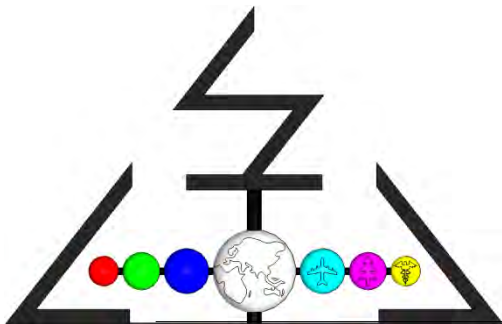




## Multiscale Damage Detection in Conductive Composites

Raj C Thiagarajan, PhD

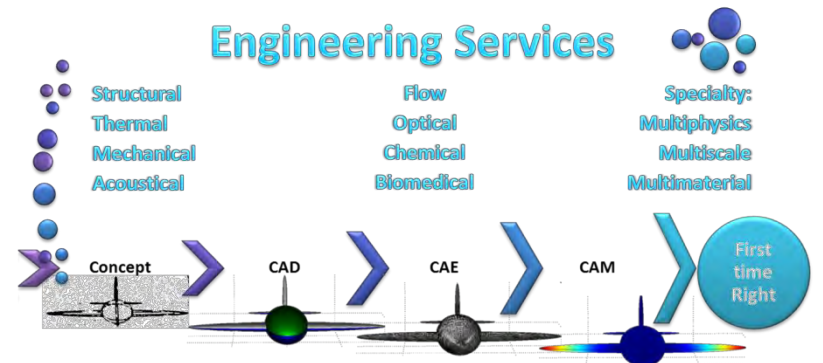
ATOA Scientific Technologies Pvt Ltd



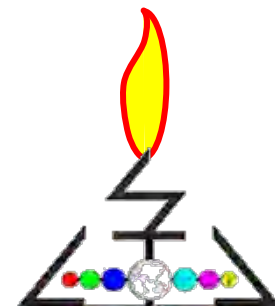
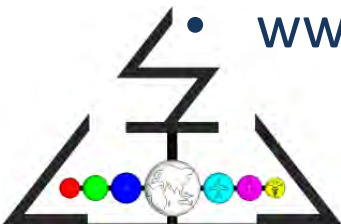
# ATOAST

- We Provide Multiphysics Engineering Design Solutions
- Driven by Material Unity Vision
- We are the first COMSOL Certified Consultant from India
- ATOAST JOTHI foundation

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Engineering Design Simulations for the First time Right



# Multiscale Damage Detection in Conductive Composites

- Multiscale nature of damage
- Damage Modes in composites
- Damage detection techniques
- Self sensing Carbon fiber Composites
- Numerical model
  - Implementation
  - Results and discussion



