# Finite Elements Solution of the Fiber-Matrix Interface Crack: Effects of Mesh Refinement and Domain Size

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Education and Culture

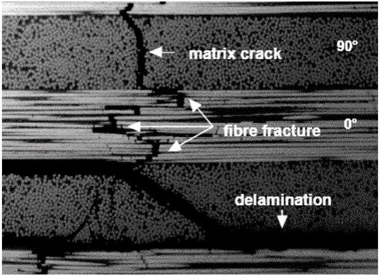
Erasmus Mundus

# Outline

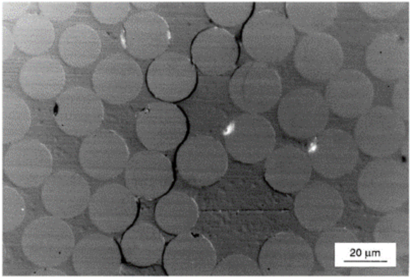
- The Fiber-Matrix Interface Problem in Fiber Reinforced Polymer Laminates
- Conclusions & Outlook
- Appendices & References

# The Fiber-Matrix Interface Problem in FRPC

# Intralaminar Transverse Cracking




(a) By Dr. R. Olsson, Swerea, SE.




(b) By Prof. Dr. E. K. Gamstedt, KTH, SE.

A visual definition of intralaminar transverse cracking.

# Characterization of the Fracture Process

$$G_m = G_m(p_1, \ldots, p_i, \ldots, p_n) \quad \text{where} \quad G = \frac{\partial W}{\partial A} - \left( \frac{\partial U}{\partial A} + \frac{\partial E_k}{\partial A} \right)$$

$$K_m = K_m(p_1, \ldots, p_i, \ldots, p_n) \quad \text{where} \quad \sigma_m \sim K_m \frac{\alpha}{(x-a)^{\beta}}, \alpha, \beta > 0$$

$$J = J(p_1, \ldots, p_i, \ldots, p_n) \quad \text{where} \quad J = \int_{\Gamma} W d\eta - \mathbf{T} \frac{\partial \mathbf{u}}{\partial \varepsilon} ds$$

$$COD = COD(p_1, \ldots, p_i, \ldots, p_n) \quad \text{and} \quad CSD = CSD(p_1, \ldots, p_i, \ldots, p_n)$$

$$p_i \in \{\text{geometry}, \text{materials}, \text{boundary conditions}, \text{loading mode}, \text{scale}\}$$

$$m \in \{I, II, III, I/II, I/III, II/III\}$$

# Evaluation of the Fracture Process

- ➔ Analytical
  - ✓ Closed form
  - ✗ Available only for particular configurations
- ➔ Experimental
- ➔ Numerical

# The Fiber-Matrix Interface Crack

# ↘ CONCLUSIONS

# Conclusions & Outlook

## Conclusions

- 2D micromechanical models have been developed to investigate crack initiation in thin ply laminates
- A numerical procedure has been devised and implemented to automatize the creation of FEM models
- Analyses for $VF_f \rightarrow 0$ (matrix dominated RVE) conducted to validate the model with respect to previous literature

## Outlook

- Investigate the dependence on $VF_f$, $t_{ply}$, $\frac{t_{ply}}{t_{bounding\ plies}}$ and different material systems
- Study numerical performances with respect to model's parameters
- Repeat for different RVEs and compare

# APPENDICES & REFERENCES

## Evaluation of $G_0$

$$G_0 = \pi R_f \sigma_0^2 \frac{1 + k_m}{8 G_m} \tag{1}$$

$$k_m = 3 - 4\nu_m \tag{2}$$

$$\sigma_0^{undamaged} = \frac{E_m}{1 - \nu_m^2} \varepsilon_{xx} \tag{3}$$

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