Center for Composite Materials (CCM)

- Founded in 1974, CCM is an internationally recognized interdisciplinary center of excellence for composites education and research.
- Three-Part Mission
  - Educate scientists and engineers
  - Conduct basic and applied research
  - Transition technology to industry
- Host to 7 NSF/DoD Centers of Excellence since 1986
- University/industry consortium – more than 3500 small, medium and large companies have benefited from partnerships with CCM.
Composites Manufacturing Science for Reliability and Automation

- Manufacturing simulations are developed to fabricate void-free composites to improve yield, and introduce reliability and automation.
- Simulations are coupled with Design and Optimization Methodologies for Tailored and Lean Manufacturing.

How to get resin and voids into flow pathways to reduce the porosity?

Effective thermal conductivity of composites
Advanced Nanocomposites for Space Lubrication

- Current MoS₂ solid lubricants coatings are poisoned by water → seizure
- UD PTFE nanocomposites: environmentally insensitive, 10,000X reduced wear compared to PTFE
- This and 4 other candidate space lubricants tested outside the ISS
- First/only active MISSE experiment

MISSE 7: Materials International Space Station Experiments

UD PTFE nanocomposite in low earth orbit over 2 years

**Experimental Conditions:**
- average normal force ~ 1N
- pin diameter: 3.125 mm
- sliding speed ~ 13 mm/s
- average Temperature: 18.7°C
- maximum temperature: 39°C
- minimum temperature: -5°C

**Graph:**
- Friction coefficient vs. cycle number (0.00 to 0.30)
Traction-Separation Behavior of Composite Interfaces

- Fiber matrix interface – potential source of energy absorbing mechanism
- Opportunity to tailor interface to achieve optimum composite structural and ballistic performance
- Objective – to develop accurate traction separation behavior of S-glass/epoxy interface at all loading rates at the micromechanical length scale

Stress state of the interface due to residual thermal stresses and during crack propagation

\[
\tau = \frac{F_e}{\pi d L_c}
\]
Multi-Scale Modeling of Kevlar KM2 Tows Subjected to Transverse Impact

- Kevlar flexible textile composites in high velocity impact applications
- Role of fiber transverse properties during impact not well understood
- Objective – to understand fundamental fiber-level mechanisms during impact to establish materials-by-design

Single fiber transverse compression response – nonlinear and inelastic
Cheng, M. et al., International Journal of Solids and Structures, 2004

Tow transverse compression response
Fiber-fiber contact plays a significant role in the spreading and deformation of individual fibers

Tow transverse impact short time scale response – significant transverse compressive strains
Nanotube Composites for Infrastructure Health Monitoring

Collaborators: T. Schumacher and J. McConnell (Civil Engineering)
Bifunctional adhesive conductor (AC) from CNT film is, for the first time, proposed and demonstrated with a higher adhesive strength than the conventional polymer binder (PVDF).

Nanocomposites coupling AC with active materials, e.g., LiMn$_2$O$_4$, exhibit superior electrochemical performance of the Li-ion Batteries.
High Strength and Multifunctional Carbon Nanotube Fibers

**CNT fiber (shown)**
- Diameter: 60 µm, Length: 10 cm
- Tex: 1.4 g/km

**CNTs (SWNT)**
- Length: 10 µm
- Diameter: 1 nm
- Density: 1.33 g/cm³

**Fiber Mass**: 0.14 mg
**Total CNT Volume**: $1.05 \times 10^{-4}$ cm³
**Single CNT Volume**: $7.85 \times 10^{-18}$ cm³

**# of CNTs in the fiber**: ~$10^{13}$

**New Electronic Materials**
- Bendable, stretchable, twistable, deformable
- Small resistance change

**CNT Fiber Characteristics**
- Electrical conductivity
- Flexibility