DAMAGE CHARACTERIZATION OF DYNEEMA® HB210 VIA X-RAY COMPUTER TOMOGRAPHY

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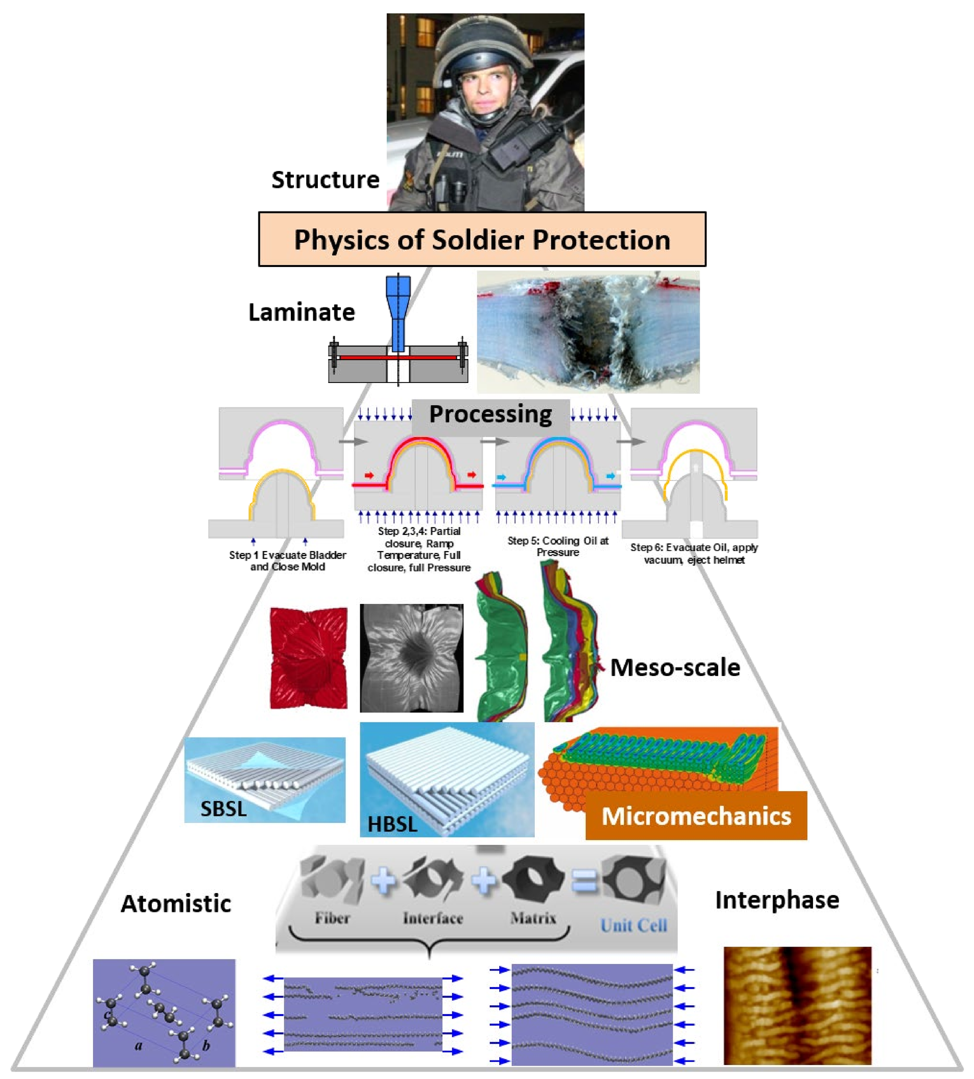
Introduction

- Dyneema® HB210 is a new material with ballistic armor applications
- HB210 has high tensile strength with low weight
- Damage mechanisms are clear at cross section of impact site for tests such as QSI and QS-PS
- Difficult to investigate cross sections without damaging fiber architecture due to high tensile strength

Objectives

- Test samples for failure response under QSI and QS-PS
- Obtain detailed images of specimen cross sections at site of impact and outside of annulus region
- Identify damage mechanisms in specimens to classify failure modes for Dyneema® HB210 for modeling

Structural Hierarchy of Materials by Design for Soldier Protection



Theory

- A parameter a/H_c serves as a boundary to define failure modes for Dyneema® HB210 where a is annulus width ($D_S - D_P$)
- Fibers fail in shear when $a/H_c <$ and fail in tension when $a/H_c > 1$

