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The Search for Multi-Functional Composite Material and Structure

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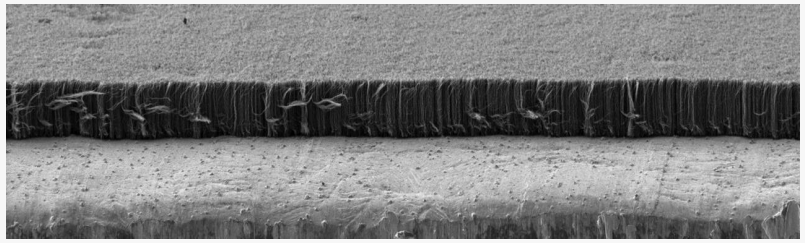
Composite Applications

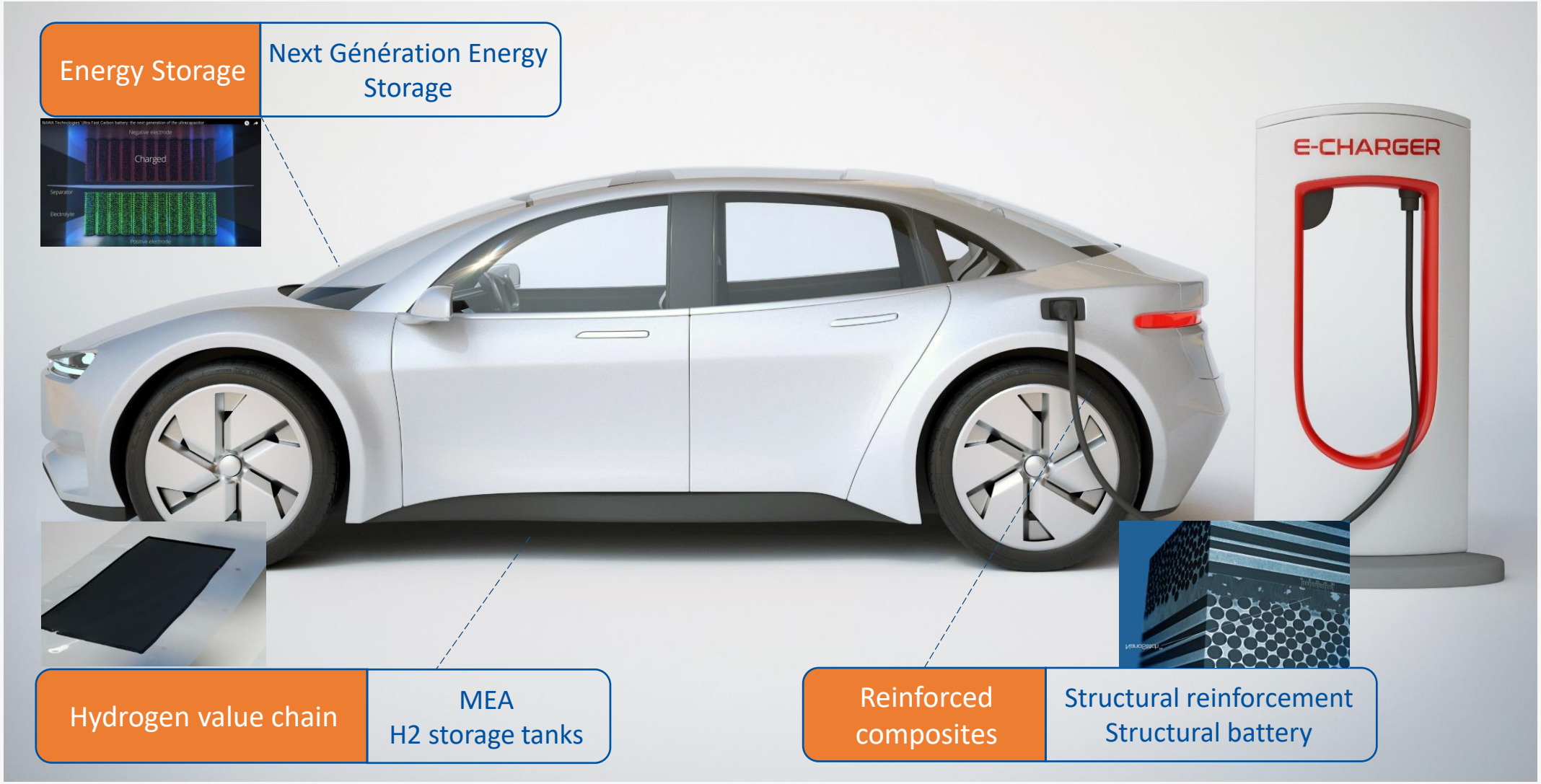
- Fatigue
- Interlaminar Shear
- Micro-Cracking
- Impact
- Thermal & Electrical properties



