Century Technology, Research, and Scholarship Enhancement Act"**

- ***"Centers of Excellence to give Florida …. leadership in key emerging technology areas*** **with …potential for** ***economic and societal*** **impact in the years to come"**

- **The only state-wide, multi-university, SUS Center of Excellence in Aerospace, Propulsion and related areas… in Florida**

- **To develop** ***innovative technologies*** **for the** ***next generation*** **of air and spacecraft and related areas (energy, power generation), in collaboration with** ***industry and government***

FCAAP Team

FCAAP
FLORIDA CENTER FOR ADVANCED AERO-PROPULSION
TECHNOLOGIES FOR THE NEXT GENERATION

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FCAAP

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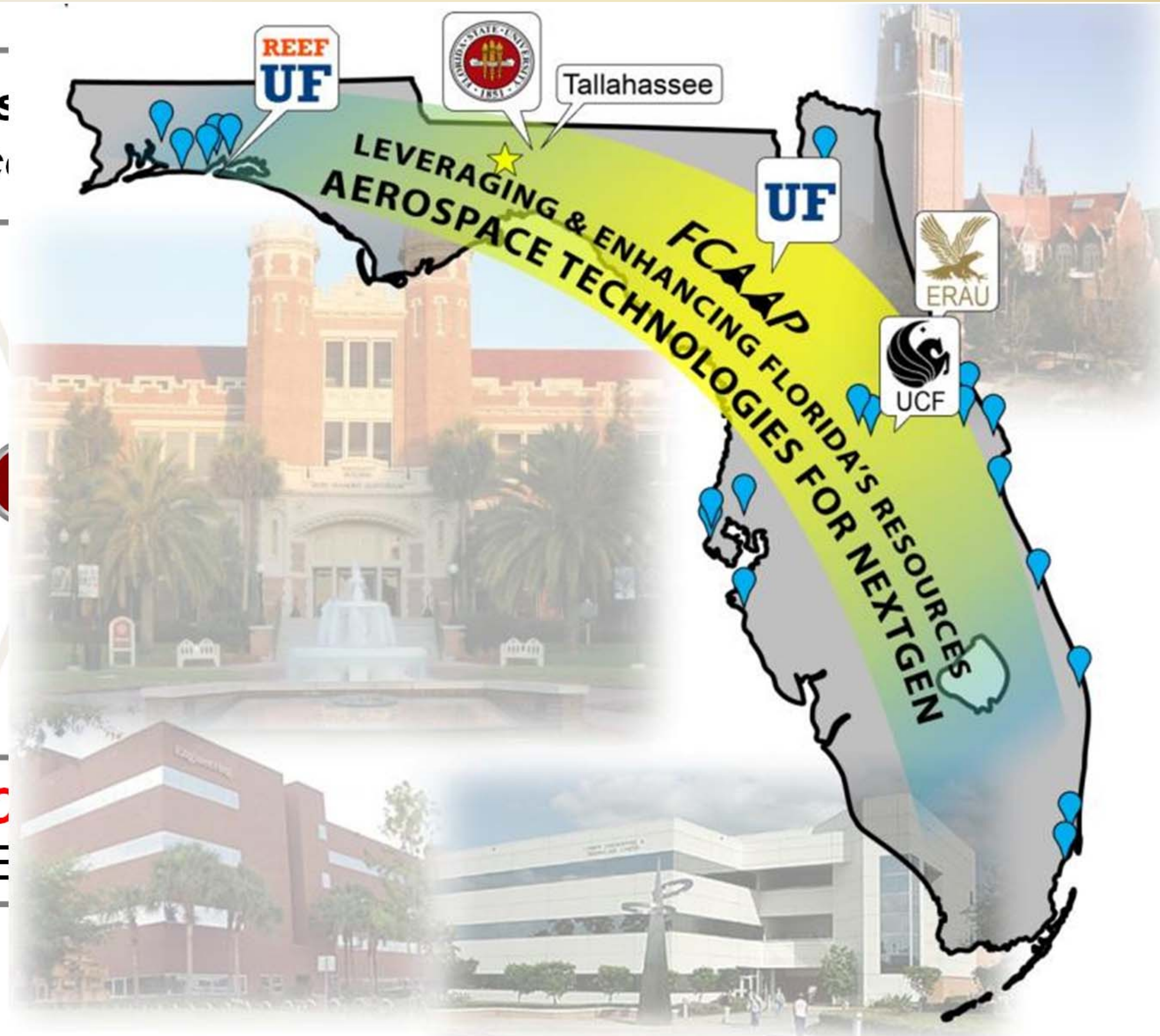

MS & PhD: > 80%

Research Areas/Expertise

- ***Experimental Fluid Dynamics***
  - ***Aerodynamics, Gas Dynamics, Aeroacoustics***
- ***Thermal Management***
- ***Advanced Diagnostics***
- ***Active Flow and Noise Control***
- ***Modeling: Low Order, Stochastic***
- ***High Performance Computing***
- ***System Design & Control***
- ***Jet & Rocket Noise and its Control***
- ***Advanced Turbomachinery: Design & Development Tools***
- ***Sensors & Actuators: Design, Fabrication & Implementation***
- ***Advanced/Smart Materials***
- ***and much much more…***

