

Testing of CFRP-metal sandwiches subject to mode I and mode II load conditions [Poster]

Andreas Monden, Markus G. R. Sause, A. Hartwig, Nora Schorer, B. Alaca, S. Burger, Siegfried R. Horn

Angaben zur Veröffentlichung / Publication details:

Monden, Andreas, Markus G. R. Sause, A. Hartwig, Nora Schorer, B. Alaca, S. Burger, and Siegfried R. Horn. 2014. "Testing of CFRP-metal sandwiches subject to mode I and mode II load conditions [Poster]." In 7th International Conference on Fracture of Polymers, Composites and Adhesives, Les Diablerets, Switzerland, September 2014. Augsburg: Universität Augsburg.

Testing of CFRP-metal sandwiches subject to mode I and mode II load conditions

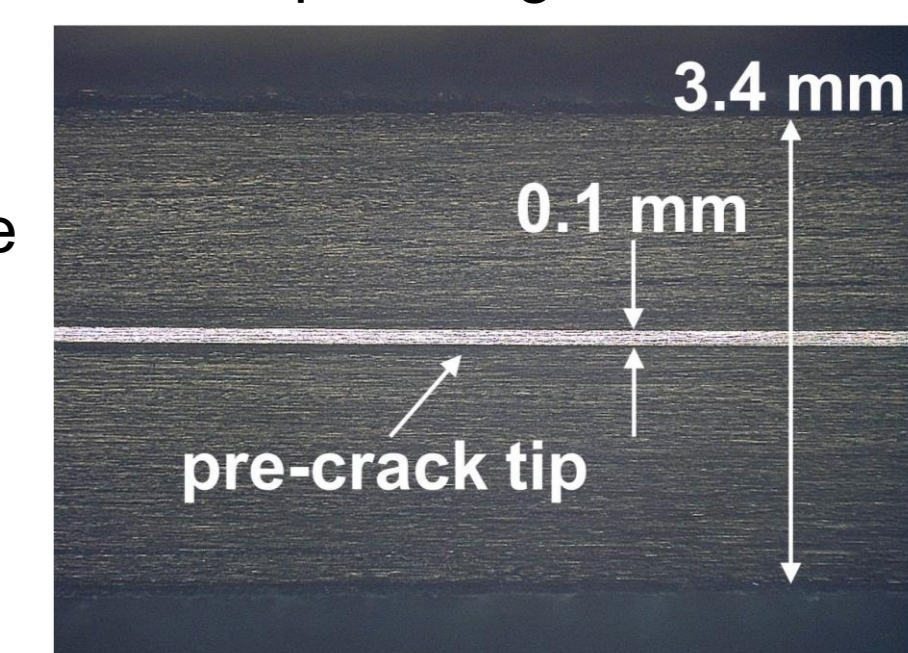
A. Monden, M.G.R. Sause, A. Hartwig, N. Schorer, B. Alaca, S. Burger, S. Horn
University of Augsburg, Germany

Introduction

- Joining Fiber Reinforced Plastics (FRP) and metals is challenging:
 - Fiber-fair joining methods are recommended
 - Direct joints of FRP and metals result in poor adhesion
 - Surface treatments and modifications are required to achieve mechanically and chemically stable joints
- Development of joint technologies has stimulated the need for mechanical testing procedures to measure the fracture toughness of the interface
- **Possibilities to evaluate the fracture toughness of symmetrical CFRP-metal laminates:**
 - Double-Cantilever Beam (DCB, mode I) test
 - 3-point End-notched Flexure (3-ENF, mode II) test
 - Apparent Interlaminar Shear Strength (ILSS) test (Short-beam Shear test, SBS)