# Multiscale damage mechanism

➤ Structure

➤ Part

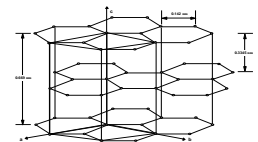
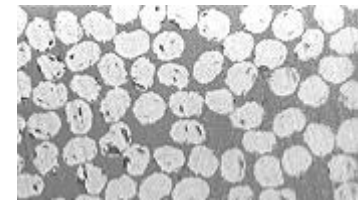
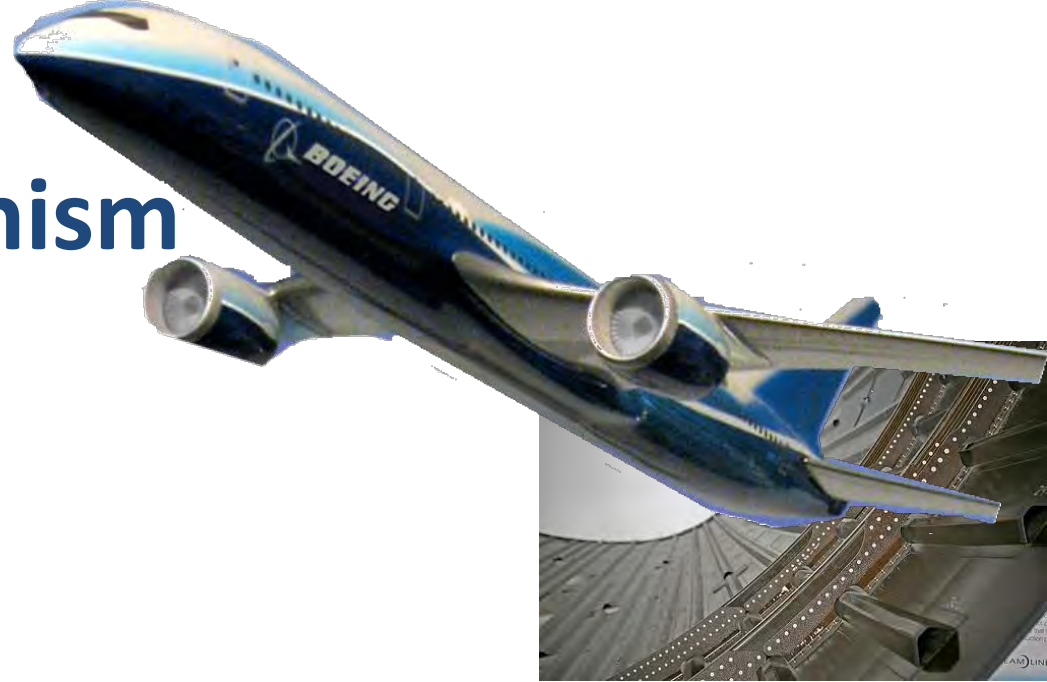
➤ Laminate