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Our Brains

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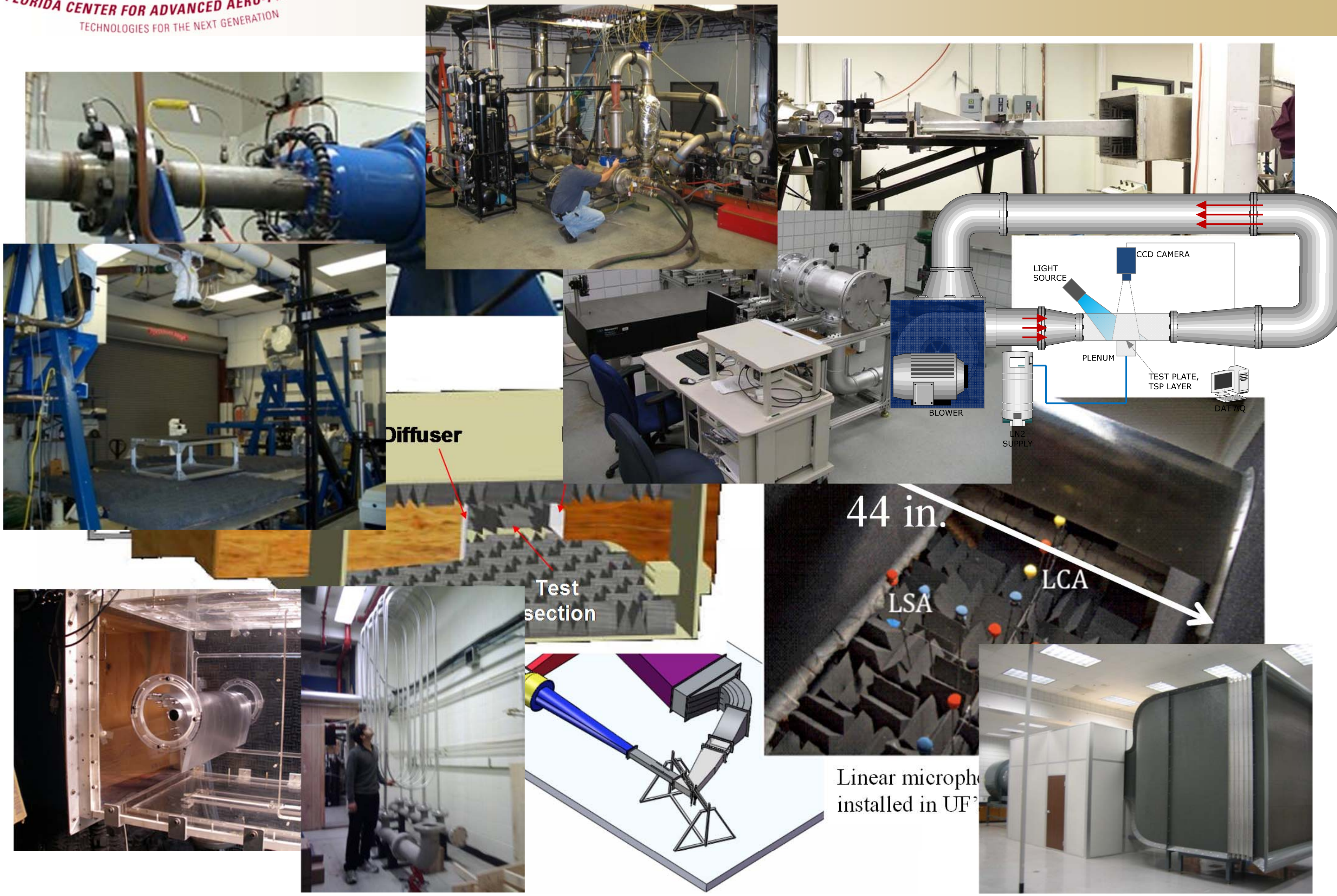
Physical Resources/Facilities



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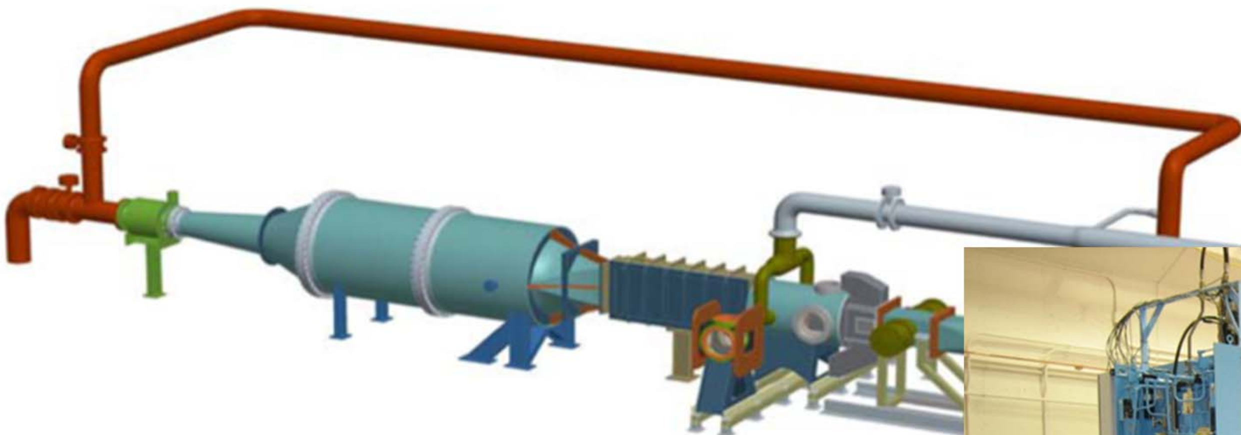
AME Research Building

