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# Engineering Composite Materials

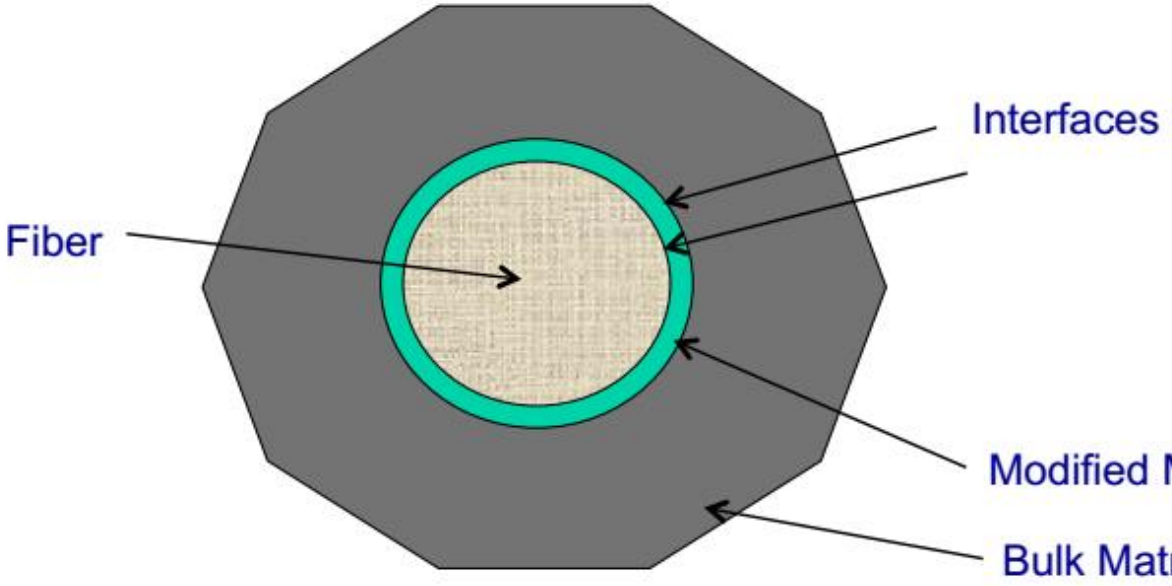
## Fiber-matrix adhesion

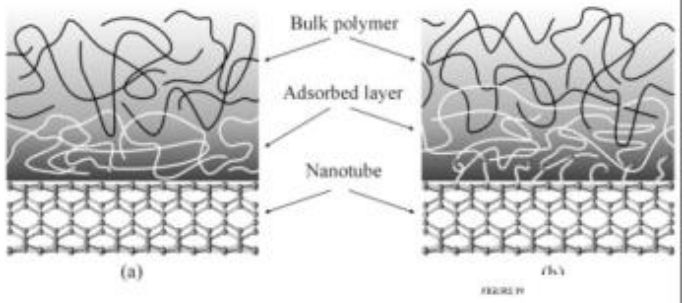
**Dawit Gemechu (Ph. D.)**

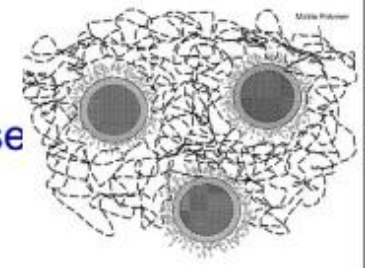
**E-mail: dawit.gemechu@aait.edu.et**

# Composite Materials

## Fiber-Matrix Adhesion : Interphase and Interface



- **Interface:** It is the boundary demarcating the distinct phase of fiber-matrix

- **Interphase:** It is a region where coating and matrix diffused into each other's domain and form a flexible, three-dimensional polymer network

- The interphase is responsible for transferring the load from the matrix to the fibers
- Interphase has different modulus and strength than fiber and matrix

# Composite Materials

## The fiber-matrix interface

- The interface between fiber and matrix is crucial to the performance of the composite - in particular fracture toughness; corrosion; moisture resistance

- Weak interfaces provide a good energy absorption mechanism - composites have low strength and stiffness, but high fracture toughness

- Strong interface results in a strong and stiff, but brittle composite

# Composite Materials

## The fiber-matrix interface

- Interface b/n reinforcement and matrix is the bounding surface between the two

- The region through which material parameters; such as concentration of an element, crystal structure, atomic registry, elastic modulus, density, coefficient of thermal expansion, etc., change from one side to another

- The behavior of a composite material is a result of the combined behavior of the following three entities:
  - ✓ Fiber or the reinforcing element
  - ✓ Matrix
  - ✓ Fiber/matrix interface

