EFFECT OF PROCESSING ON POLYMER STRUCTURE IN ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE COMPOSITES

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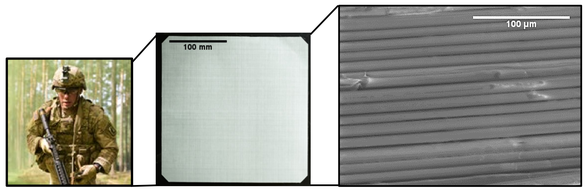
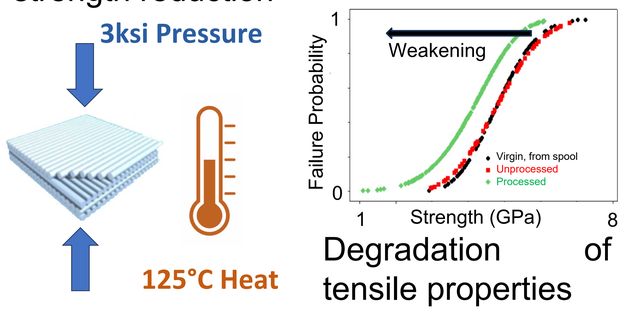
Ultra high molecular weight polyethylene (UHMWPE) composites

are used in a variety of applications for personnel protection for DoD and First responders

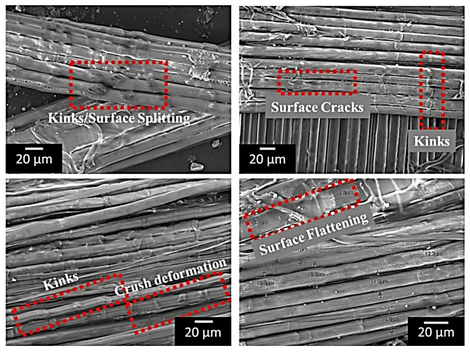


The processing of these composites requires compaction and heat to consolidate the laminates

This damages the individual fibers, resulting in defects and significant strength reduction



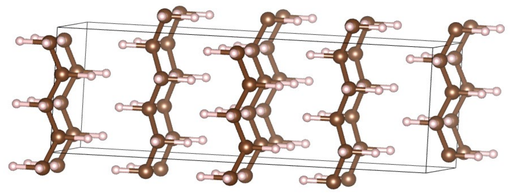
Degradation of tensile properties



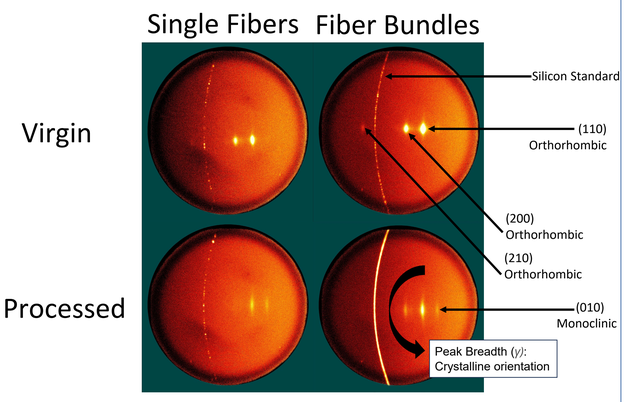
Project statement: Understand the processing-induced damage modes occurring at the crystalline level

X Ray Diffraction (XRD)

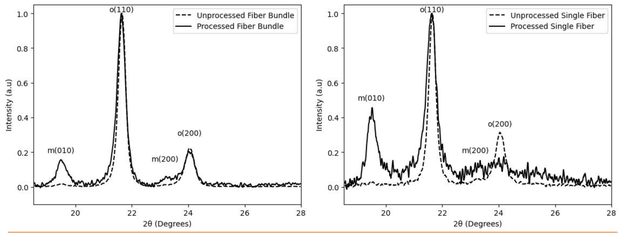
UHMW Polyethylene is approximately 90% crystalline, stable at room temperature in the orthorhombic phase



XRD enables identification of crystalline properties through characteristic diffraction

