Designing Adhesive Interfaces with Superior Bond Strength: A Bioinspired Approach

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OBJECTIVE

Compare methods for grading the Young's modulus and thickness of a FGM to reduce interfacial stresses when joining dissimilar materials.

Motivation

Enhancing the bonding of dissimilar materials in engineered composites remains challenging due to significant interfacial stresses, a problem effectively managed by biological structures like natural teeth with graded transitions at the dentin-enamel junction.

Methods

We use ABAQUS to set up the problem as shown in Figure 1. The Young's Modulus of the Surface Layer is set constant at 72 GPa, while it varies for Adherend 1 (E_1) and Adherend 2 (E_2) to reflect different values. Consequently, the ratios (E_1/E_2) are adjusted to 4, 10, 35, and 135.

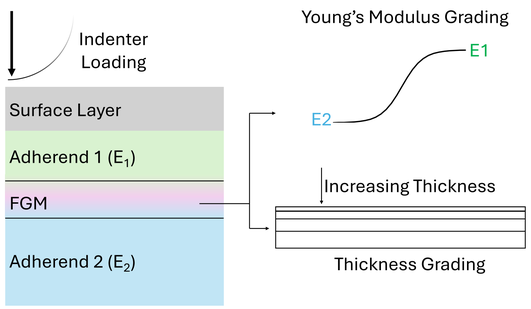

Figure 1. ABAQUS model with FGM and indenter loading.

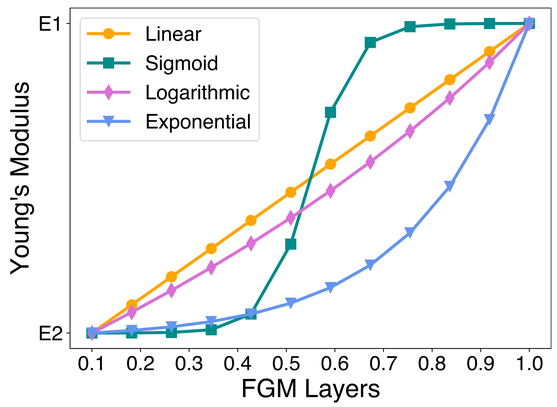

Figure 2. Various stiffness variations in FGM layers.

Results

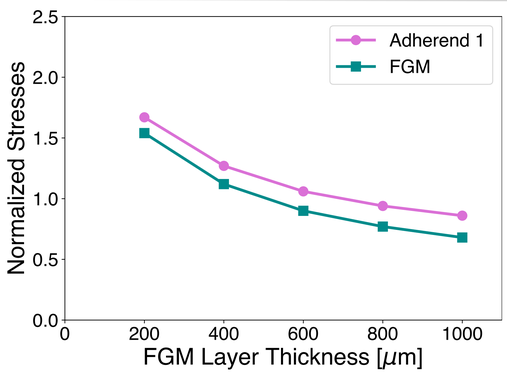

Figure 3. E_1/E_2 ratio of 4.

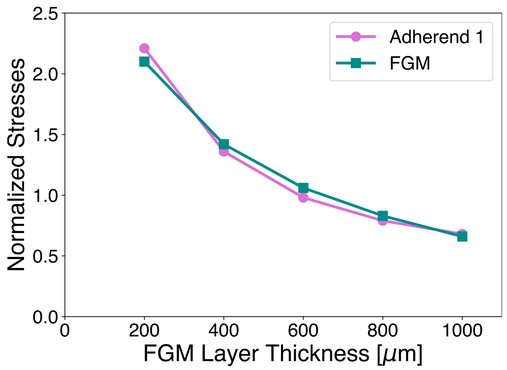

Figure 4. E_1/E_2 ratio of 10.

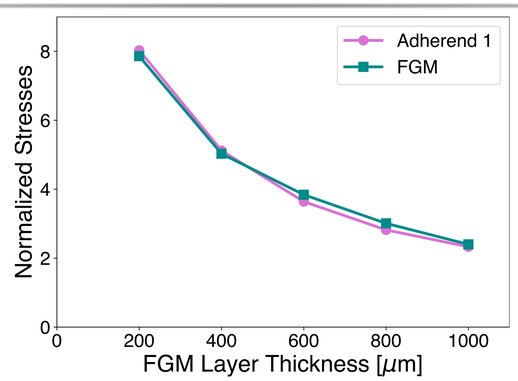

Figure 5. E_1/E_2 ratio of 35.

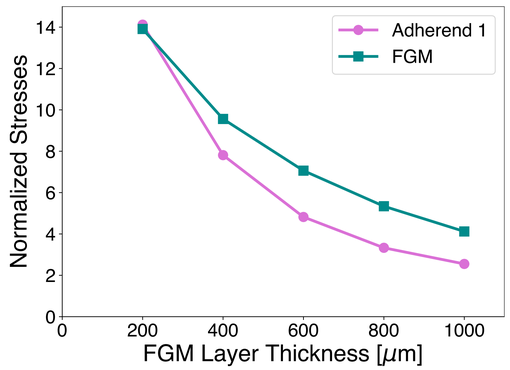

Figure 6. E_1/E_2 ratio of 135.

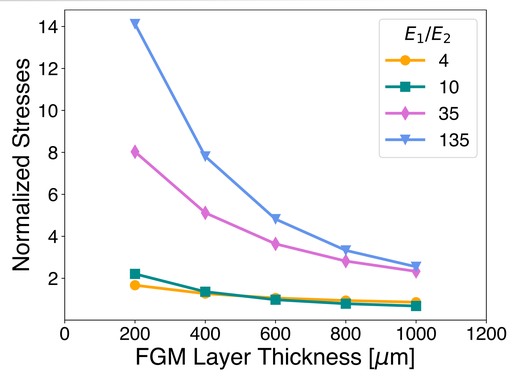

Figure 7. Adherend 1 Results.

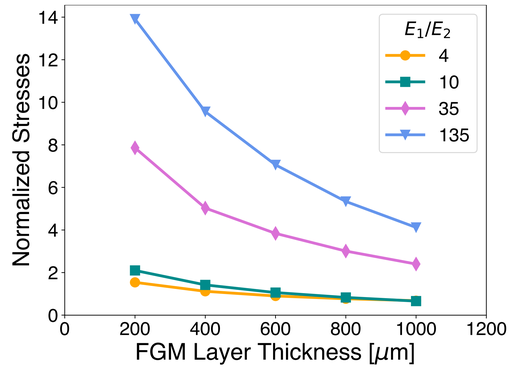

Figure 8. FGM Results.

Conclusions

- FGM layer effectiveness is modeled after the dentin-enamel junction in teeth, emphasizing graded stiffness and layer thickness.
- Thicker FGM layers significantly lower stress in both Adherend 1 and the FGM itself.
- Varying E_1/E_2 ratios alters stress patterns, especially as FGM thickness increases.
- Identified optimal Young's modulus grading and thickness configurations for minimal internal stress.
- Findings are applicable to aerospace, protective armor, and biomedical implant design.

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Acknowledgements

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References

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