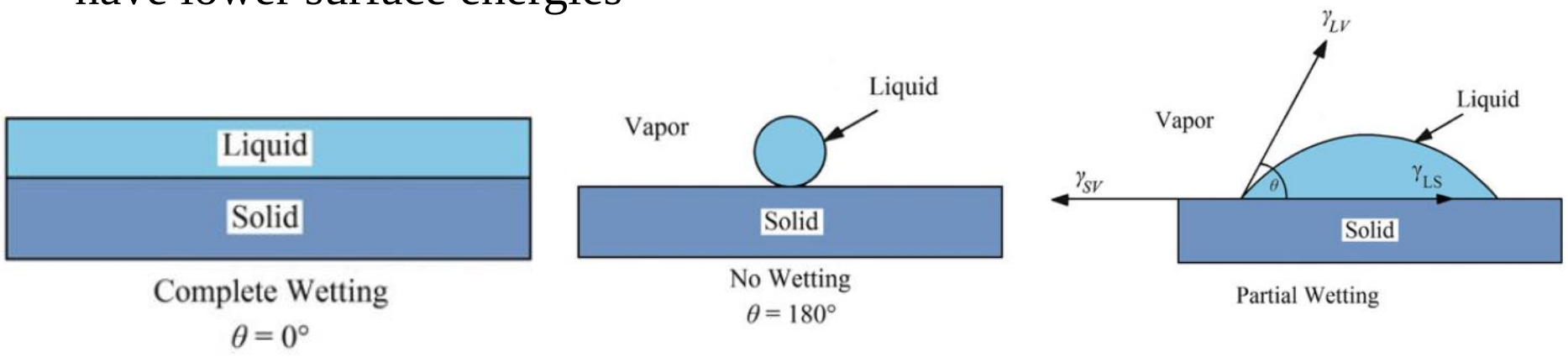
# Composite Materials

## The fiber-matrix interface

Adhesion between fiber and matrix is due to one (or more) of 5 main mechanisms:

1. **Adsorption and wetting** - depending on the surface energies or surface tensions of the two surfaces

- Wettability tells us about the ability of a liquid to spread on a solid surface
- Glass and carbon are readily wetted by epoxy and polyester resins, which have lower surface energies

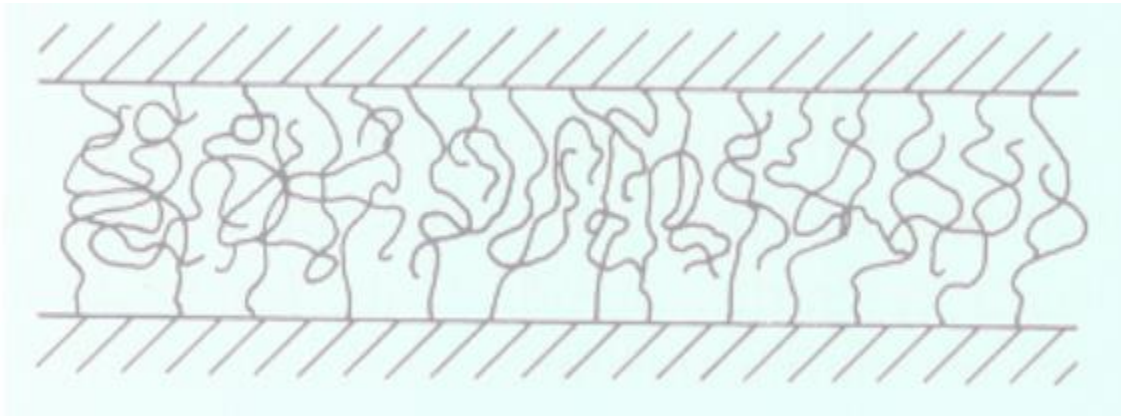



Three different conditions of wetting: complete wetting, no wetting, and partial wetting