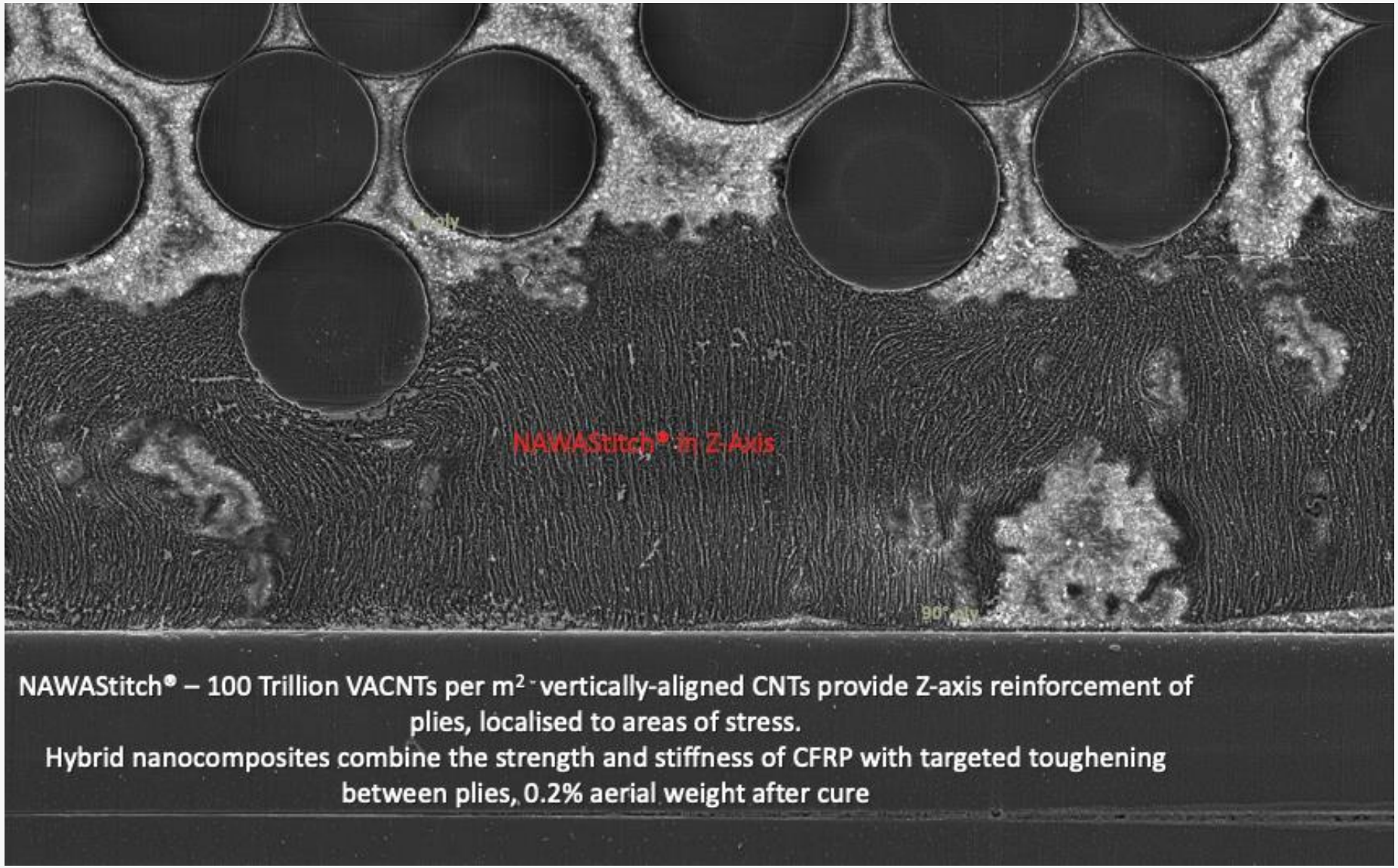
Advanced Energy Solutions

- Ultra Fast Charging
- High Power Density
- Long Life (lower Cost)
- Temperature Stability
- Safe

UNIQUE FUSION OF NANO TECHNOLOGY TO SOLVE COMPLEX TECHNICAL CHALLENGES

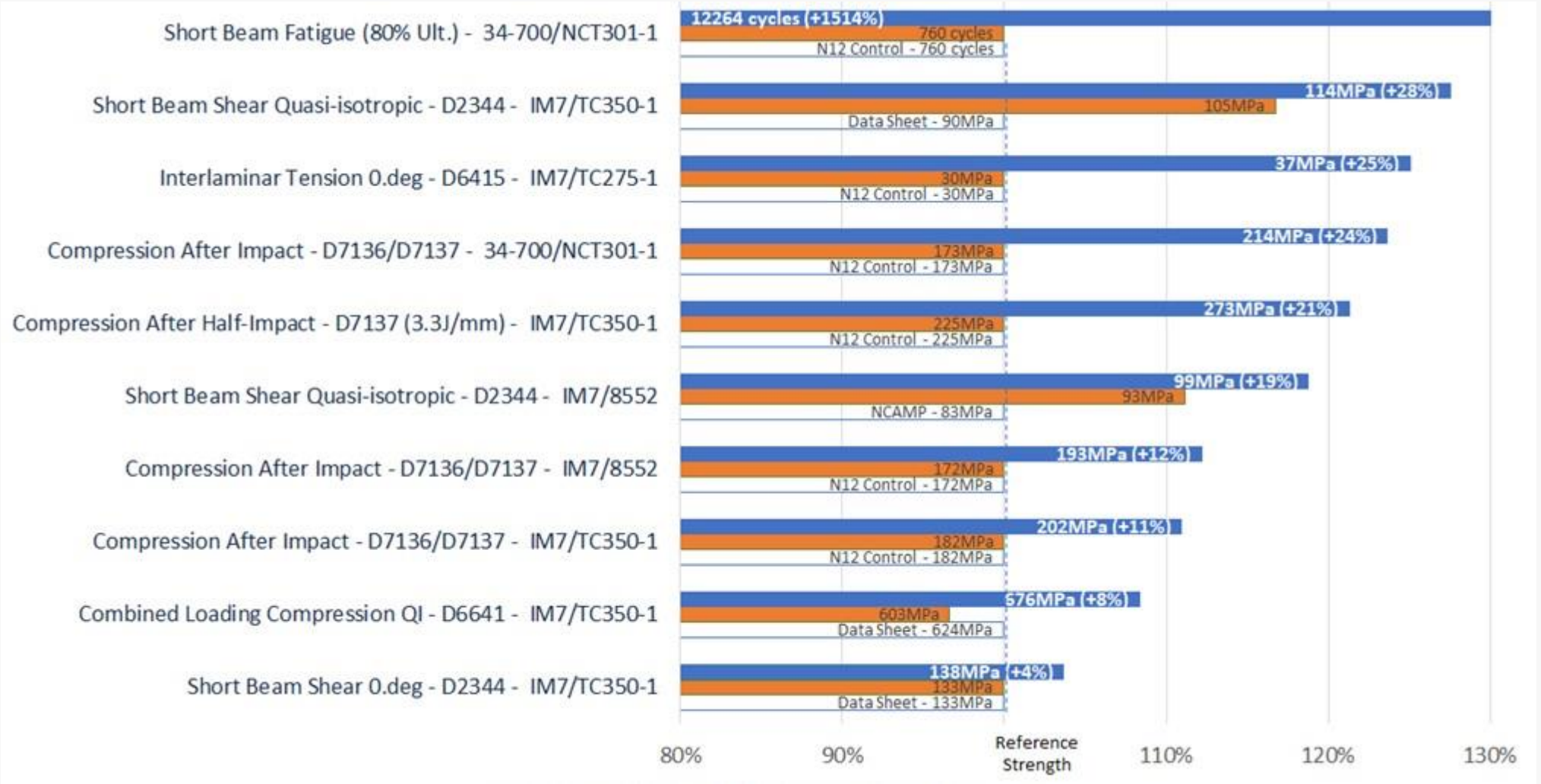


Introduction of NAWAStitch



NAWAStitch® – 100 Trillion VACNTs per m^2 - vertically-aligned CNTs provide Z-axis reinforcement of plies, localised to areas of stress.
Hybrid nanocomposites combine the strength and stiffness of CFRP with targeted toughening between plies, 0.2% aerial weight after cure