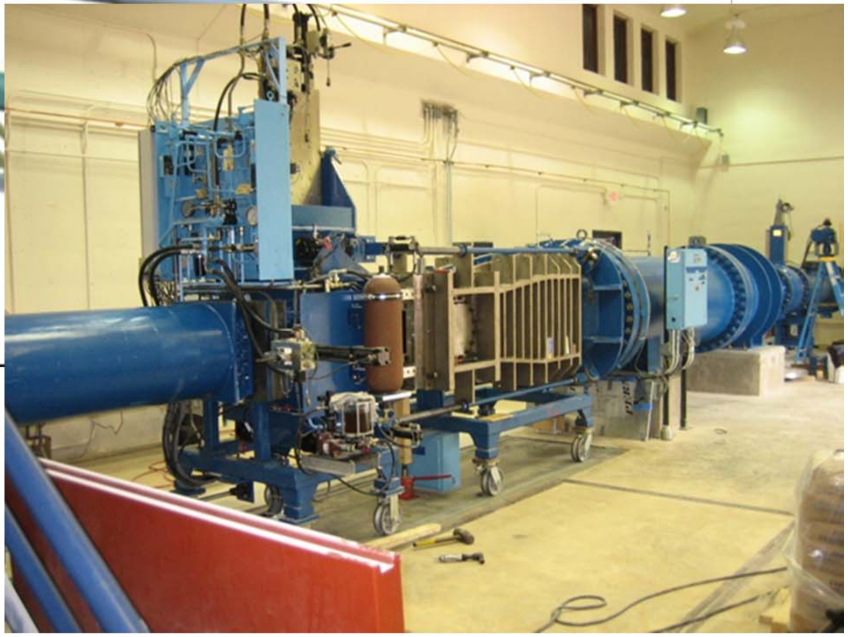
A New FCAAP Facility

~ $25 + million, 60,000 + sf, Multidisciplinary Research Center

Polysonic Wind Tunnel

Next Generation Polysonic Facility for Transformative Active Control Technologies & Non-Intrusive Flow



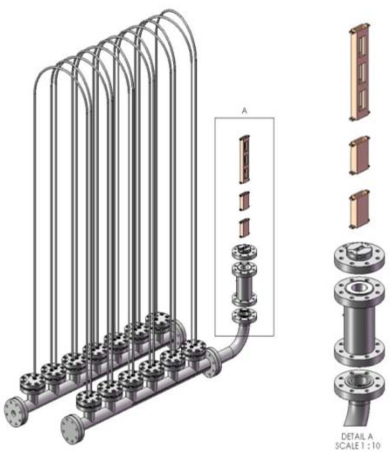


- ***Mach No. : 0.2 to 5.0***
  including Transonic regime
- *Test Section Size: 12" x 12" Square cross-section*
- *Variable Re #:*
- *Typical Run Time: 60 sec.*
- *Optical access on three sides*
- *Excellent Flow Quality*

Facilities

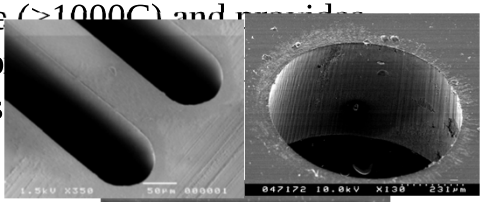
Non-vitiated (clean air), continuous operation, high-enthalpy, facility

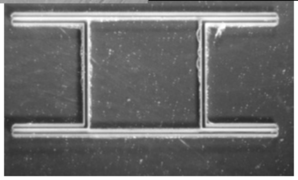
- electrically operated, first stage heater with maximum temperature of 1300K (1880F)
- a second, water injection/high-enthalpy heating stage with a continuous, **maximum operating temperature of 1800K** (2780F).
- **Mach 6.5 flight** enthalpy **simulation**.



Laser Micromachining of Materials for High Temperature MEMS-based Sensors

- Goal: To produce miniature, **robust mechanical sensors for high-temperature applications**.
- Approach: Develop process for laser micromachining of sapphire to facilitate use of optical transduction schemes
- Payoff: Enables measurements in environments that





Laser and machined sapphire samples

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Our Partners & Sponsors

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH · UNITED STATES AIR FORCE
AIR FORCE RESEARCH LABORATORY
BOEING
Gulfstream A GENERAL DYNAMICS COMPANY
LOCKHEED MARTIN
GE imagination at work
ONR Office of Naval Research
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Pratt & Whitney A United Technologies Company
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CRAFT Tech
freescale semiconductor
THE JOHNS HOPKINS UNIVERSITY
AVAGO TECHNOLOGIES
Danfoss TURBOCOR
NM STATE UNIVERSITY
SPACE FLORIDA
ETREMA PRODUCTS, INC
Spectral Energies, LLC

Current FAA-COE Projects

- **241** - High Temp Pressure Transducers

(Oates– FSU; Sheplak - UF)

- **244** - Autonomous RDV & Docking for Space Debris Mitigation

(Collins – FSU; Fitz-Coy – UF, *Axelrad – CU; Rock - SU*)

- **253** - Ultra High Temp Composites

(UCF – Gou, Kapat)