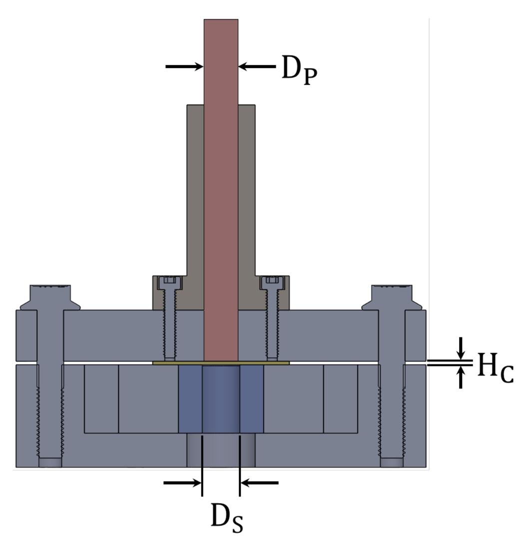
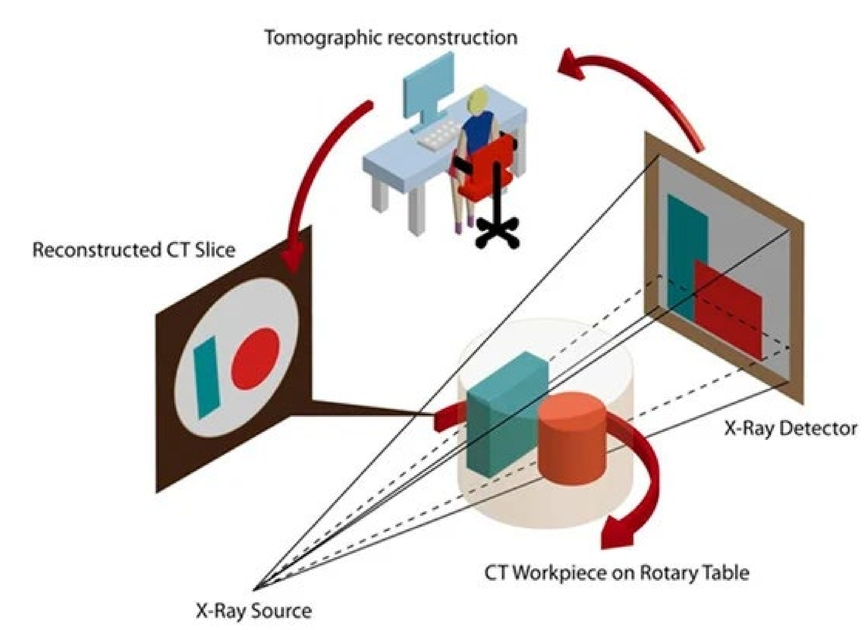


Figure 1: Diagram of cross-sectional QS-PS fixture setup featuring a/H_c parameters and a thin specimen (yellow).

X-ray CT Process

- Objects are scanned with X-rays on a rotating stage to capture 360 degrees of 2D images which are reconstructed into slices to form 3D model



QS-PS X-ray CT

- X-ray CT provides detailed 3D virtual volumes of specimens to identify failure

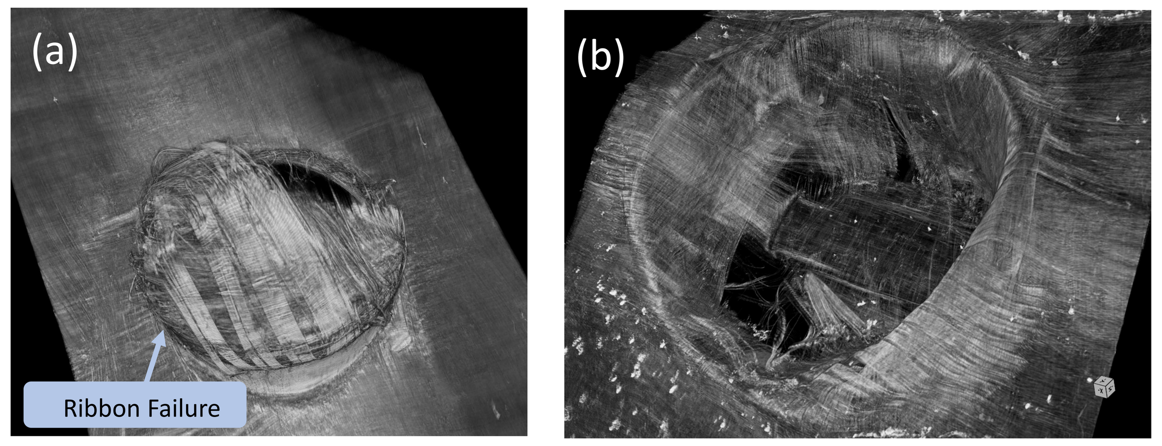


Figure 2: Isometric view of underside (a) and Impact face (b) of 2" x 2" 2L-HB210 specimen after QS-PS test beyond max failure load. HB210 specimen fibers often fail in "ribbons"

