MEANS-II Bidder's Conference

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MATERIALS ENGINEERING FOR AFFORDABLE NEW SYSTEMS

MISSION

Exploit computational materials science and engineering to develop a design methodology that incorporates models of structure-process-property relationships of materials into engineering design software, enabling materials design to be an integral part of the system design process.

MEANS-I Projects in Polymer Matrix Composites

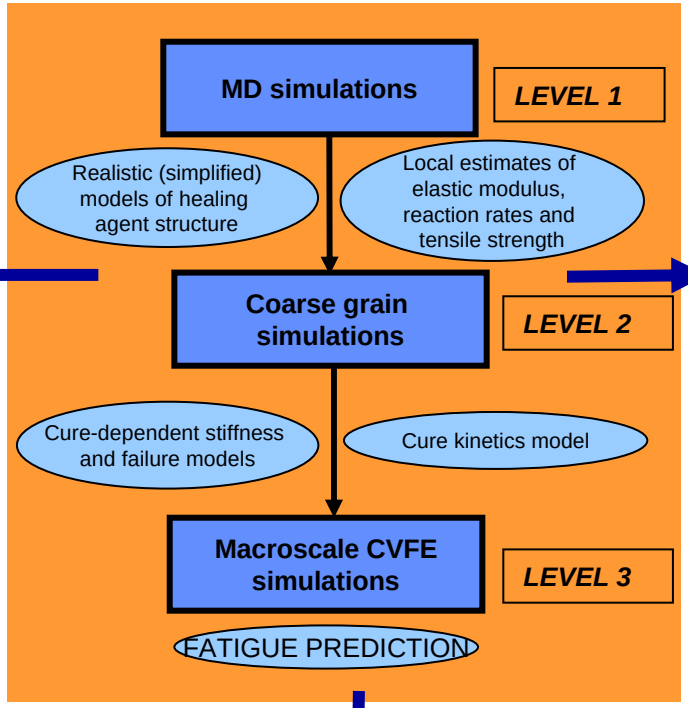
- **MULTISCALE MODELING AND EXPERIMENTS FOR DESIGN OF SELF-HEALING STRUCTURAL COMPOSITE MATERIALS; PI- S. White, UIUC and J. Kieffer, U. Mich.**
- **INFLUENCE OF PREPREG MICROSTRUCTURE OF STRUCTURAL PERFORMANCE OF POLYMER MATRIX COMPOSITES; PI- G. Dillon, Penn State U.**
- **MODEL-BASED DESIGN FOR COMPOSITE MATERIALS FOR LIFE MANAGEMENT; PI- G. Schoeppner, AFRL/ML**
- **CURING OF COMPOSITES: AN INTEGRATED MULTISCALE PROCESS DESCRIPTION TOWARD TAILORED STRUCTURES AND PROPERTIES; PI- R. Pitchumani, U. Conn.**

MULTI-SCALE SIMULATION
(*U Ill: White & U Mich: Kieffer*)

SELF-HEALING:

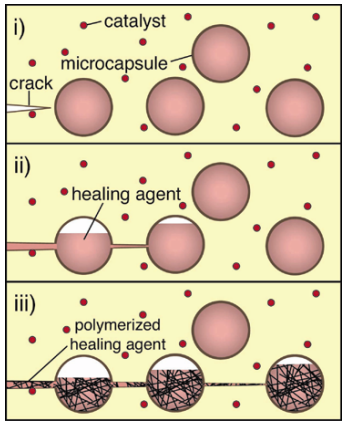
Macro-scale modeling

- **Verification of experimental results with cohesive zone model**
- **Coupling with cure kinetics at macro- and coarse grain levels**



Micro-scale modeling

- **Verify reaction pathways**
- **Large-scale simulation of polymer network formation**
- **Characterization of constitutive properties**