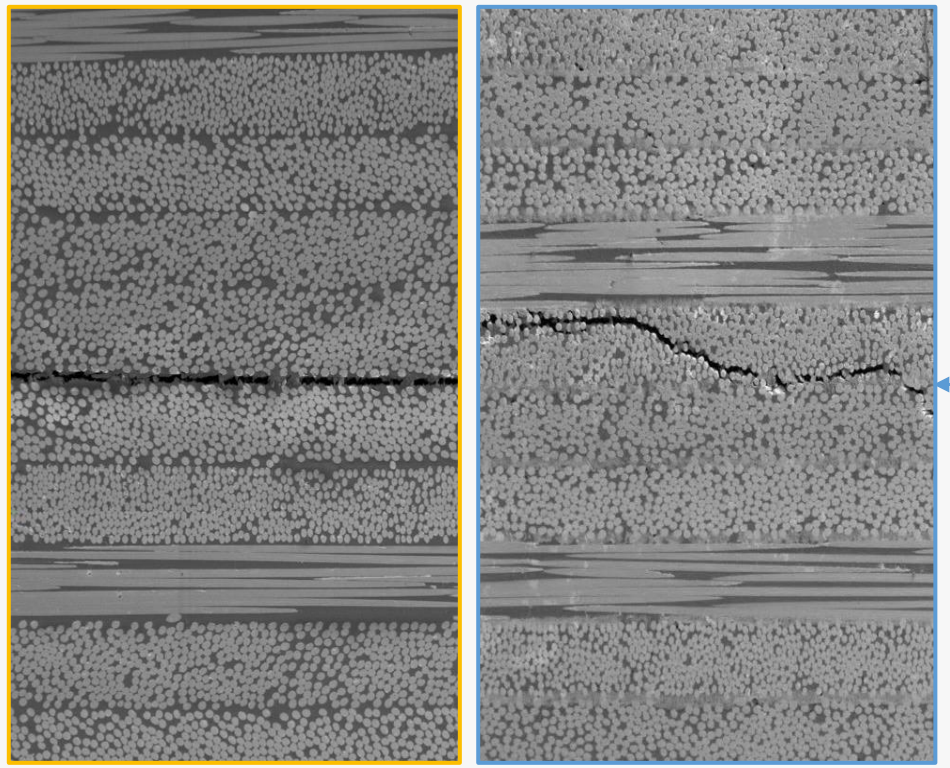
Understanding the Advantage of VACNT's in Composite Structures



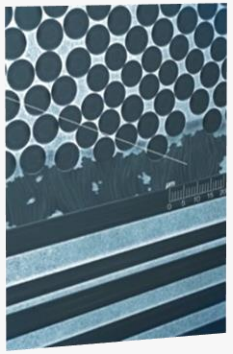
Understanding the Advantage of VACNT's in Composite Structures