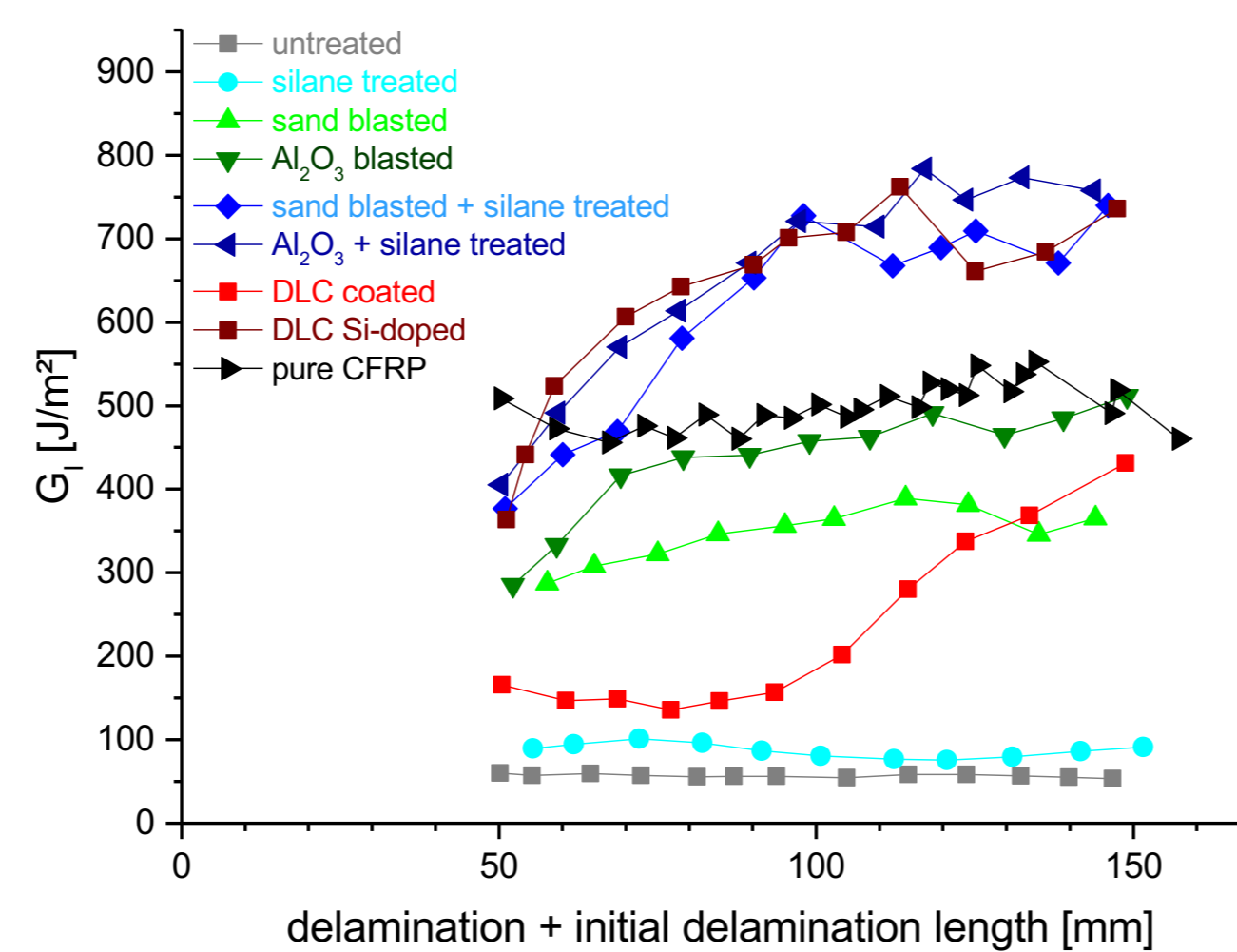
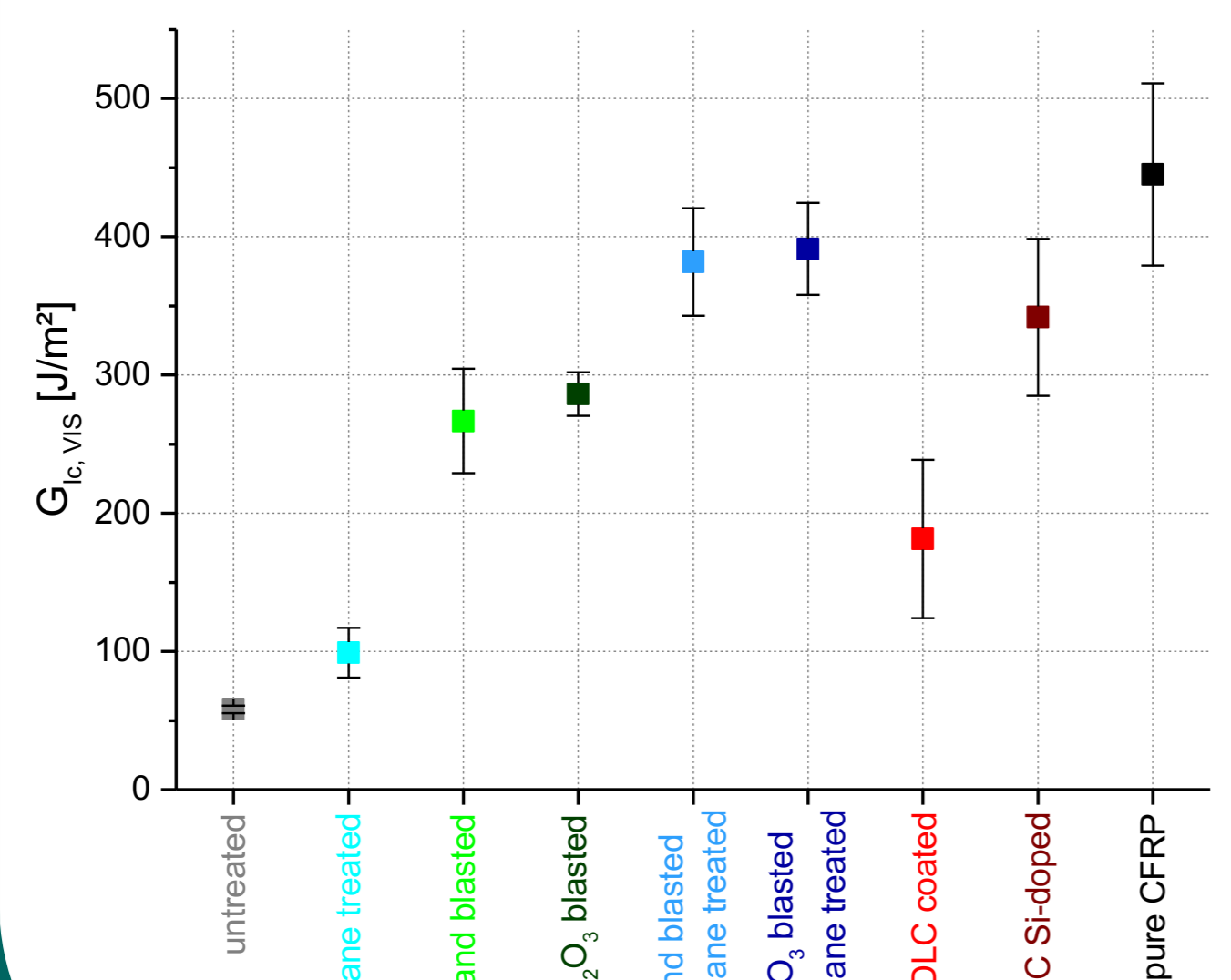
Sample preparation