COE-CST Related Research Ongoing & Future

COE-CST Related Activities

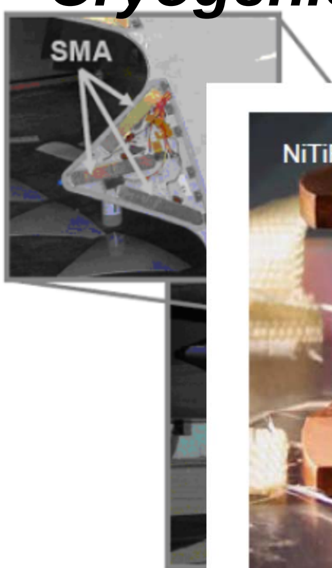
- ***ASTREC***: *Advanced Space Technologies Research & Engineering Center* - An NSF I/UCRC to promote advancements in the principles and technologies of responsive, cost efficient spacecraft systems
- **JOSS:** *Journal of Small Satellites* (online peer reviewed journal)
- **EdUCE Workshop:** (Educate Using CubeSat Experience – NSF RET) Hosted workshop for high school teachers to introduce/implement STEM principles using CubeSats.
- **DebriSat:** Design and fabrication of a micro class satellite subjected to hypervelocity impact to emulate an on-orbit collision. Debris fragments will be used to improve the *NASA standard breakup model*. (NASA Orbital Debris Programs Office JSC)
- **Microscale Sensors for Hypersonic Flow:** NASA SBIR Phase I – (with Interdisciplinary Consulting Corporation) Phase II in review

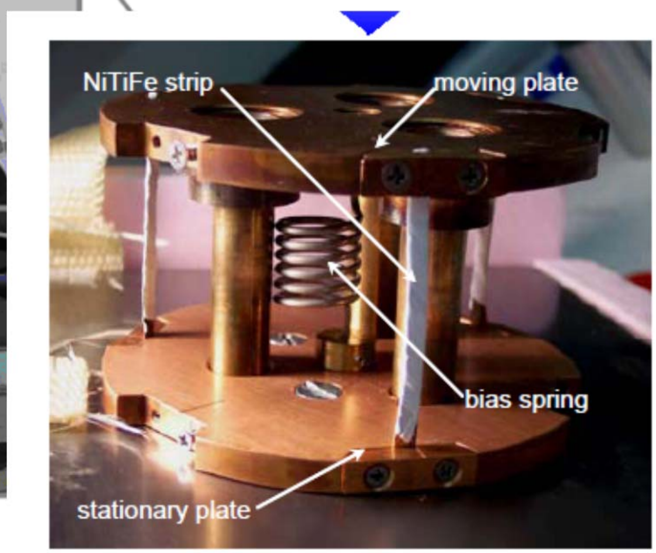
Shape Memory Alloys

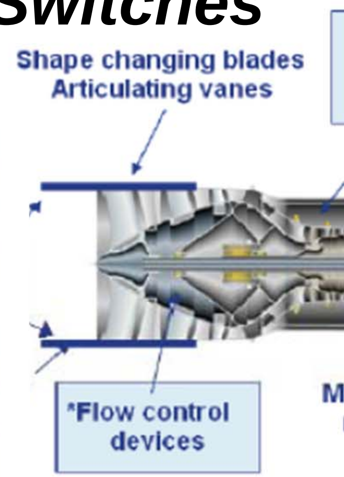
Variable Geometry Chevrons

Higher Transformation Temp. SMAs

Cryogenic Temp. Thermal Switches







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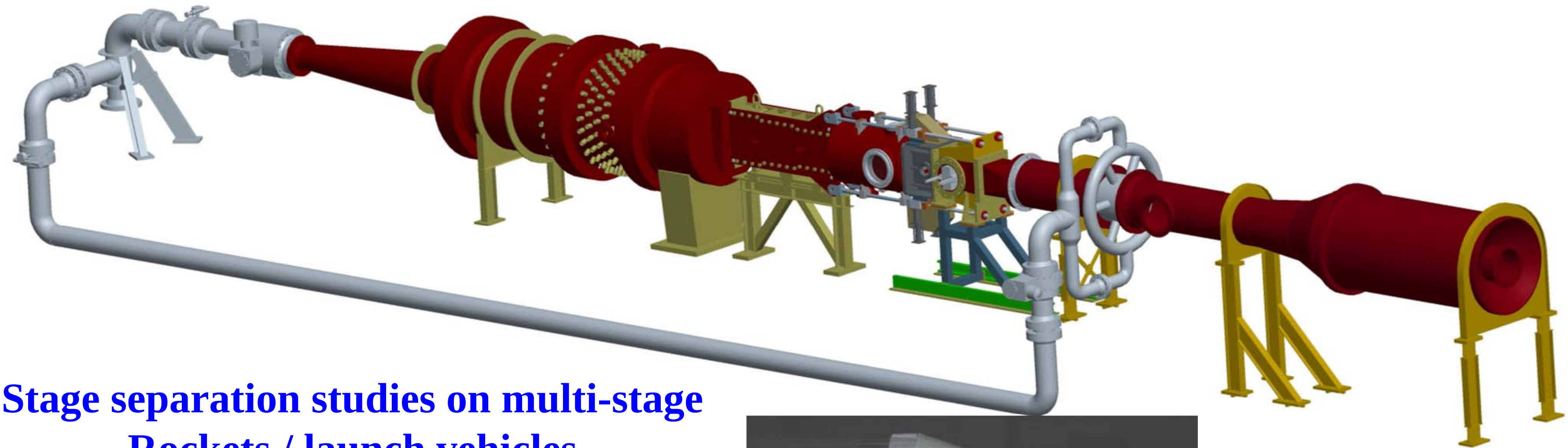
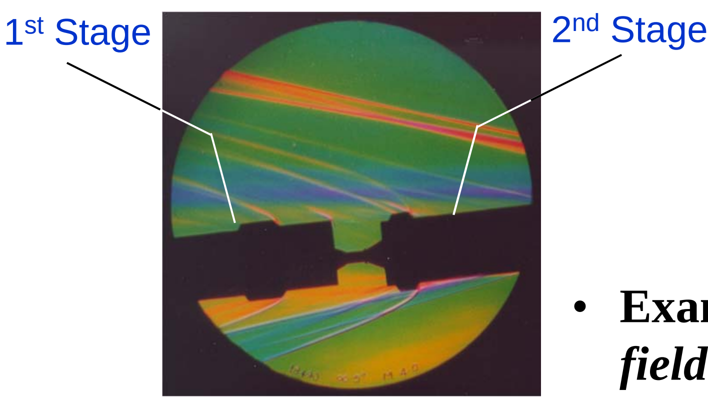
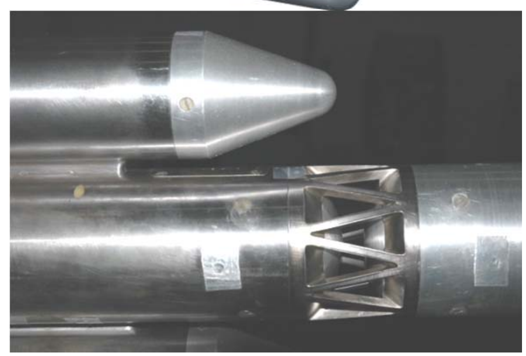
Heat Pipe Type Thermal Switch