Experiments

- **In situ self-healing response**
- **Cure-dependence of fracture toughness**

MULTI-SCALE SIMULATION
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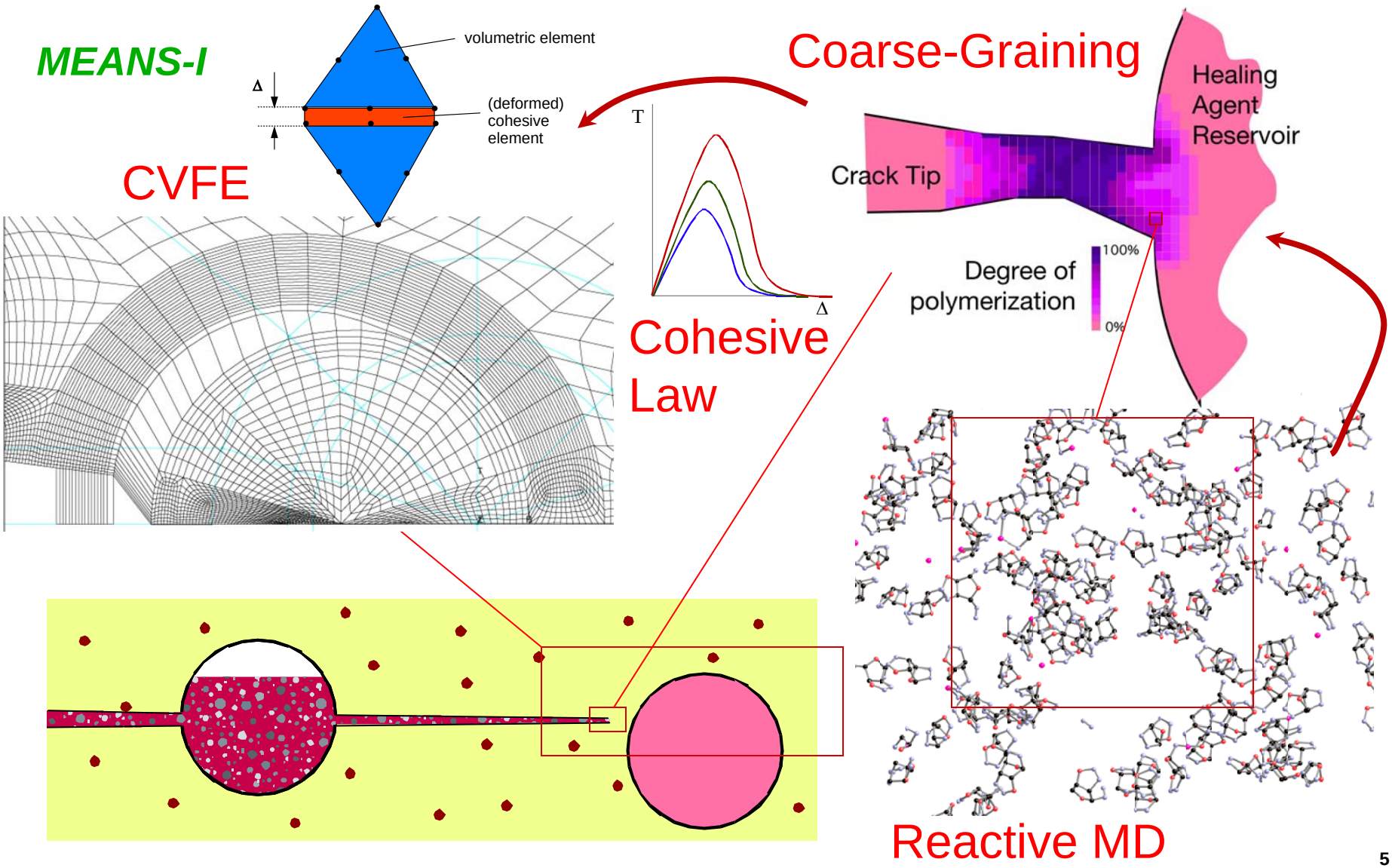
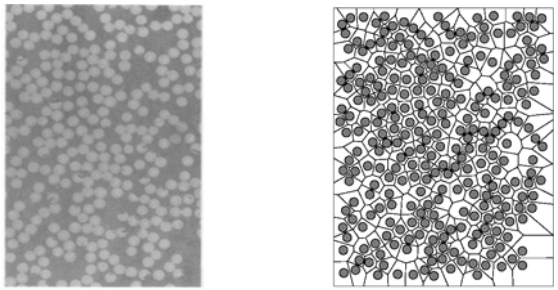
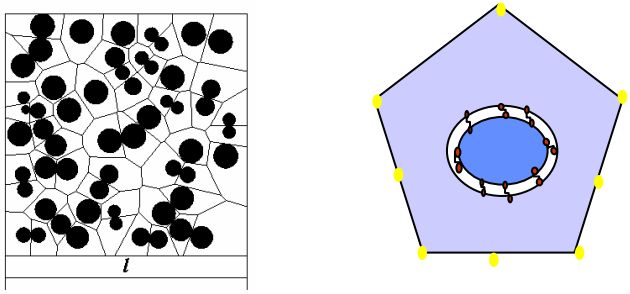


MULTI-SCALE MODEL OF COMPOSITES (*Ohio St U: Ghosh*)