- Symmetrical sandwich laminates fabricated using X5CrNi18-10 steel foil of 0.1 mm nominal thickness and SGL CE 1250-230-39 unidirectional epoxy-based prepreg
- Surface treatments and modifications applied to the steel surfaces:
 - Silane dip coating (10 vol% in aqueous solution)
 - Sand blasting (70-150 μm) and Al_2O_3 grit (106-150 μm) blasting
 - Sand blasting and Al_2O_3 grit blasting combined with silane dip coating
 - Diamond-like Carbon (DLC) coatings
- Metal sheets laminated at the centre plane [0₇/steel/0₇] with a pre-crack of 50 mm length prepared at one interface
- Laminate cured 90 min at 130 °C
- Specimen prepared according to ASTM D5528 (mode I), ASTM WK22949 (mode II) and DIN EN 2563 (ILSS)

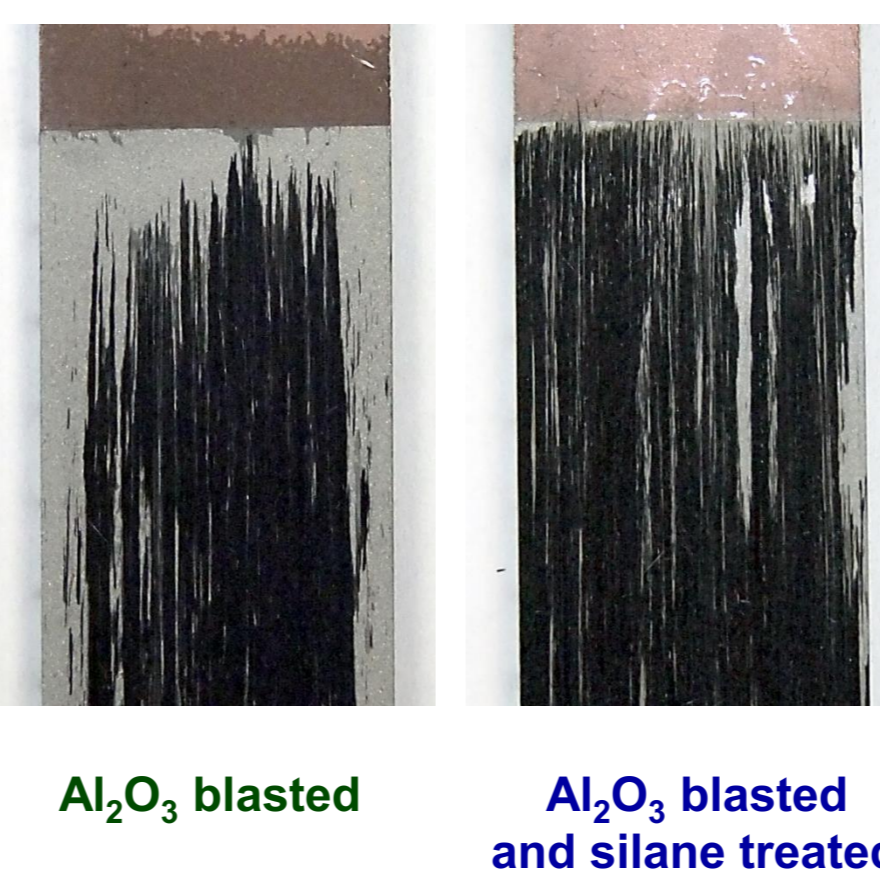


Mode I results

G_{Ic} evaluated via visual onset of delamination movement (VIS) based on 5 samples each:

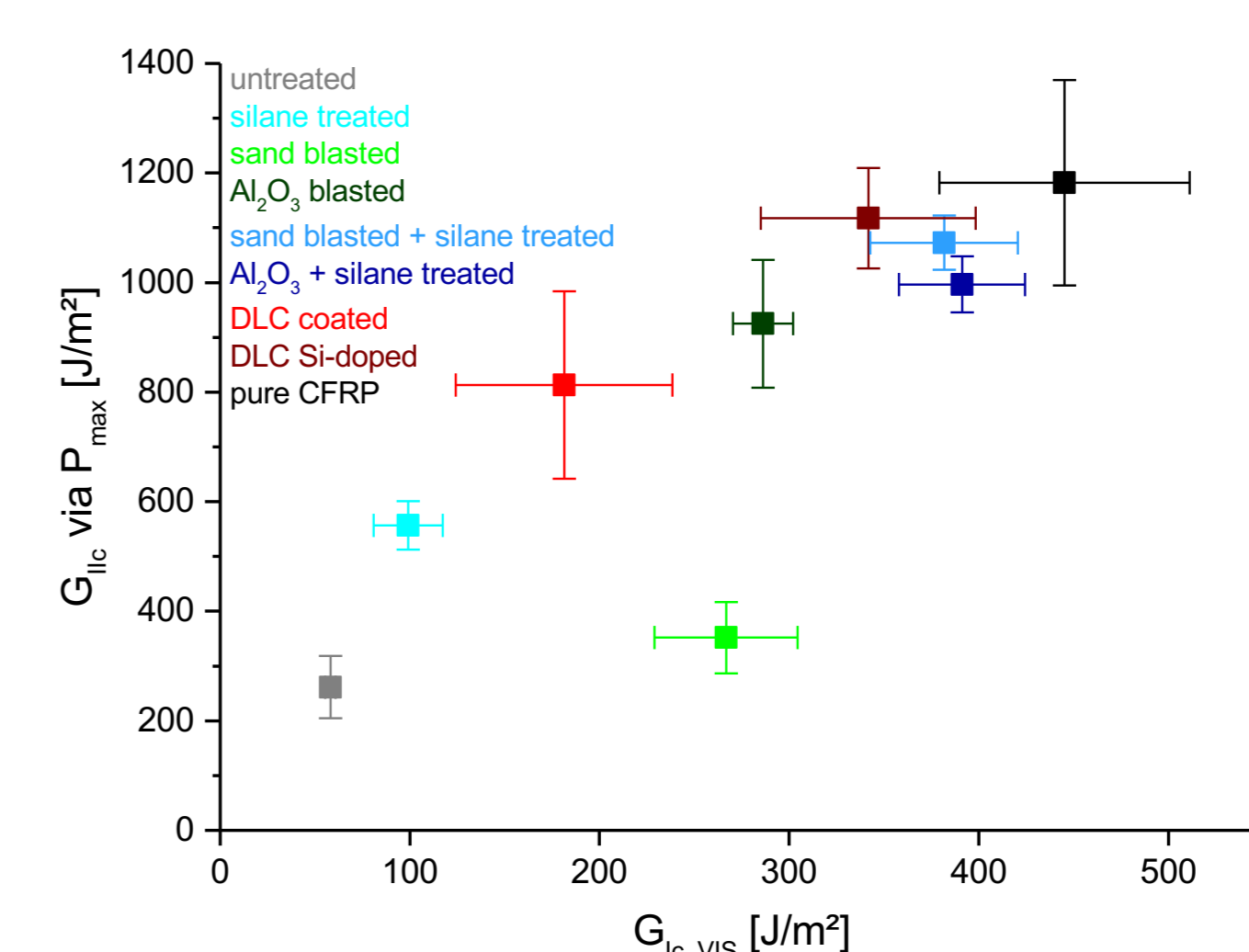


Representative Mode I fracture surfaces



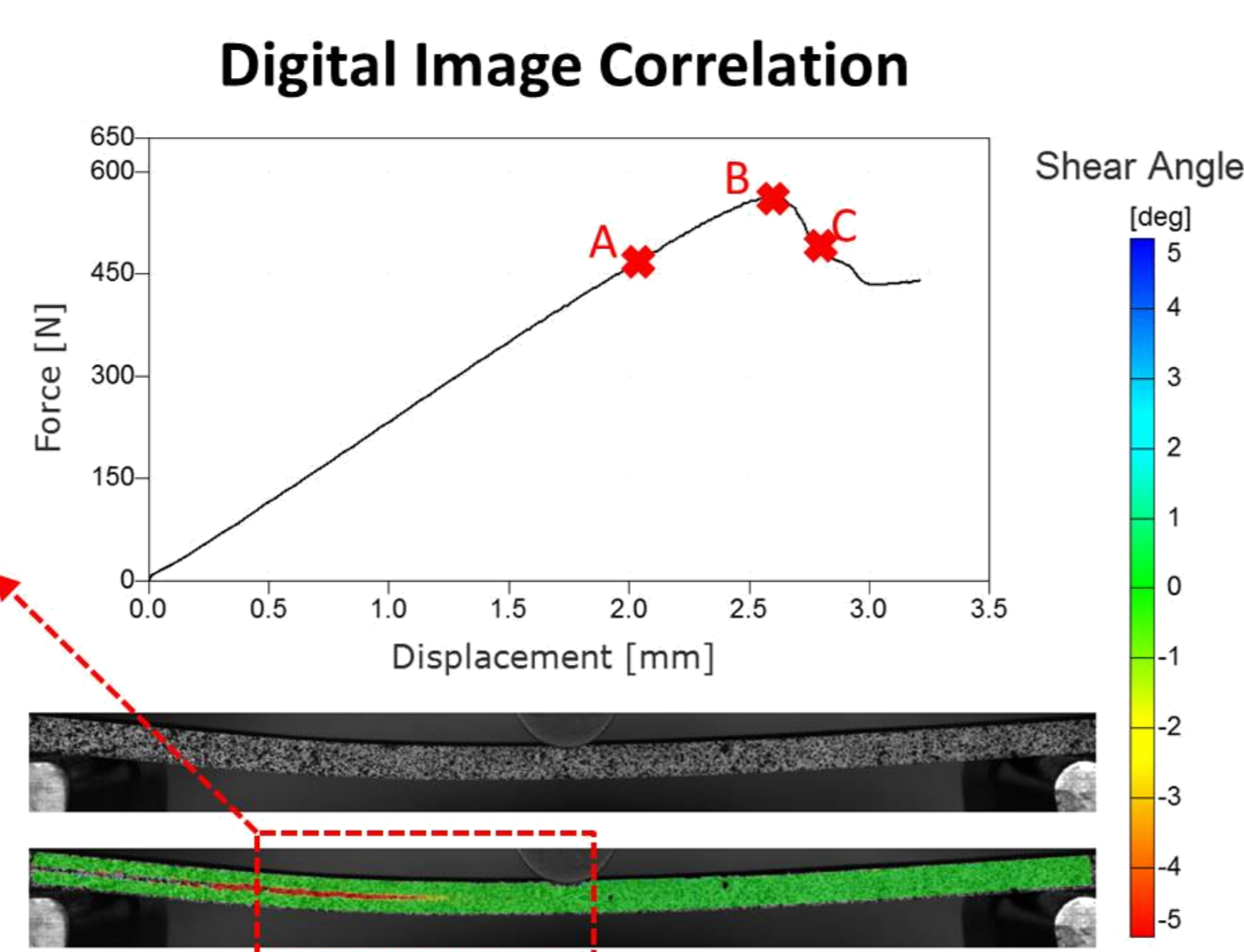
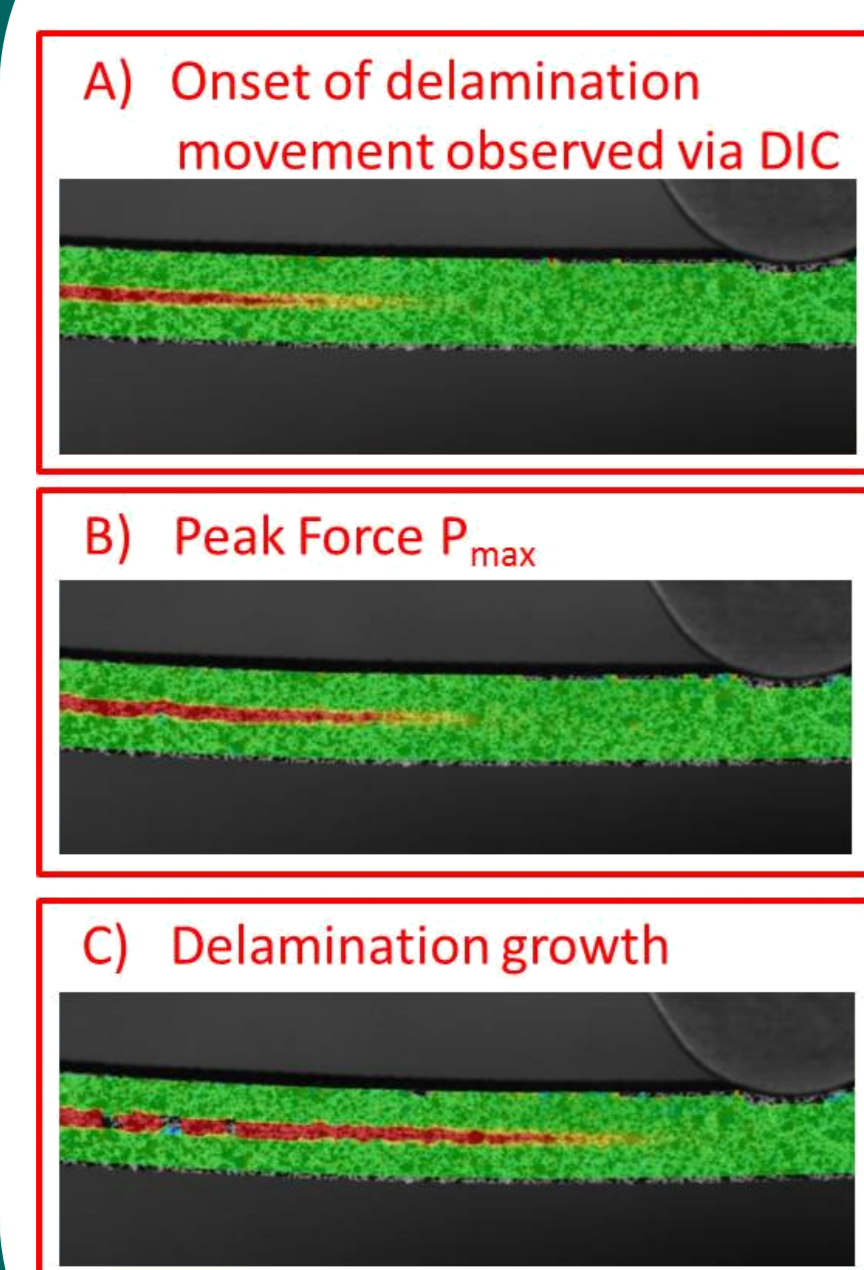
Representative R-curves: Increasing G_I values indicate crack deflection away from the interface (verified by visual examination of crack surfaces)