Supersonic Wind tunnel Studies



Stage separation studies on multi-stage Rockets / launch vehicles

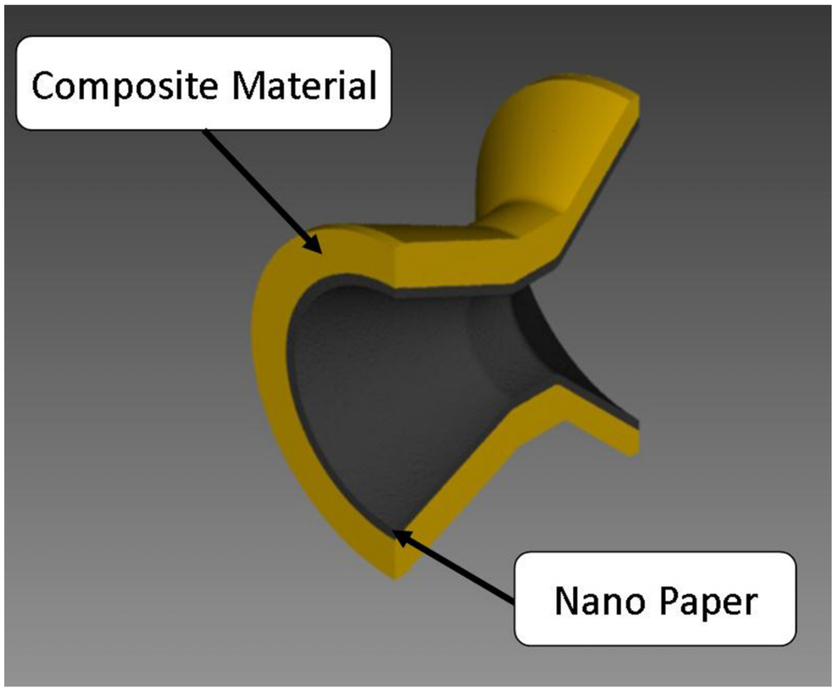




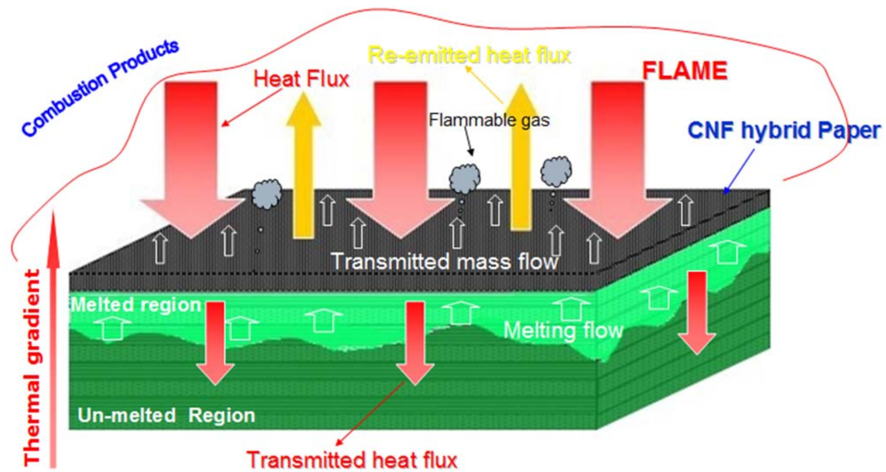
- **Examine and understand the *complex interference flow field* between two separating stages of multi-stage vehicles**
- **Measurement of *forces, moments and surface pressures* on separated stage**

Nanocomposite Based Ablative Thermal Protection System

- Conducting heat in one direction, along the alignment of the nanotubes, but reflecting heat at right angles to the nanotubes
- Anisotropy of thermal conductivity of nanopaper: in-plane and through-thickness direction



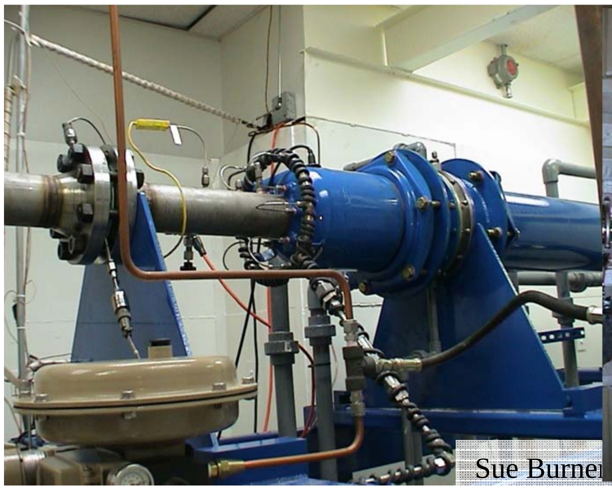
Nanocomposite Nozzle of Solid Rocket Motor