(a) From Optical Micrograph to Computed Microstructure

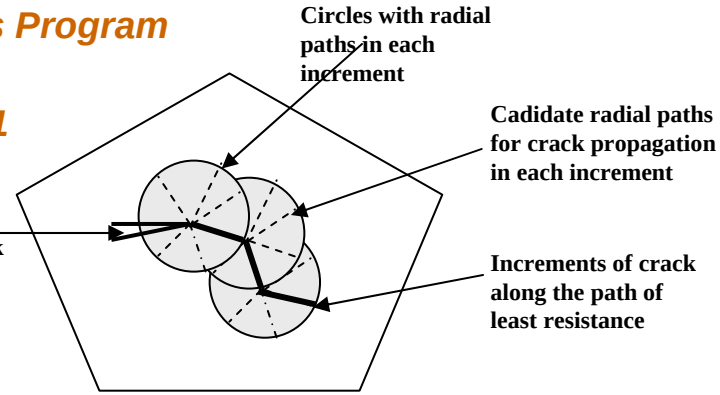


(b) Voronoi Cell FEM Analysis for Microstructure & Interface Damage

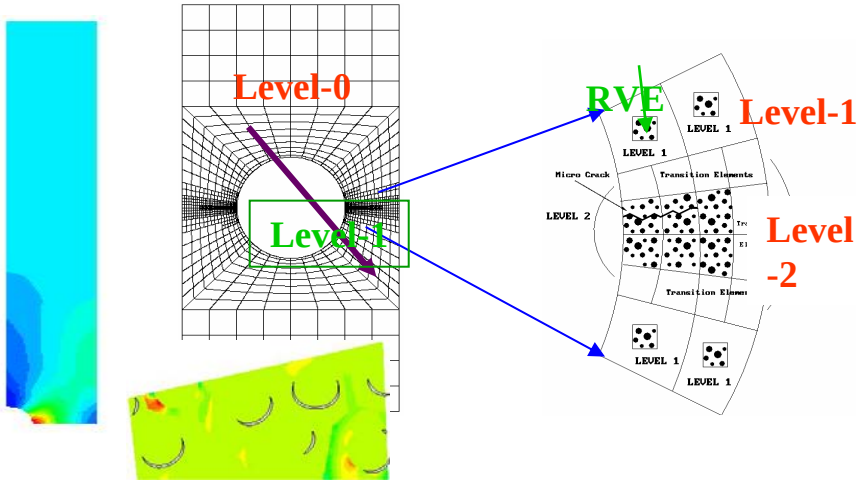


(d) Damage Growth by Matrix Cracking & Linking

Mechanics Program
CORE
since FY01



(c) Macro- and Microscopic Stress with Debonded Interface



The first "multi-scale" model of damage evolution in composite structures

MULTI-SCALE SIMULATION

NEW AREAS OF INTEREST:

- **Development of molecular dynamics-integrated numerical analysis tool for materials design**
- **Multi-scale mechano-chemical models for high-temperature durability of polymer composites**
- **Multi-scale simulation of failure of hybrid composite structures for thermal management**

Mechanics Program
CORE
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GOALS:

- **Strengthening of Schoeppner's Research Program**
- **Closer coordination with the current strategy for high-temperature PMC insertion for AIM-C Phase II**

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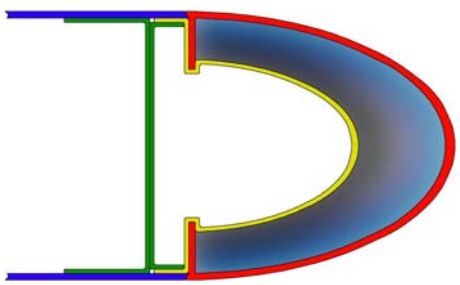
MEANS-II:
NEW INPUTS

Rainbow Solution: Innovative TPS for Leading Edge of Space Access/Hypersonic Vehicles – 100% Empirical

- **"Think out of the Box" design philosophy**
- **"Non-parasitic" structural integration**
- **Novel combination of materials**
  - **C/C Composites**
  - **Ceramics**
  - **Metals**
  - **Foams**
  - **Aerogels**
  - **Phase Change Materials**



The right combination of materials for the job!!

Urgent Need to Develop Modeling Tools for Integration of Dissimilar Structural Materials

MEANS-II:
NEW INPUTS (Cont'd)

OTHER AREAS OF INTEREST:

- **Modeling of materials behavior at the joints of metal and polymer matrix composites (PMC)**
- **Design criteria for the integration of metals, ceramics, and PMC in the form of hybrid laminates**
- **Multi-scale mechano-chemical models for high-temperature durability of joints and hybrid material systems**
- **…….**

Following the Vision