Correlation of results

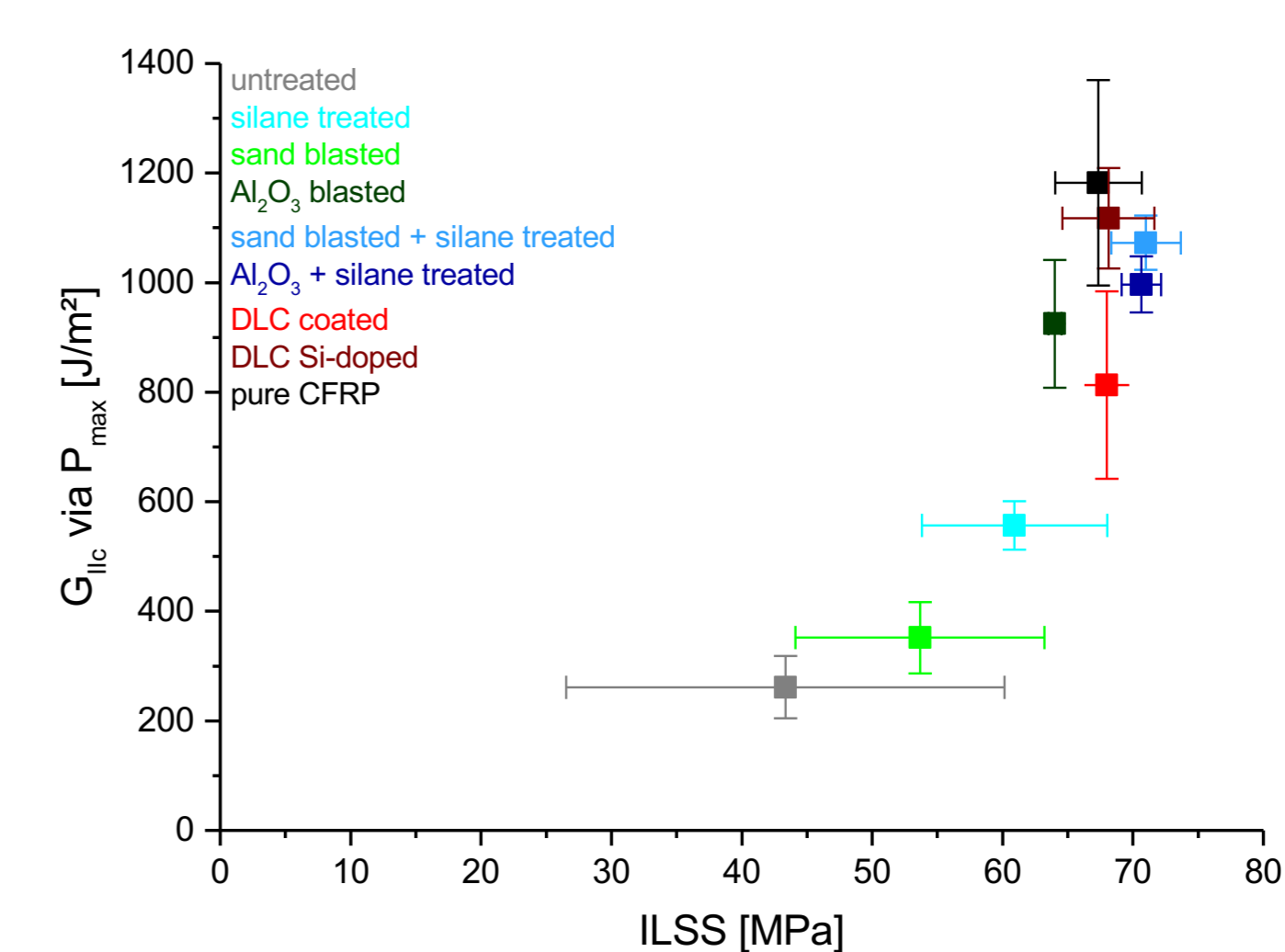