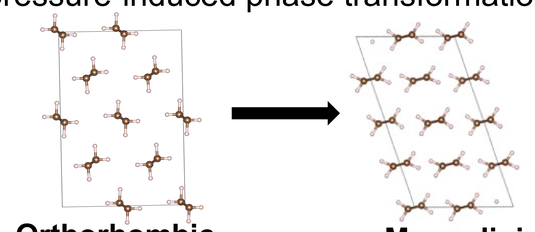


Integration of data radially generates 2θ plots



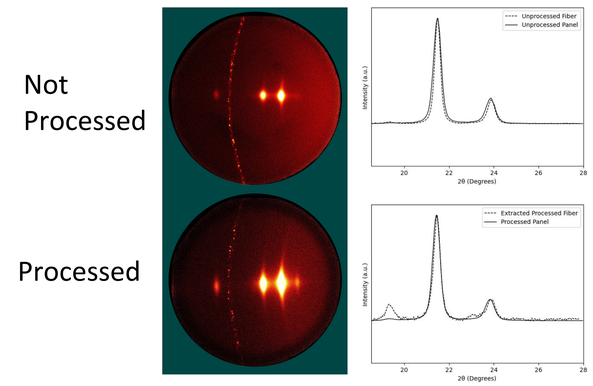
Unprocessed fiber → 95% orthorhombic phase, 0% monoclinic phase
Processed fiber → 67% orthorhombic phase, 38% monoclinic phase

Processing the sheets gives rise to a pressure-induced phase transformation

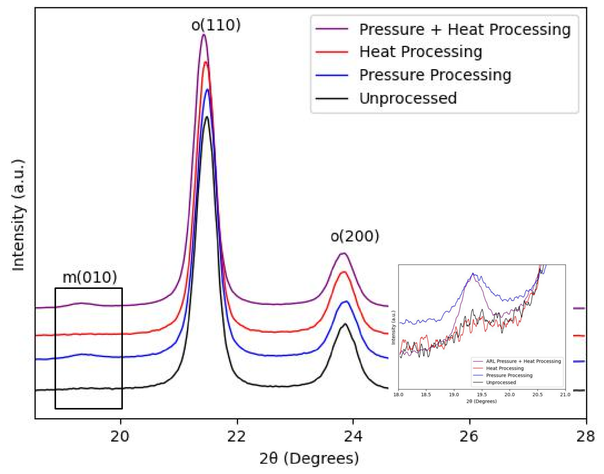


Effects of Temperature and Pressure on Crystalline Structure

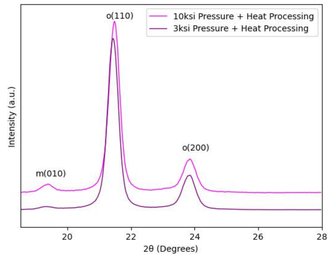
Analyzing composite sheets avoids the fiber extraction step, and decreases acquisition time while maintaining orientation and phase information



Processing elements were separated:



The phase transition can be linked to the application of sustained pressure



3ksi pressure: 1% monoclinic phase

10ksi pressure: 3% monoclinic phase

Conclusions

The processing of UHMWPE composites damages the fibers, causing a reduction in tensile modulus and thus composite properties

Application of pressure and temperature

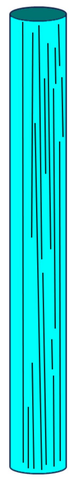
Macroscopic deformation of filaments

Shear-induced phase transformation

XRD identifies evidence of deformation in sheets

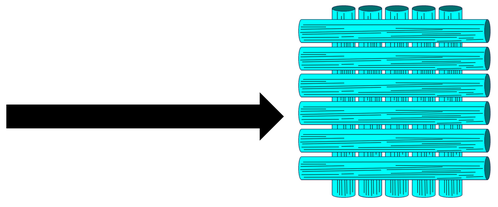
A new high-throughput UHMWPE composite analysis was proven

Future Work



There is a need to understand the variation in the crystalline structure of single fibers.

Understanding single fibers will enable understanding UHMWPE composites



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