➤ Fiber

➤ Matrix

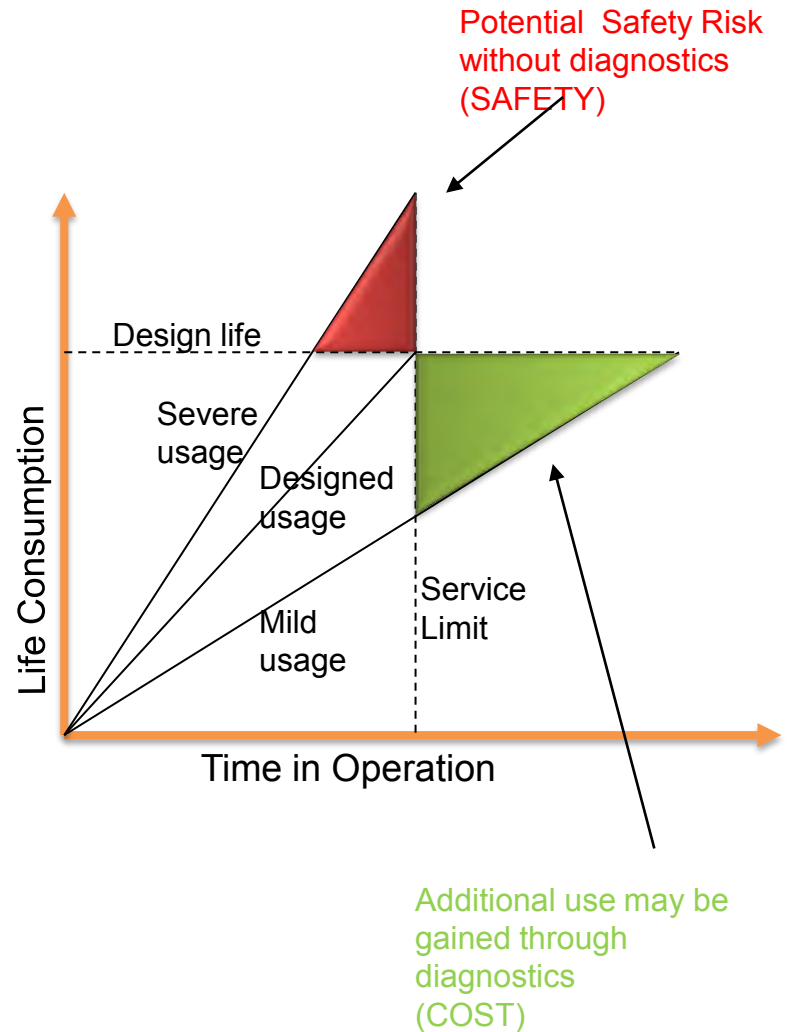
➤ Molecular

➤ ATOMIC bond breakage



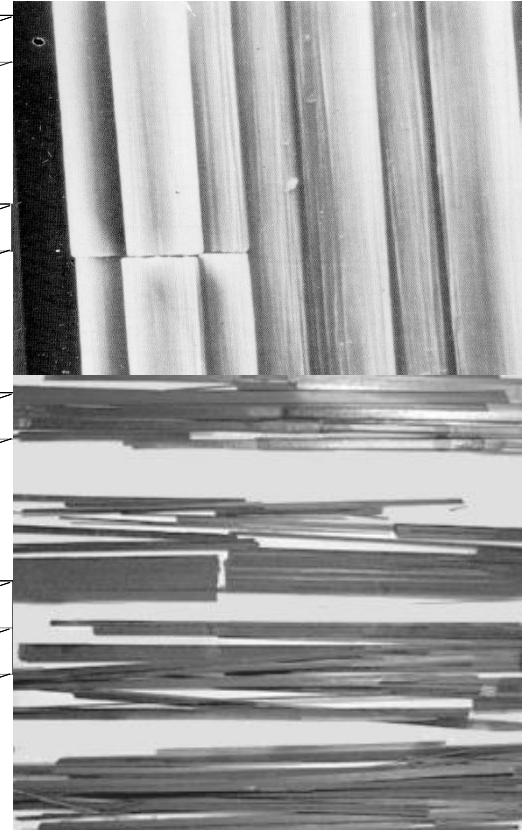
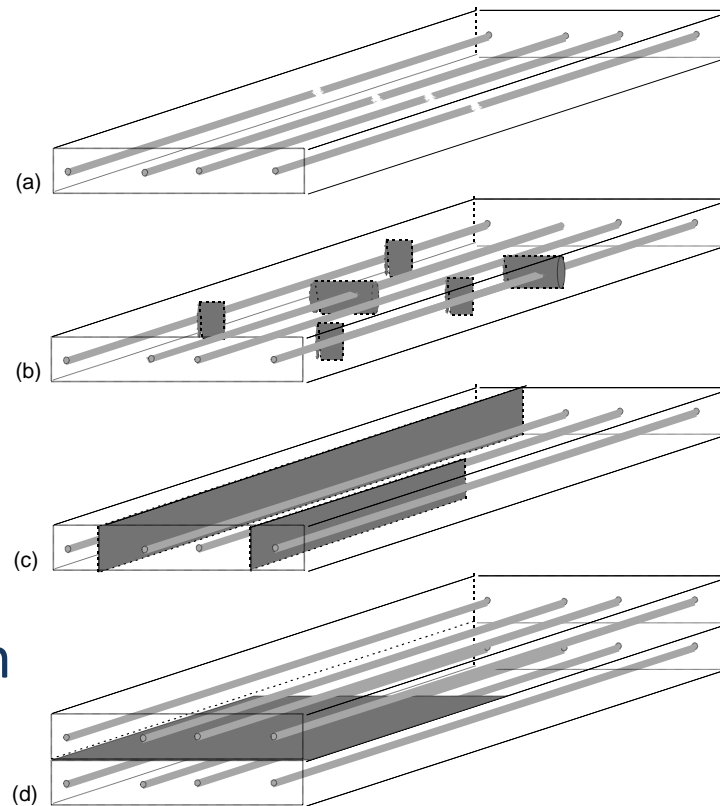
# Why

- Increase use of composites in safety critical application.
- Increase reliability and safety levels
- Reduce cost and cycle time
- Focus on carbon fiber composites



# Damage Mechanisms

- Fiber
  - Fiber breaks
- Matrix
  - Matrix crack
- Interface
  - Delamination
  - Longitudinal cracks



# Structural Health monitoring

## Existing Techniques

- ultrasonic, acoustic emission, X-ray and eddy current Piezo sensors with ultrasonic tomography, Embedded Optical fibers (FBGs)

## Limitations

- Based on external or embedded sensors.
- Embedded sensors/electrodes/FBGs lead to initiation of damage in composites.