No Nawastitch at interfaces

Fracture propagates along interface



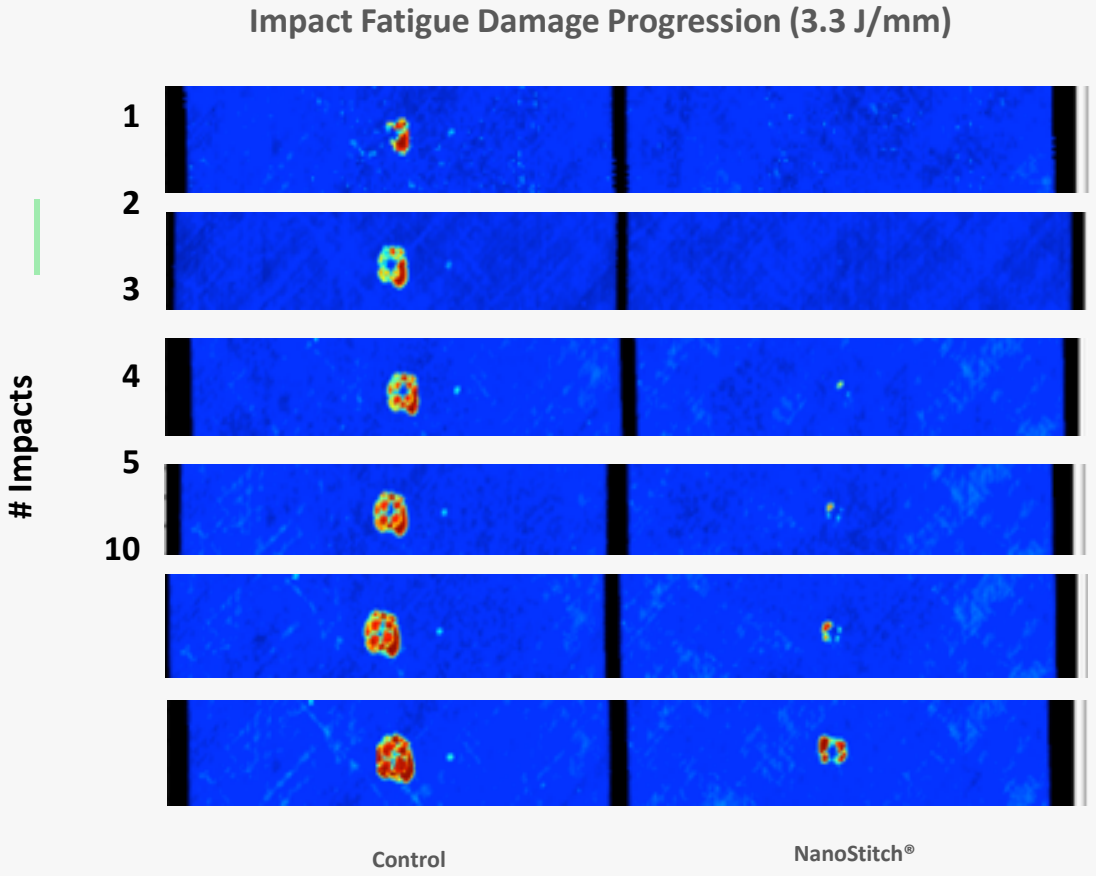
Nawastitch at interfaces



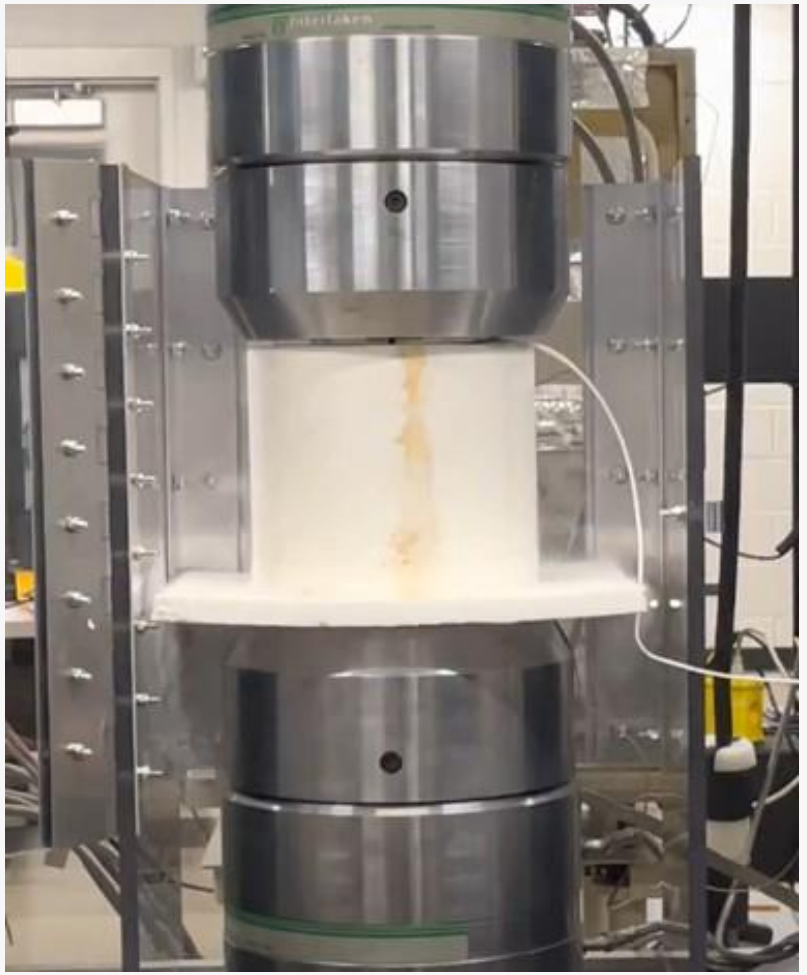
Fracture is driven into ply and stops propagating

- ✓ Impact damage tolerance (+900%)
- ✓ Shear fatigue (+5x-40x)
- ✓ ILSS (+20-30%)
- ✓ ILT (+25%)
- ✓ CAI (+15-50%)
- ✓ Compression (+10%)
- ✓ No negative deltas against baselines.

Understanding the Advantage of VACNT's in Composite Structures



Impact "fatigue" is conducted by hitting a single point multiple times at low energy, illustrating the growth of impact damage over time



Testing at -195C (-320F)

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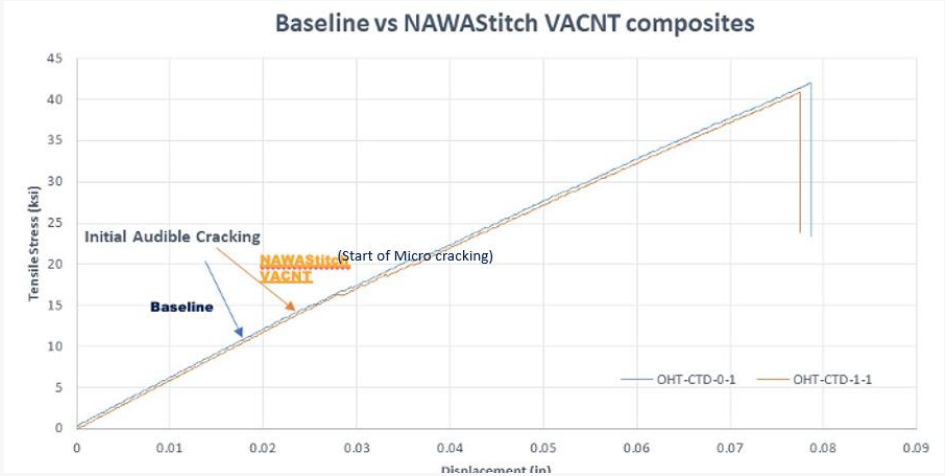
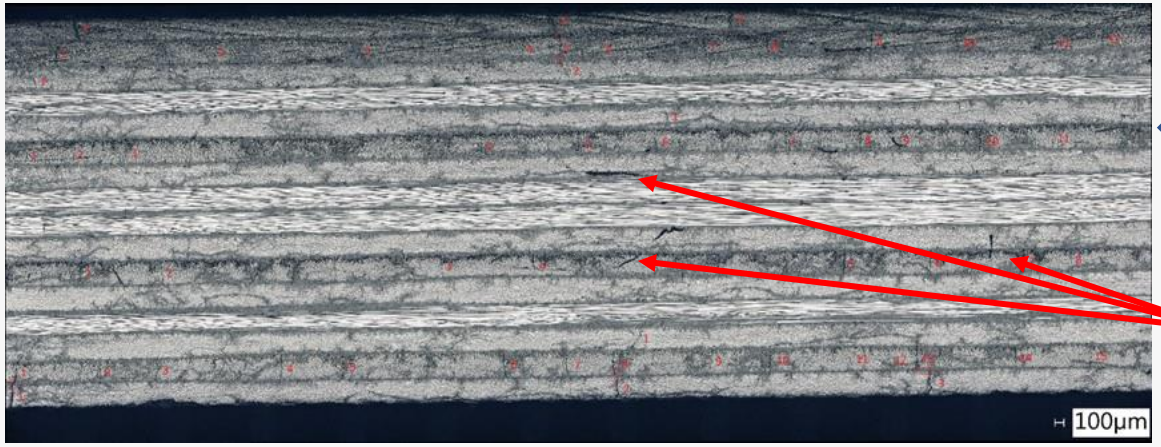
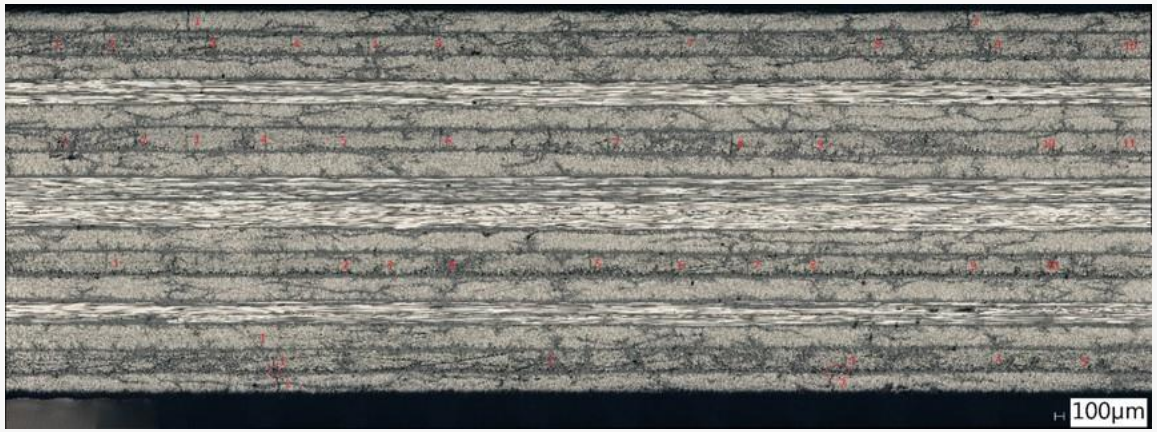
H2 Tank Testing, Cyclic Strain / Stress Testing at -195.8C (-320F)