## The fiber-matrix interface

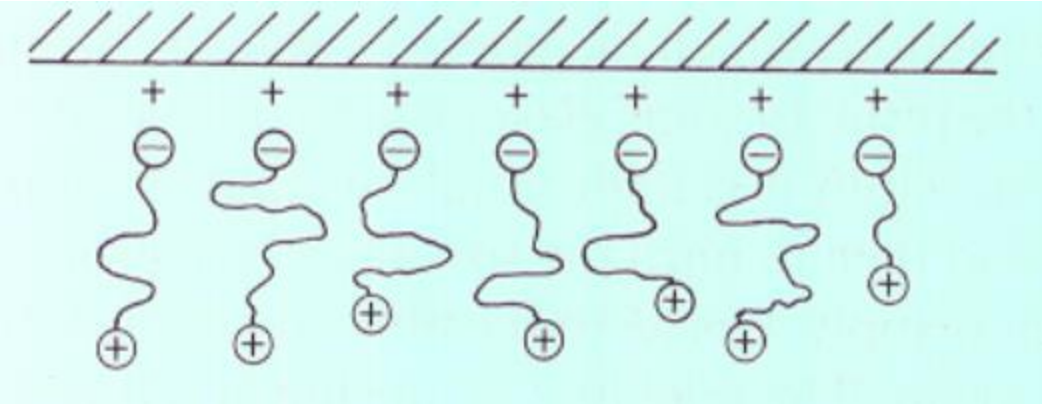
Adhesion between fiber and matrix is due to one (or more) of 5 main mechanisms:

2. **Interdiffusion (autohesion)** - diffusion and entanglement of molecules, direct-bonding or self-bonding - formation of bonds between two surfaces

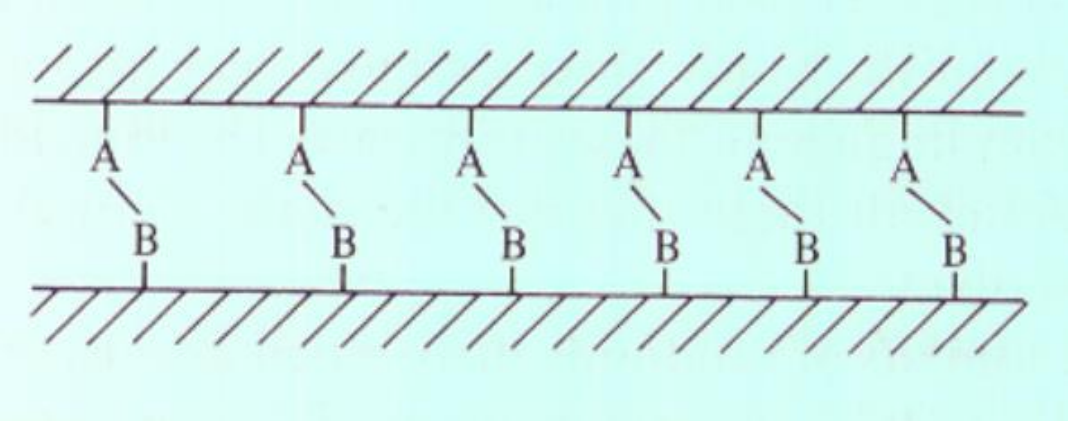


## The fiber-matrix interface

**3. Electrostatic attraction** – between two/more electrically charged surfaces (of matrix and fiber). Glass fiber surface may be ionic due to oxide composition:

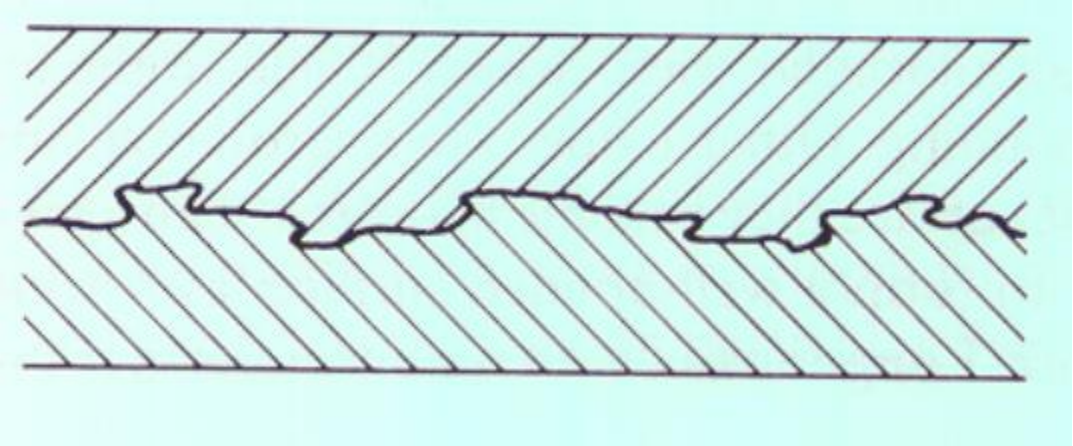


**4. Chemical bonding** – between chemical group in the matrix and a compatible chemical on the fiber surface:

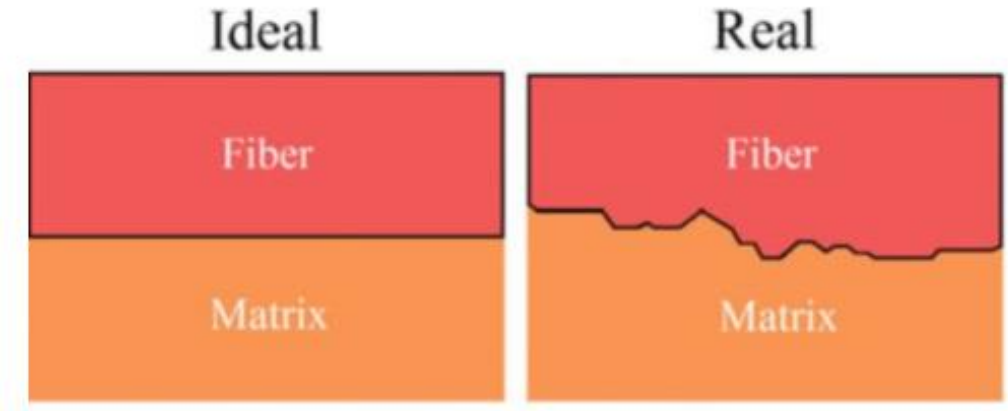


## The fiber-matrix interface

**5. Mechanical adhesion -** depending on degree of roughness of fiber surface.

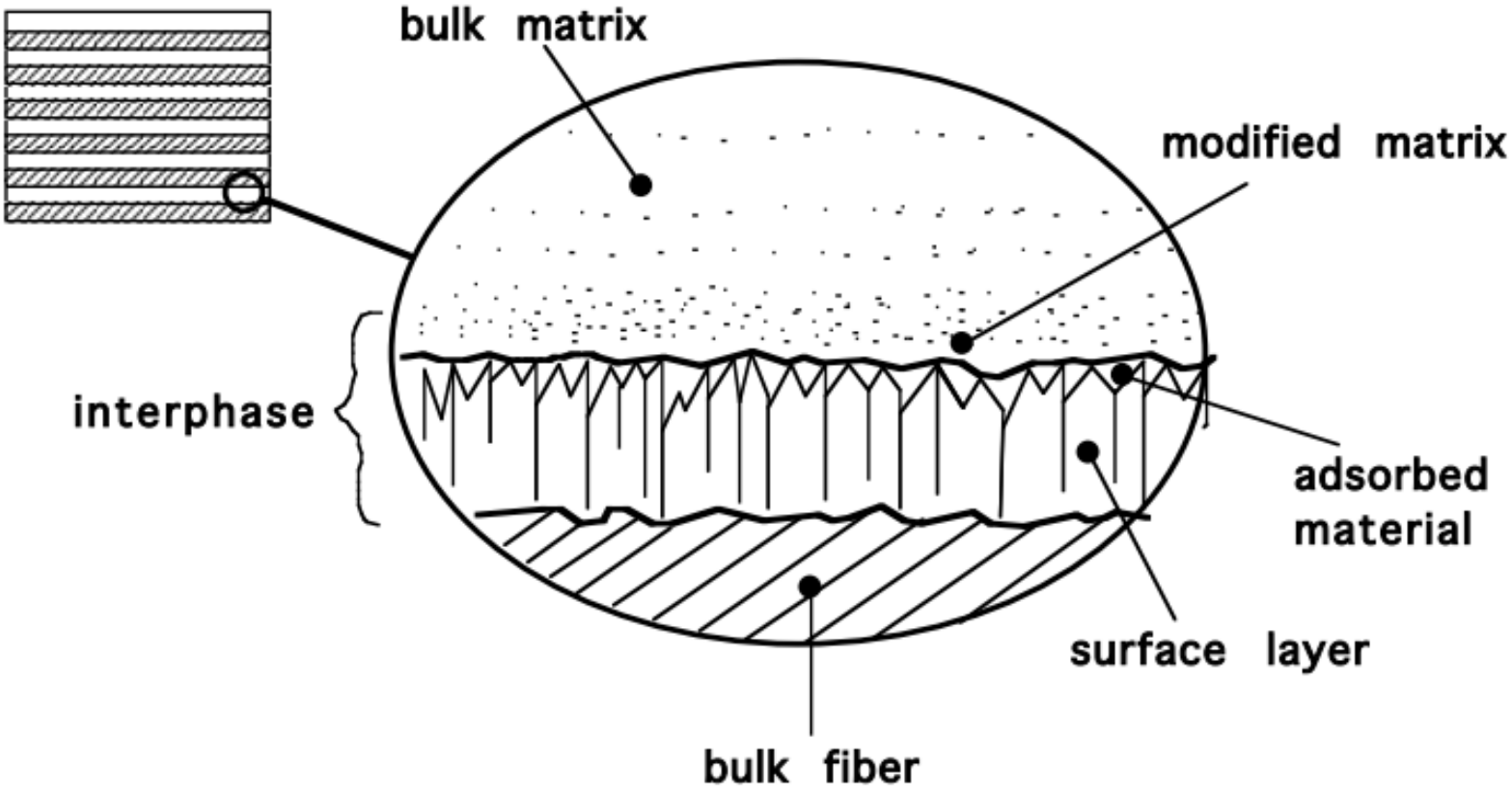


Interface between fiber and matrix is rough instead of the ideal planar interface



# Composite Materials

## The fiber-matrix interface

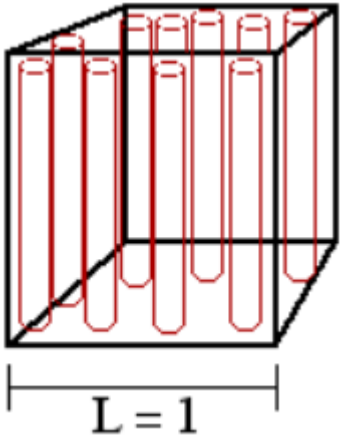


# Composite Materials

## Why interface in composite is important?

### Surface Area

Fiber filled

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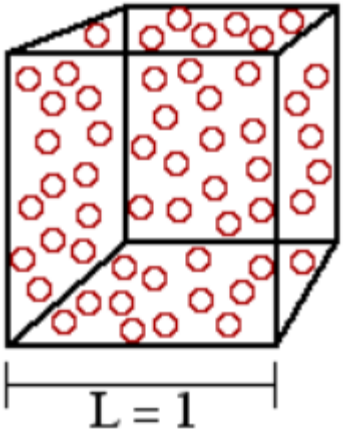