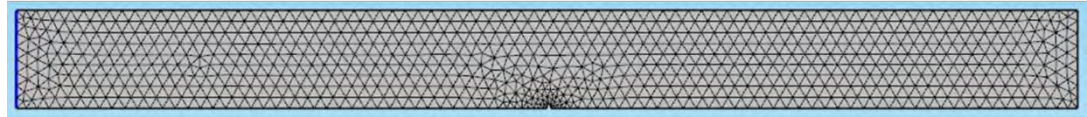
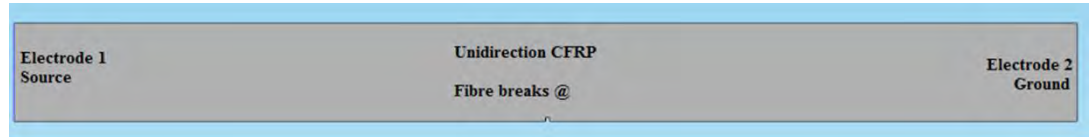
## Self sensing of Carbon fiber composites



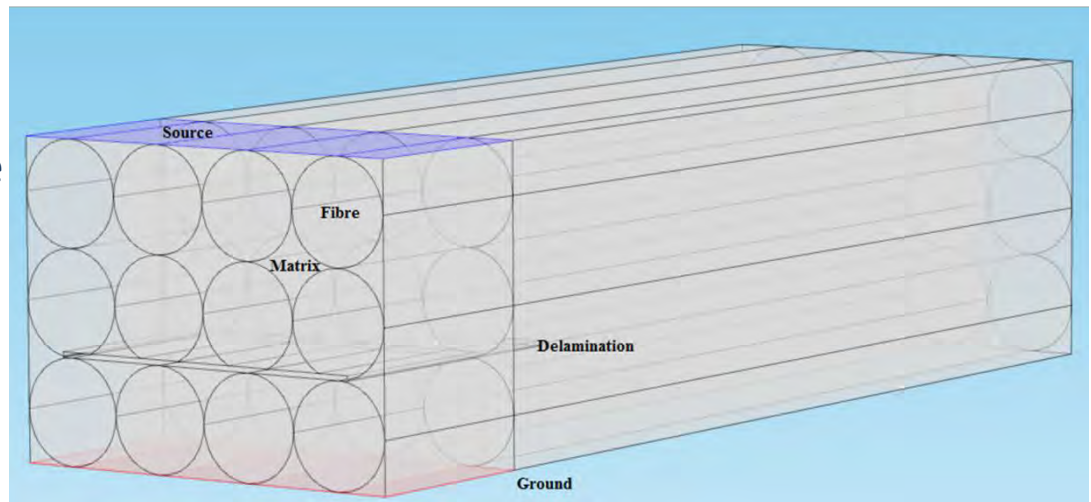


# Numerical investigation

- The electrical conduction mechanism and the effect of damage in CFRP composites were simulated in COMSOL using AC/DC Electric Currents Interface.