Baseline laminate

Visible Micro Cracking
(microcracks on the NAWA Panel are smaller and fewer in number, also the microcracks on the NAWA Panel did not link up



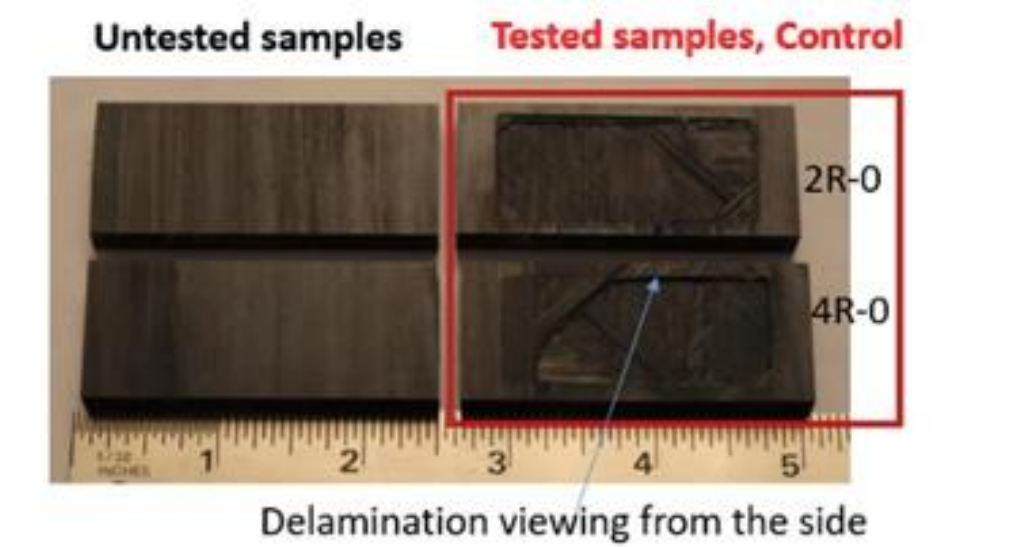
NAWAStitch VACNT laminate

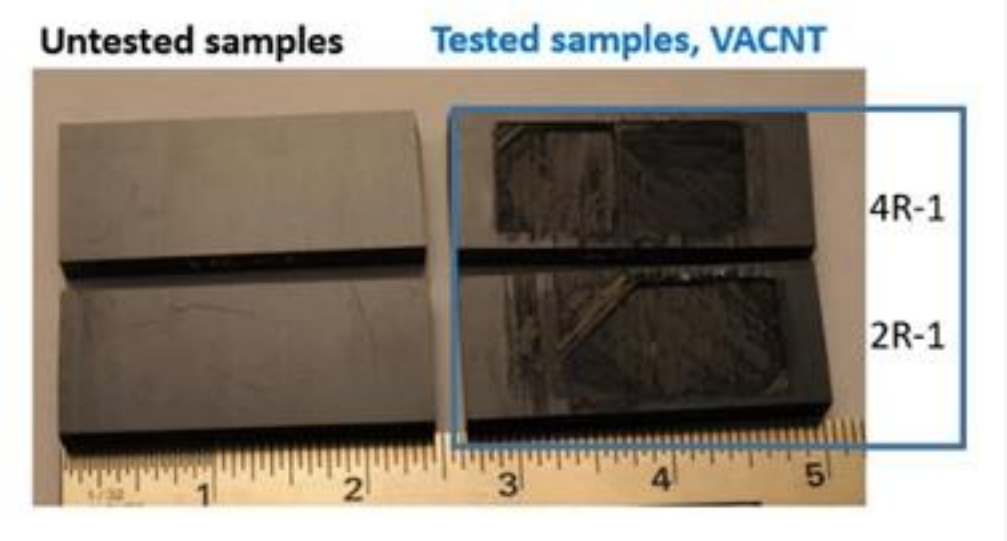
Benefits of NAWAStitch

- 50% less microcracking on 45 degree plys
- 20% less microcracking on 90 degree Plys
- Micro cracking starts at 20% higher strain levels