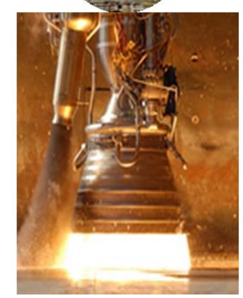


Ablation Performance of Nanopaper

- Permeability of the nanopaper
- Thermal stability of nanoparticles used
- Dispersion of nanoparticles
- Quality of char formation
- Heat capacity and thermal conductivity

Supersonic Jet Impingement





Vehicle Design, Flight Safety: Propulsion Systems: Analyses, Computations & Testing

Operational/Test Capabilities
- ***Mach Number = 0.5 - 2.5***
- ***T_o= 70 - 2000 F***
- ***D_{Jet} = 25.4 – 76.2 mm***
- ***NPR = Under-ideal-over expanded***
- ***Run duration = 15 min – 20 min***
- ***Anechoic chamber: 5.8 m x 5.2 m x 4.0 m Calibrated to 100 Hz***

Launch Systems – Study and **Control** the extreme, highly unsteady launch environment due to rocket plume impingement.

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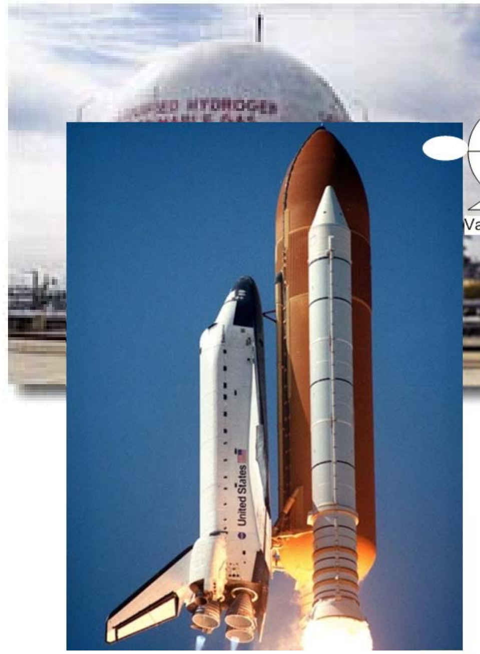
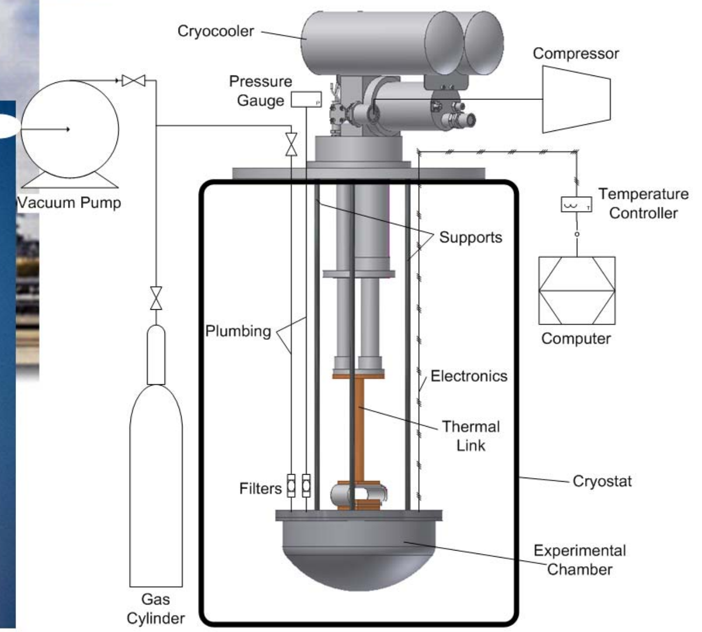
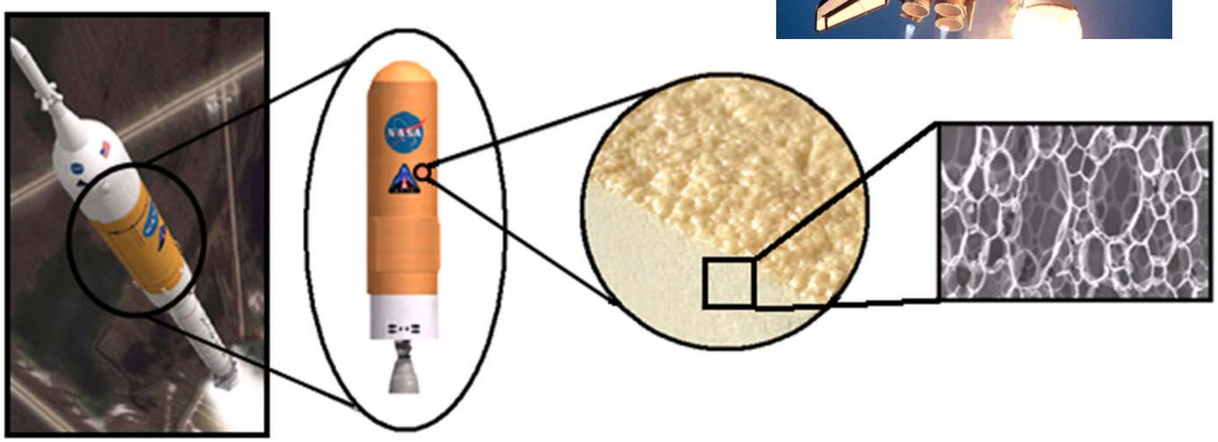
Cryogenic Insulation Materials For Aerospace Vehicles