QS-PS Damage Evolution

- X-ray CT provides 3D virtual volumes of specimens with which cross sections can easily be investigated at any position in the sample

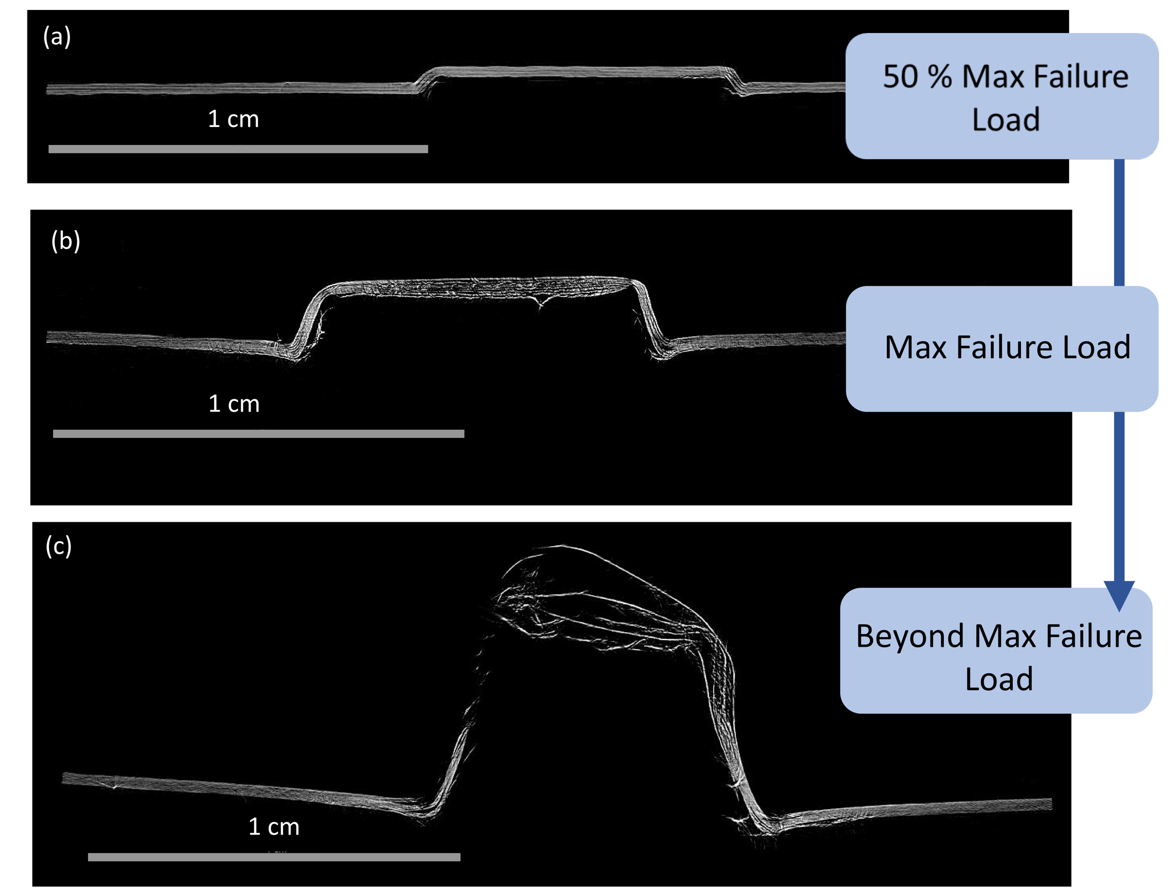


Figure 3: 2D cross sections of 3 separate 2L-HB210 specimens after QS-PS demonstrating damage evolution. The samples were displaced to 50% of max failure load (a), 100% of max failure load (b), and beyond max failure load (c)