NAWA H2 tank Patent in Process

Understanding the Advantage of VACNT's in Composite Structures / Erosion Testing

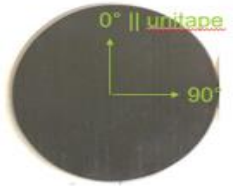


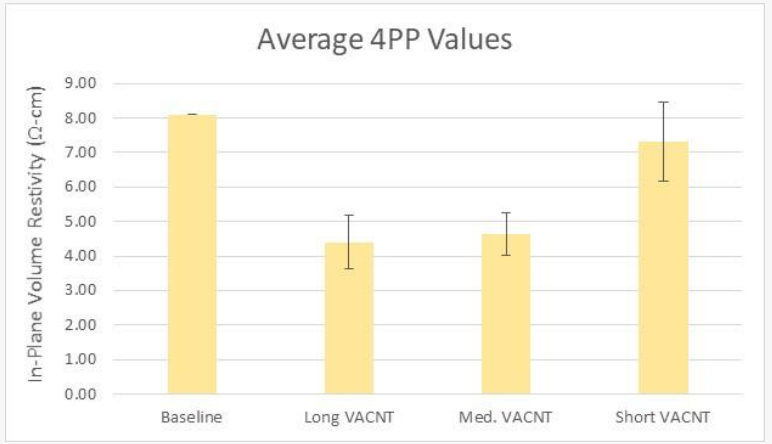


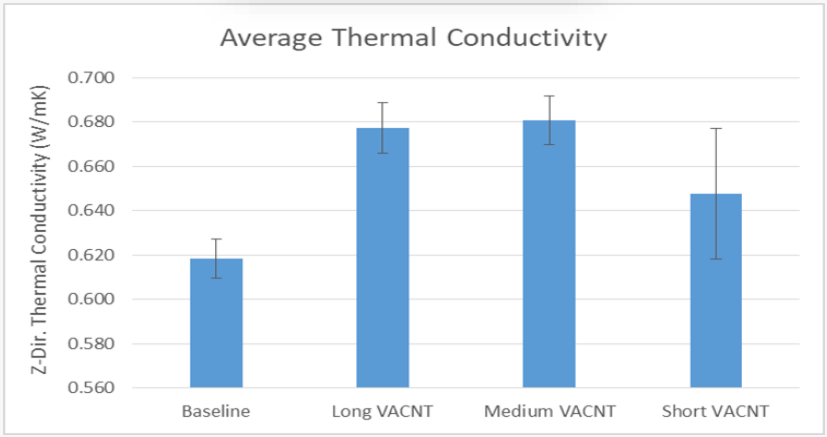
The following results were observed in the rain erosion tests at certain time markers test conducted at 300 mph:

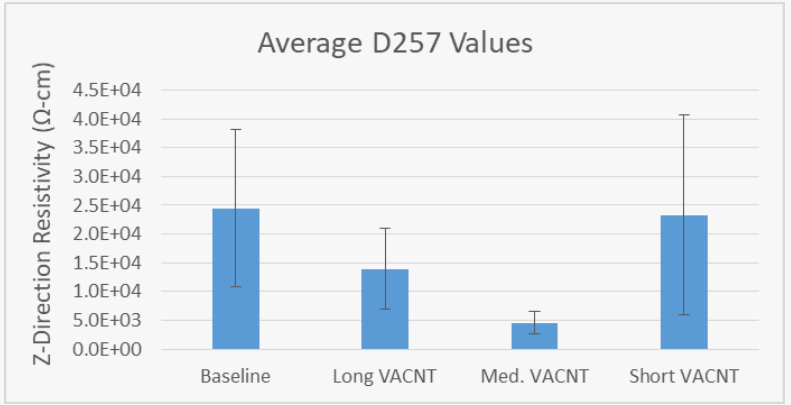
- 30 minutes: erosion was observed on the control sample but no damage was observed on the panel with VACNTs on the surface
- 60 minutes: the VACNT panel started to show some minor pitting damage on the surface
- 180 minutes: the VACNT panel showed less than half the damage of the control panel
- Throughout all the tests the VACNT panel showed less damage than the control panel

Understanding the Electrical & Thermal Properties

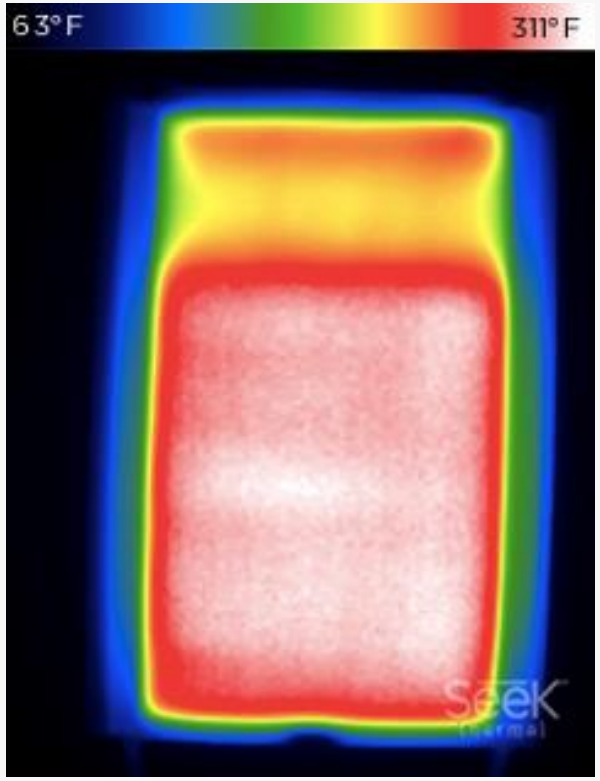




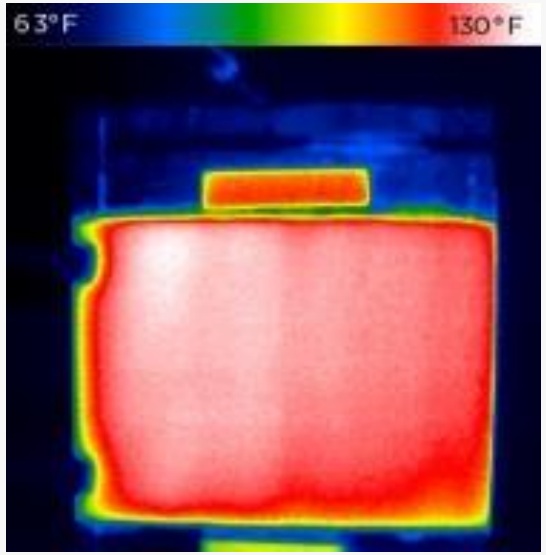




- VACNT's electrical & Thermal properties / heating rate very stable and consistent