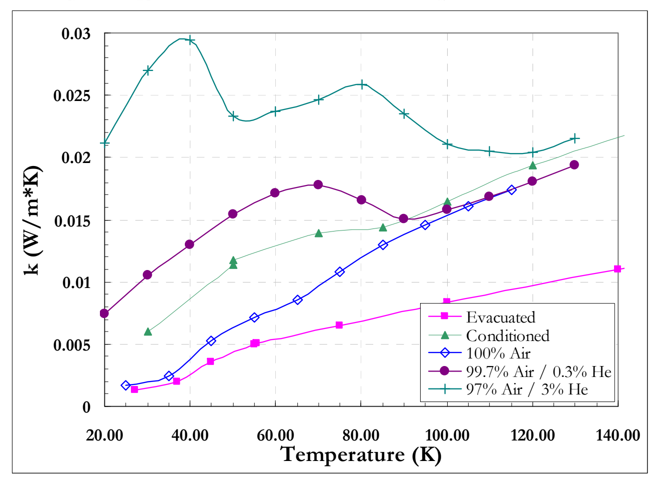
Motivation

- Cryogenic fuel storage
- Aerospace applications
- Ground and vehicle systems





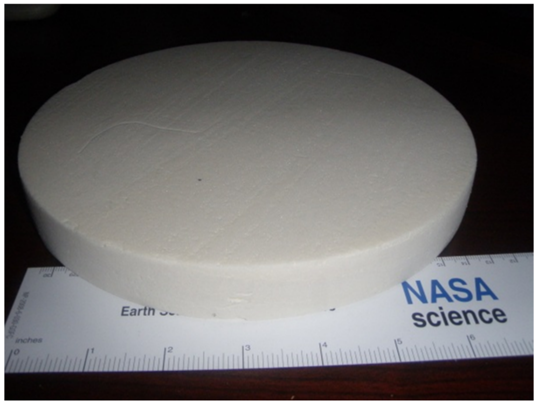




Proposed Activities for 2012

Challenge: Thermal conductivity of porous media cannot be measured directly. Dependent on gas type, pressure, temperature, contact force...

Goal: Determine effective thermal conductivity of different materials while measuring and/or controlling the above factors



Solid Foam Insulations

Powder Insulations

Multi-Layered Insulations (MLI)

Next COE-CST Meeting
THIRD FCAAP SYMPOSIUM

Late April 2012
HOLD THE DATE!

Additional slides

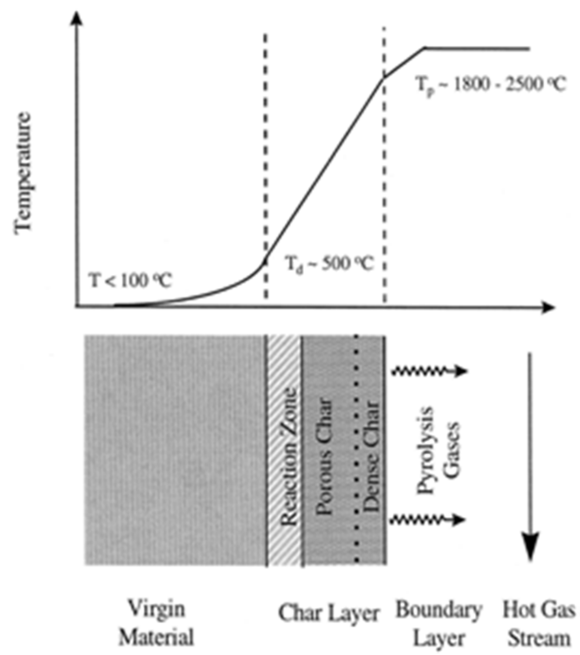
Ultra High Temperature Composites for Thermal Protection Systems

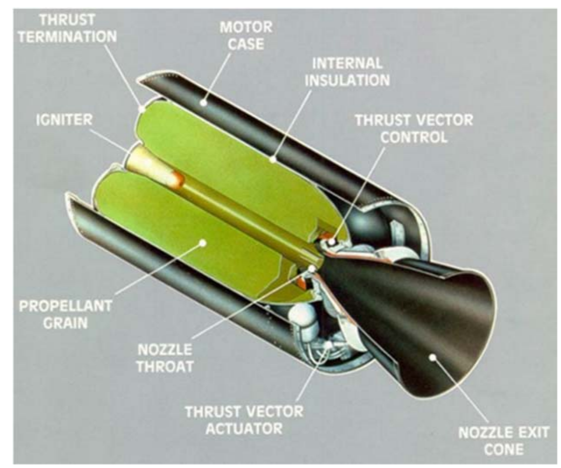
Objective

To develop ultra high temperature light weight composites with embedded health monitoring for **inherent safety** and **real-time assessment** of thermal protection system applications in hypersonic space vehicles

Goals

- Ablatives materials against solid rocket exhaust plumes at 3,600^{o}C with Al_2O_3 at very high velocity (>Mach 1)
- Less ablative weight for current rockets and/or higher power rocket motors within current ablative performance envelopes