QSI X-ray CT

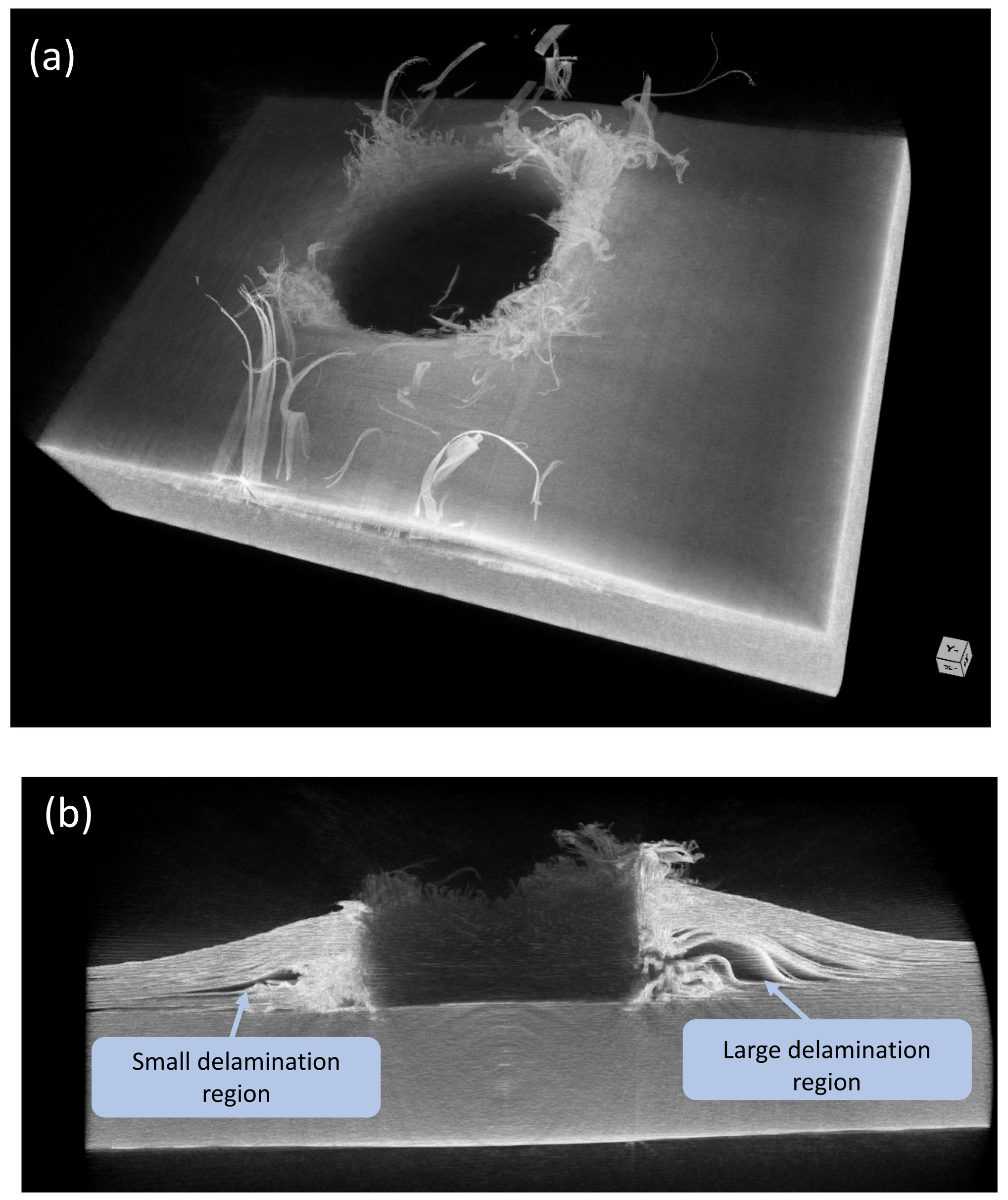


Figure 4: Isometric (a) and half width 3D cross-sectional view (b) of 5 mm thick HB210 specimen after QSI with 7.5 mm punch.

Summary and Conclusion

- X-ray CT was completed on various HB210 specimens after QSI and QS-PST testing
- Internal damage of fiber architecture is easily studied without any additional unnecessary damage
- Delamination is a primary failure mechanism preceding complete fiber failure and material flows towards punch

Future Work

- Perform Nano X-ray CT to photograph undamaged fiber cross sections to more accurately model fibral architecture
- Develop methodology to capture live X-ray Images during testing to record video of internal damage mechanisms
- Export mesh of scans as finite element model to directly compare experimental results to FEM simulations
- Use results of X-ray CT imaging to model interfibrillar damage interactions in LS-DYNA

Acknowledgements

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References

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