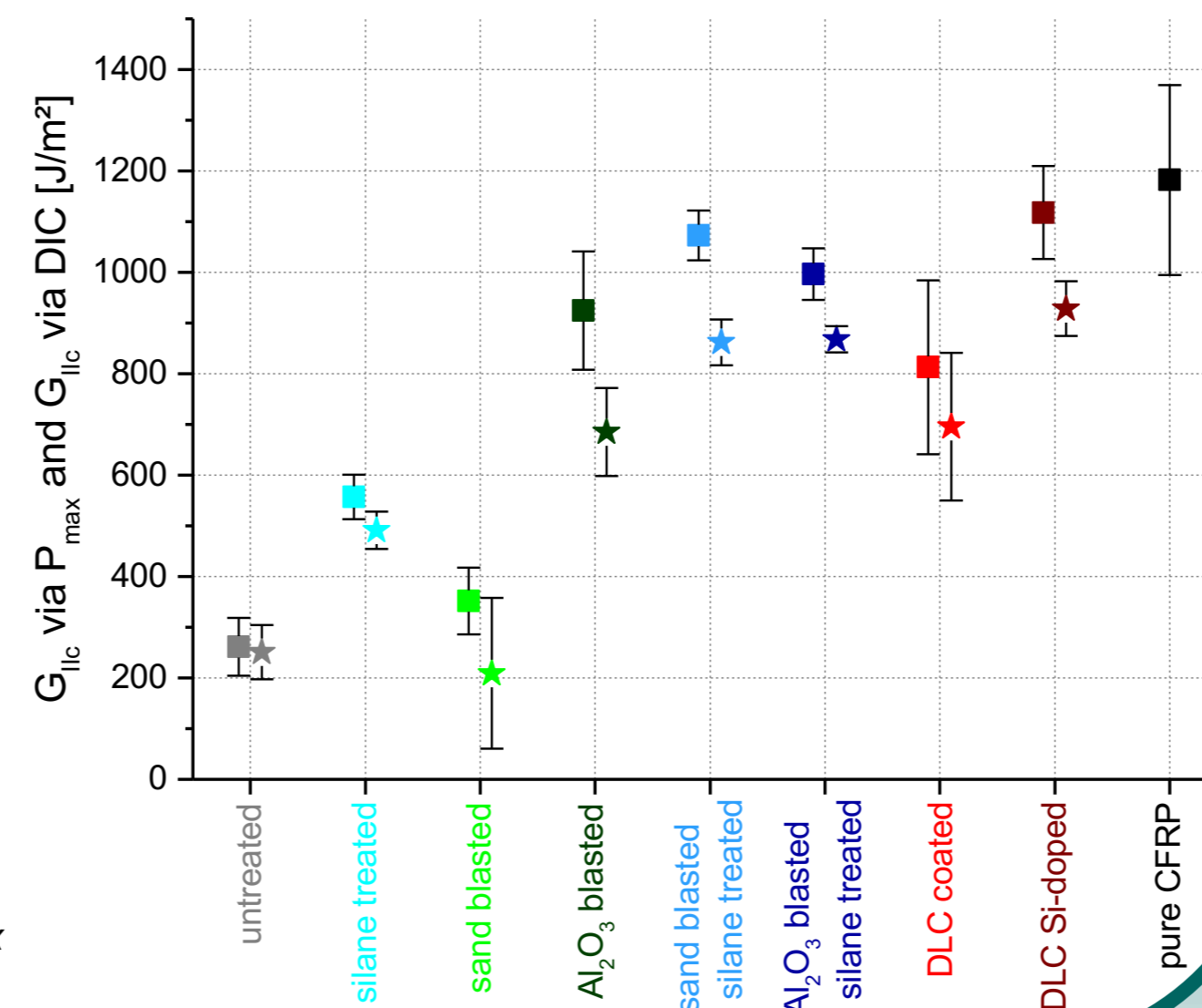