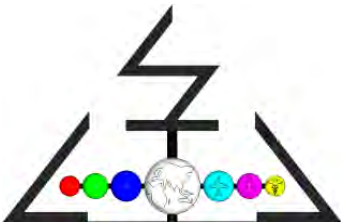
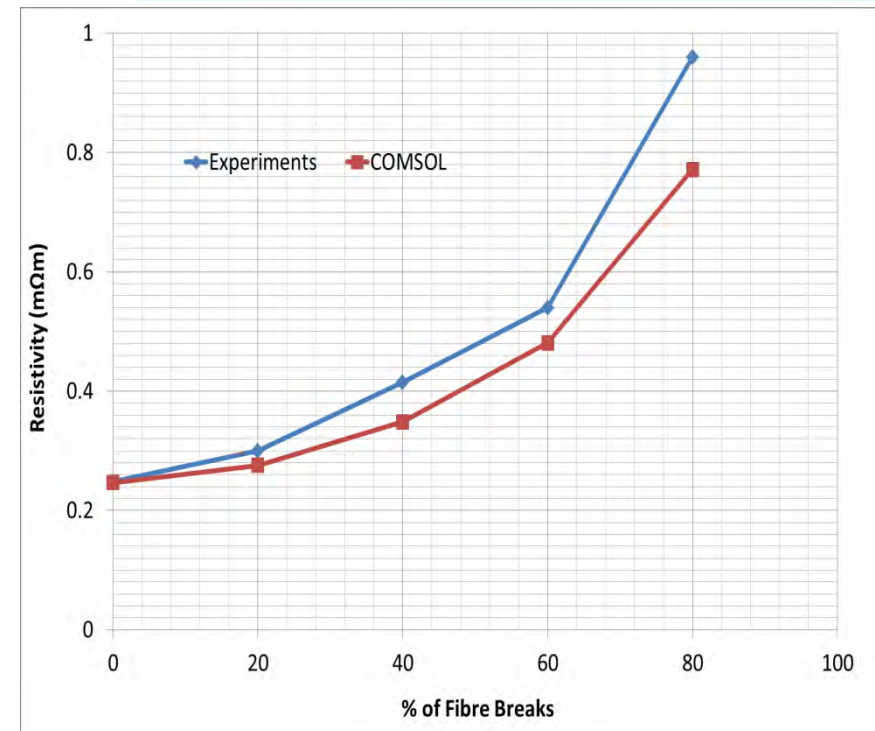
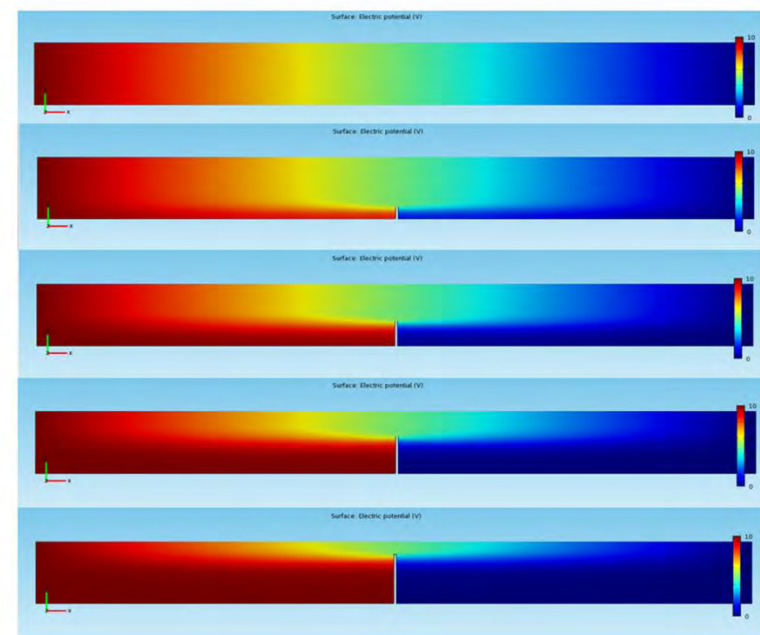
- Homogeneous composite model with effective properties
- Micromechanical model with constituent properties