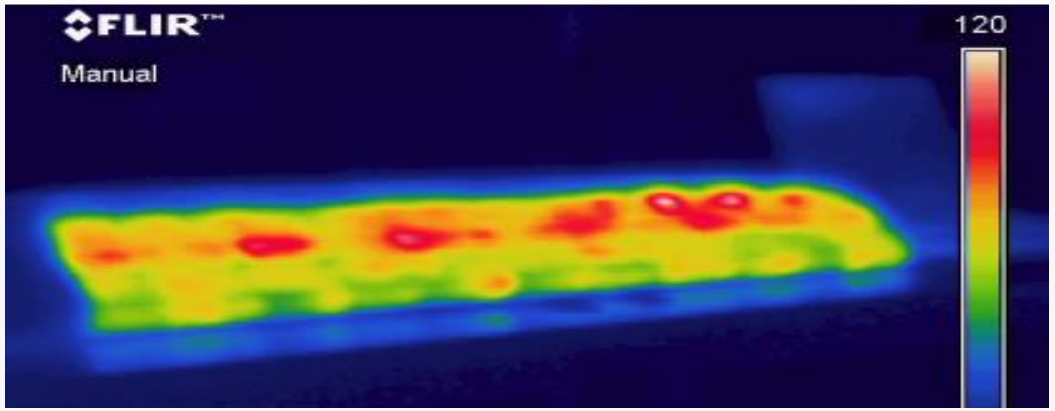


Zoned Heating Capability
310F = 154C



24 hour test at 52C (125F)
Power usage at 18.6A

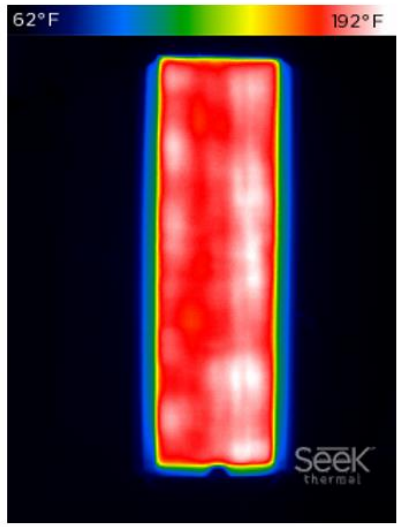
NAWA Anti Icing / Deicing Patent in Process