Particle filled



## Why interface or interphase?

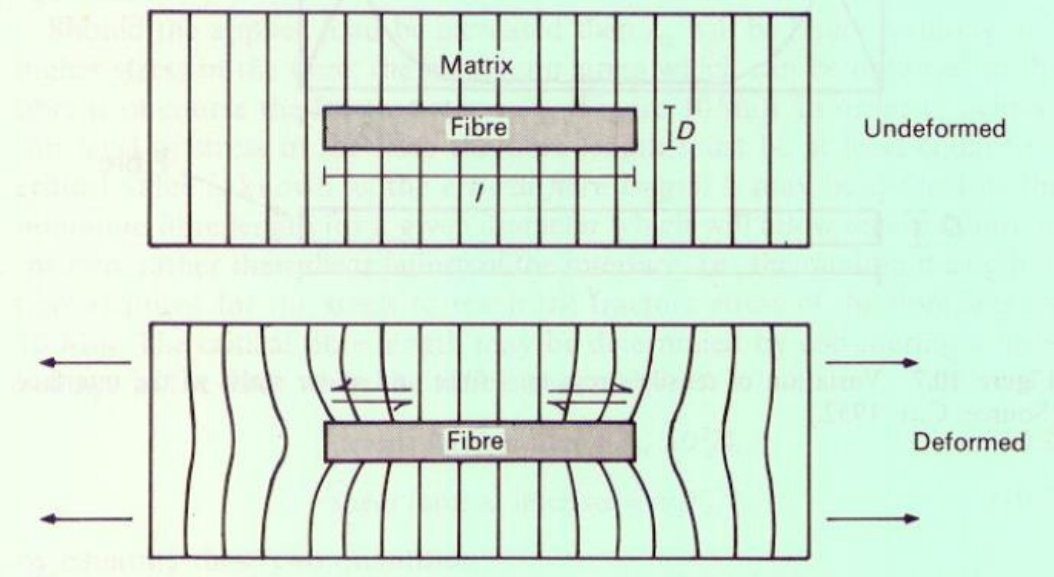
- ✓ Differential thermal contraction (***residual stresses***)
- ✓ Different cooling conditions (e.g. carbon fiber is thermally conductive)
- ✓ M***atrix contracts*** during cure (thermosets)
- ✓ ***Different Poisson´s ratio**** of fiber and matrix
- ✓ Fiber surface influences cross-link density
- ✓ ***Crystals can nucleate*** at fiber contact

** Define and explain the relevance of poisson's ratio*

# Composite Materials

## Load transfer between matrix and fiber

- Under applied tension, load is transferred by shear at the matrix/fiber interface




- At fiber ends, the strain in the matrix is higher than in the fiber