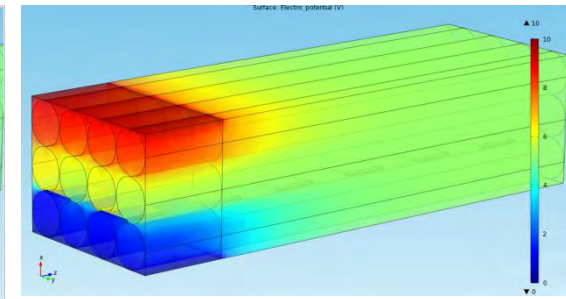
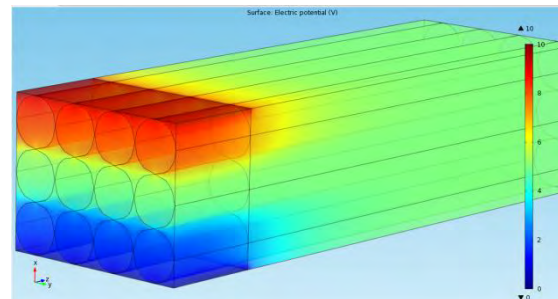
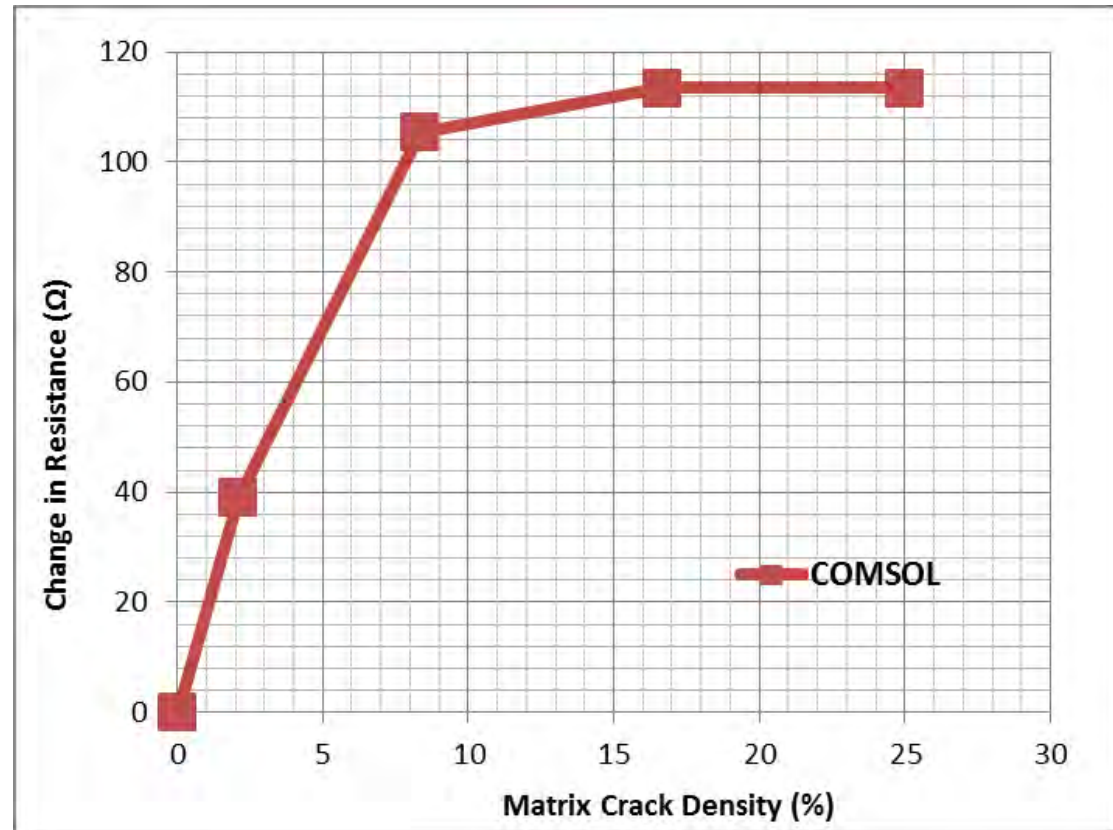
# Results : Fiber breaks

- UD composites
- Electrode on edge
- Resistance change vs fiber breaks
- Parallel resistance model behavior
- Very sensitive to fiber breaks.