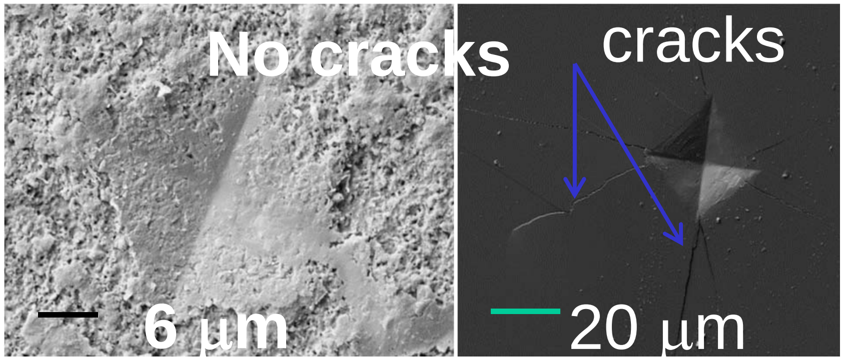


High Temperature Pressure Sensors for Hypersonic Vehicles

- Purpose
  - Design, fabricate, and characterize a robust, high-bandwidth micromachined pressure sensor for harsh environments
- Objectives
  - Develop laser micromachining processes for patterning of structures in sapphire and alumina
  - Develop bonding process to for fabrication of multi-wafer sensors
- Goals
  - Sensor operation in temperatures >1000°C
  - Large operational frequency range (>10 kHz)

Fracture Mechanics of Sapphire: High Temperature Sensor Applications

- Commercial presssure sensors capable of ~500℃
- Sapphire based sensors can potentially **extend temperature** range to **~1500℃**
- Research Goal: Understand **material failure** as a function of **manufacturing processes** and **temperature**
- Objective: Quantify anisotropic **fracture** as a function of **laser micromachining**
- Observations**:** Laser micromachining **mitigates** surface **fracture**



Laser machined surface　　Virgin specimen

Fast Trajectory Planning for Autonomous Rendezvous and Docking

Motivation:

- A recent study by NASA identifies a minimum of at least five debris removal missions per year beginning in 2015 is required to maintain (not reduce!) the current population of space debris.
- One approach to space debris mitigation is the development of an autonomous "Space Tow Truck" capability for direct removal of aged or disabled spacecraft.
- This research considers ***fast trajectory generation for autonomous rendezvous between a space tow truck and a debris***

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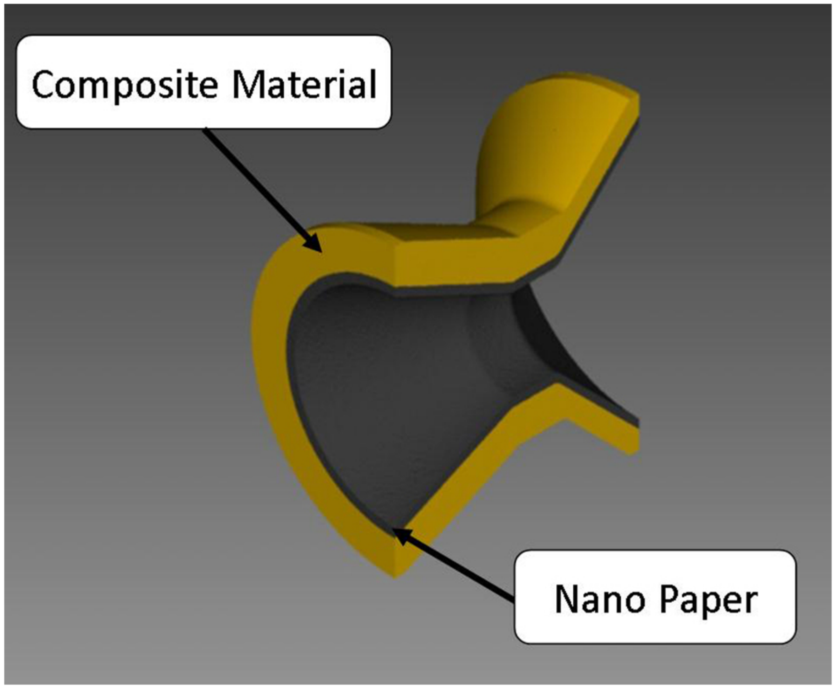

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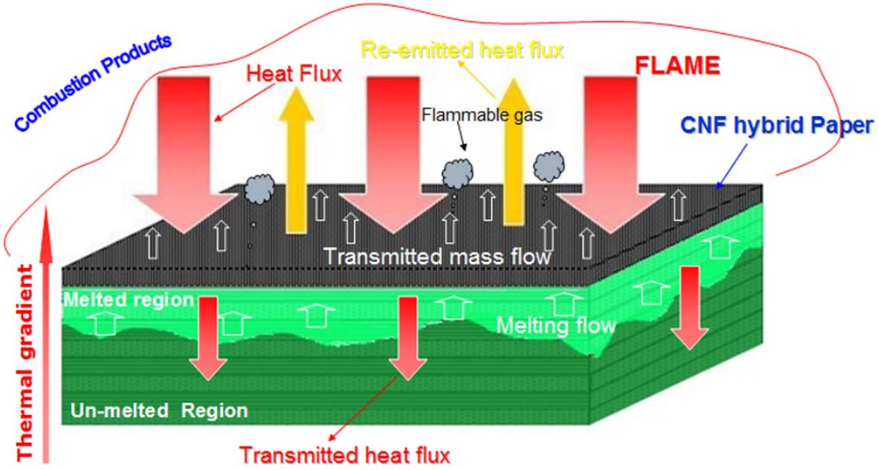

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