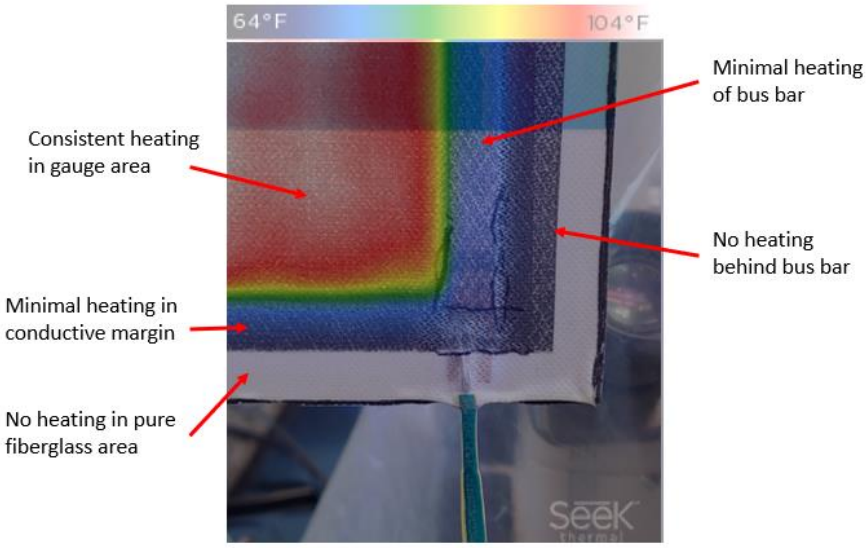


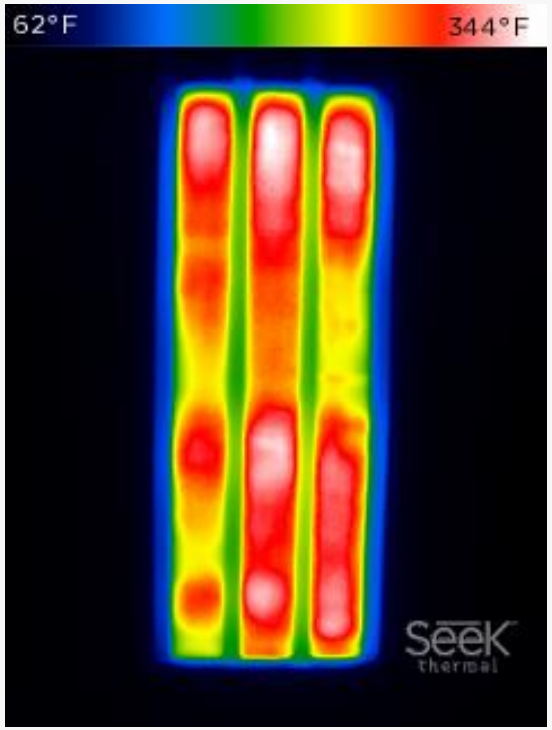
Structural health monitoring

Multi Functional Structures

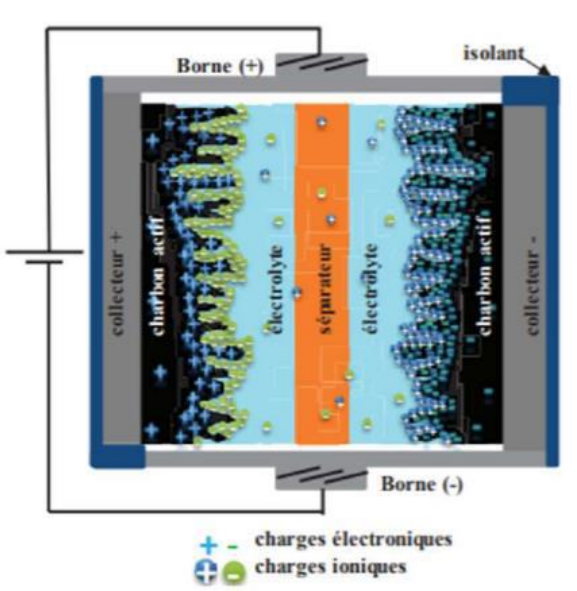
NAWAStitch Cured Panel



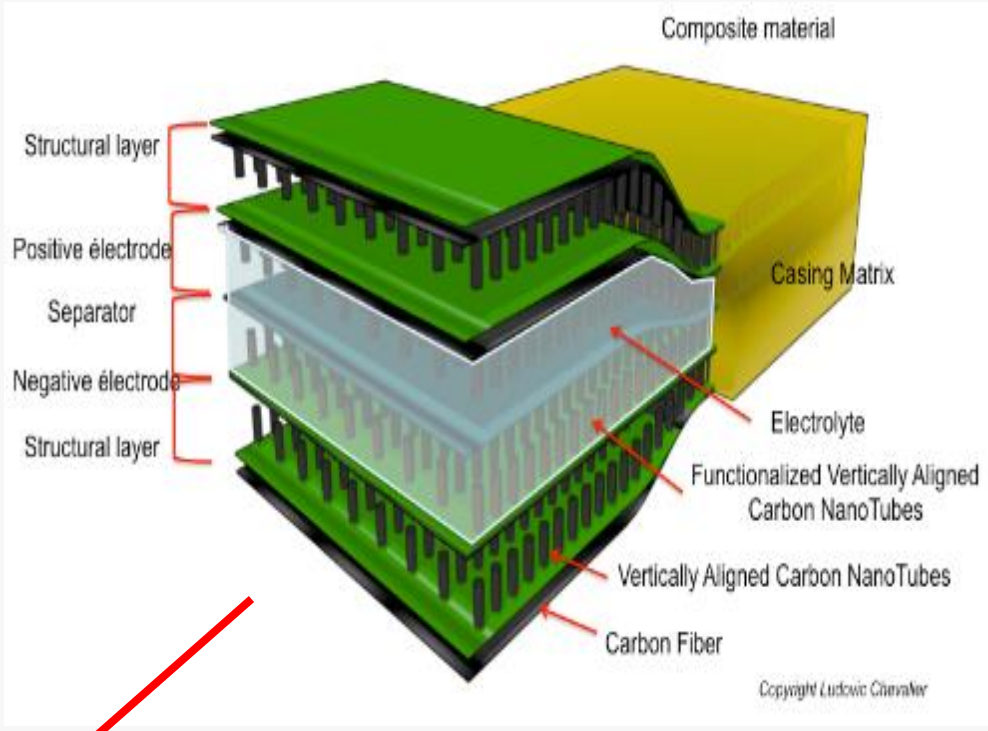


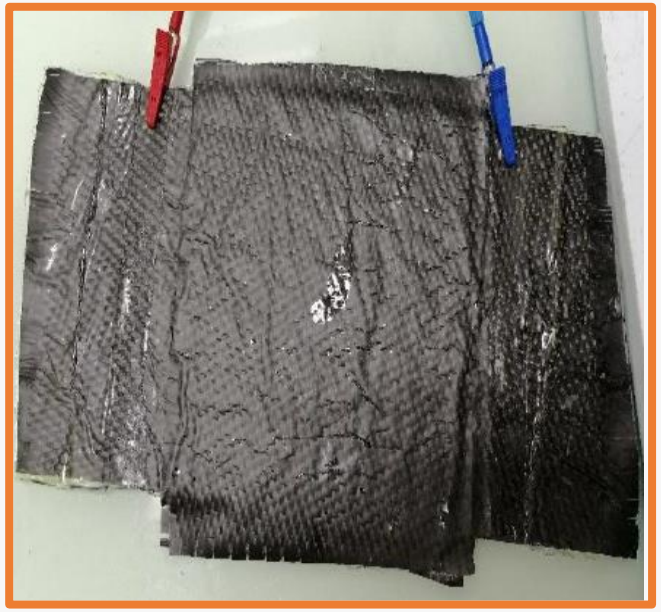


Multiple Zoned heating

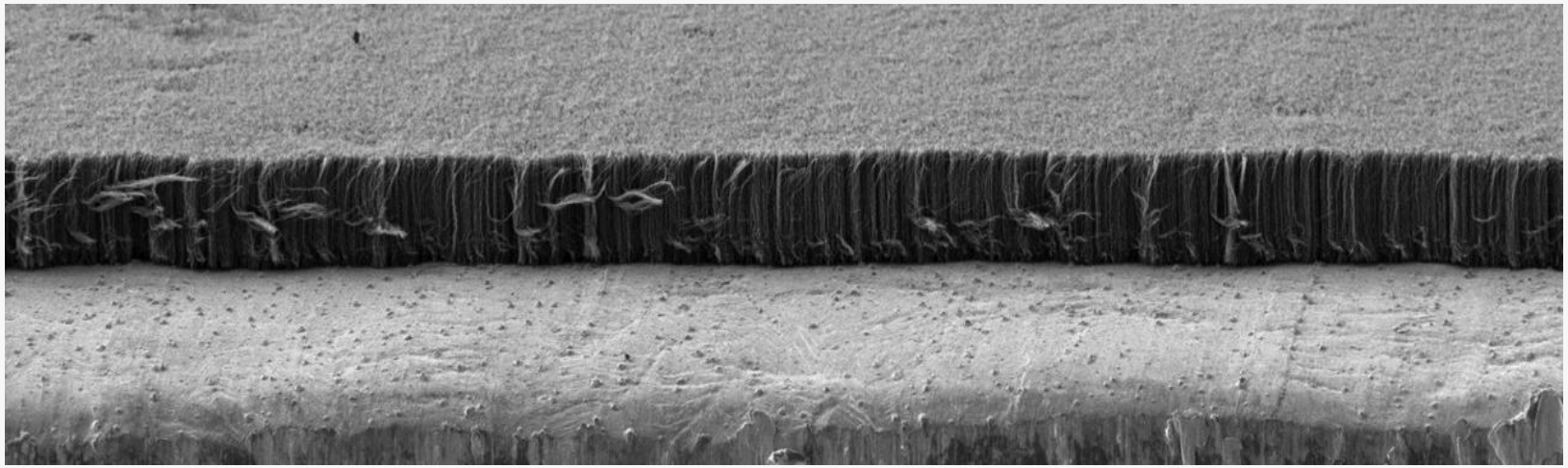


Typical Electrical Double Layer superCapacitor (EDLC)





Carbon fiber reinforced structural supercapacitor



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