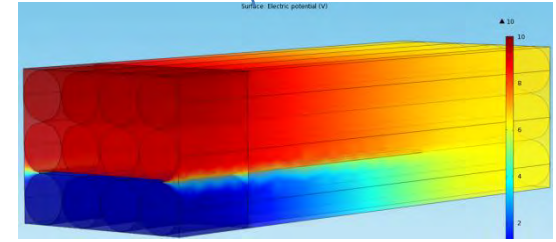
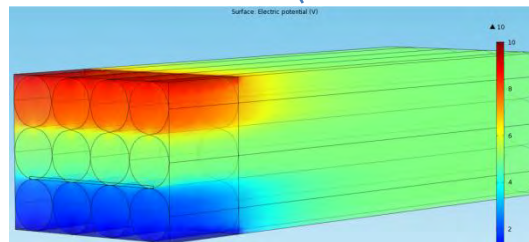
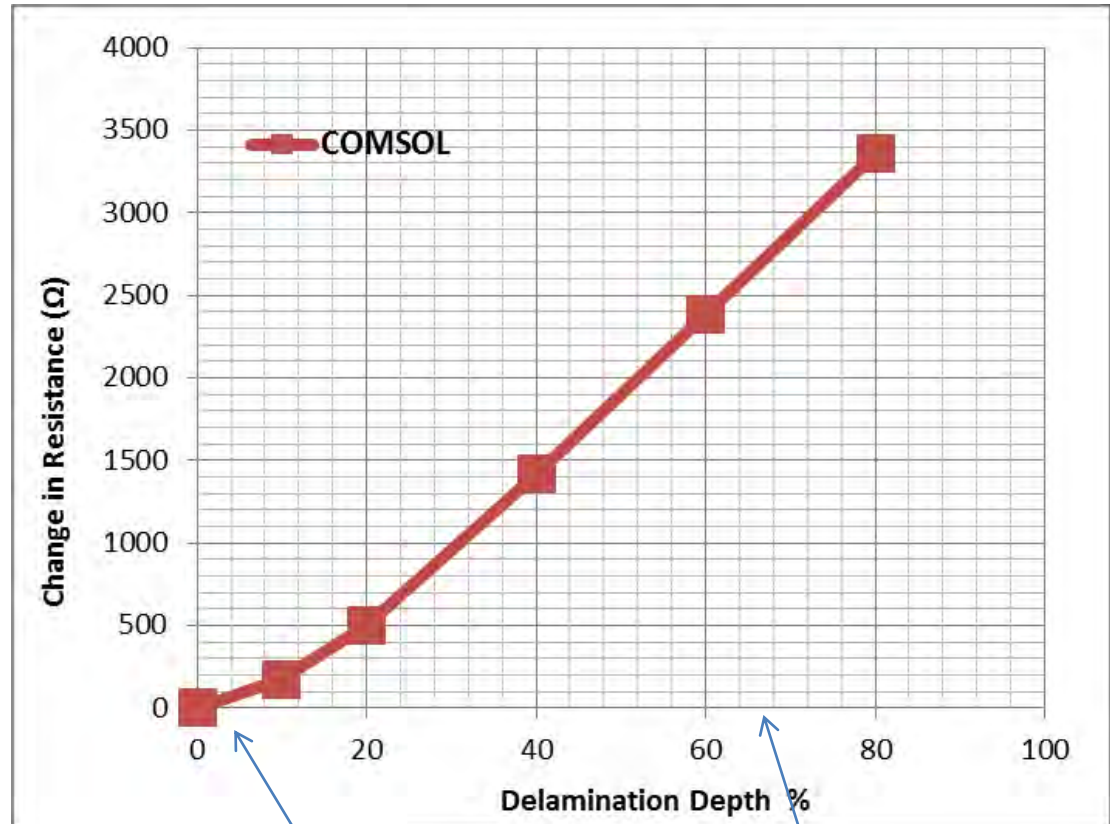
# Results: Matrix Cracks

- Matrix crack density vs change in resistance
- Can detect matrix cracks also



# Results : Delamination

- Delamination length vs resistance change.
- Delamination growth between fibres



# Conclusions

- The COMSOL model results show that the electrical resistance change is sensitive to fiber breaks and delamination.
- The homogenized and micromechanical model demonstrated the changes in resistance as function of damage.
- The methodology developed can be used to improve the damage detection capability and reliability of composite structures by Virtual optimisation.