- G_{Ic} and G_{IIc} values show a significant trend (exception: sand blasted surface)
- Some G_{Ic} and G_{IIc} values approach the values of pure CFRP, indicating a high ratio of cohesive failure (crack deflection away from the interface)

Mode II results



G_{IIc} evaluated via peak force (P_{max}) and delamination onset via Digital Image Correlation (DIC):



- G_{Ic} and ILSS values show a certain correlation (ILSS test was used to screen promising surface treatments prior to mode I and mode II tests)

Onset of delamination movement observed via DIC significantly lower than P_{max}

Summary

- DCB and 3-ENF test configuration was successfully applied to symmetrical CFRP-metal laminates
- G_{Ic} and G_{IIc} values show a significant trend
- Increasing R-curves indicate crack deflection away from the interface and thus an increasing ratio of cohesive failure within bulk CFRP. This was verified by visual examination of the delamination surfaces
- ILSS test configuration applied to similar sandwich layups can be used to screen promising surface treatments
- Highest G_{Ic} and G_{IIc} values were reached by Si-doped DLC coatings, sand blasting and Al_2O_3 grit blasting combined with silane dip coating

Acknowledgements

This work was conducted within the project "FORCiM³A – Forschungsverbund CFK/Metall-Mischbauweisen im Maschinen- und Anlagenbau", which is funded by the Bayerische Forschungsstiftung (BFS). The authors want to thank the "AxynTeC Dünnschichttechnik GmbH" for the collaboration and for providing the DLC coatings.