COMPRESSION AFTER IMPACT FATIGUE DAMAGE GROWTH IN CFRP – WHAT DOES NO-GROWTH REALLY MEAN?

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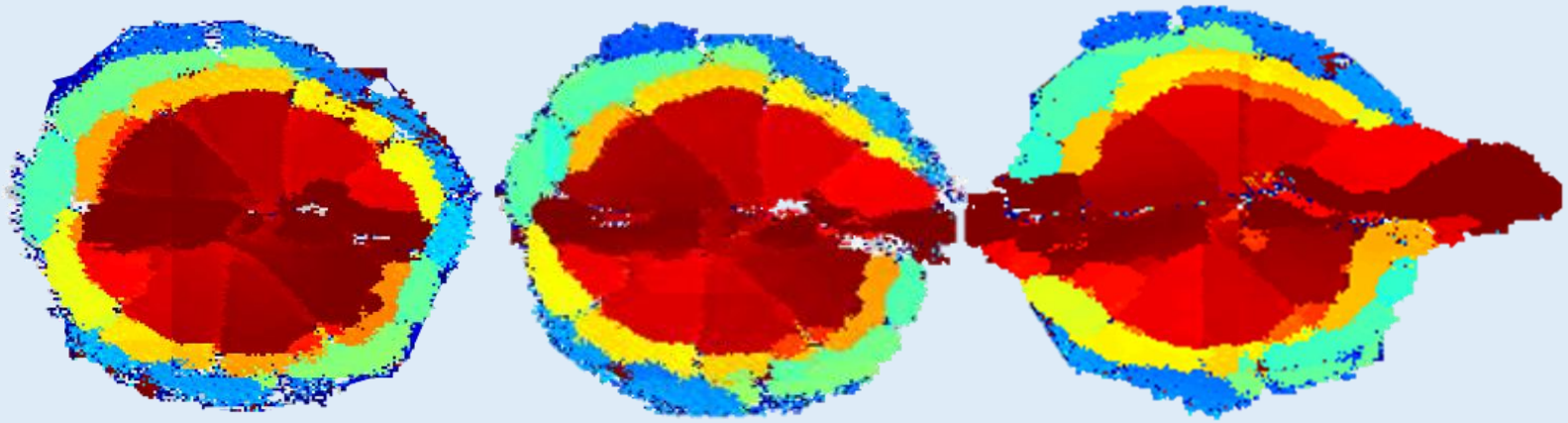
Aerospace Structures & Materials

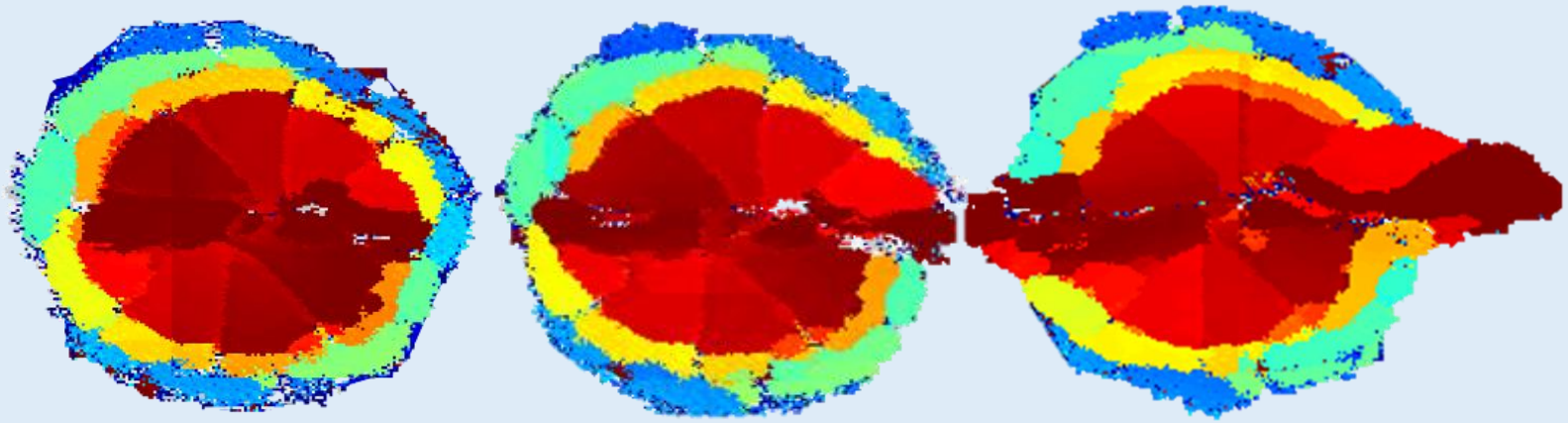
CAI fatigue in CFRP



No observed growth ≠ no absolute growth

projected delaminated area

CAI fatigue in CFRP

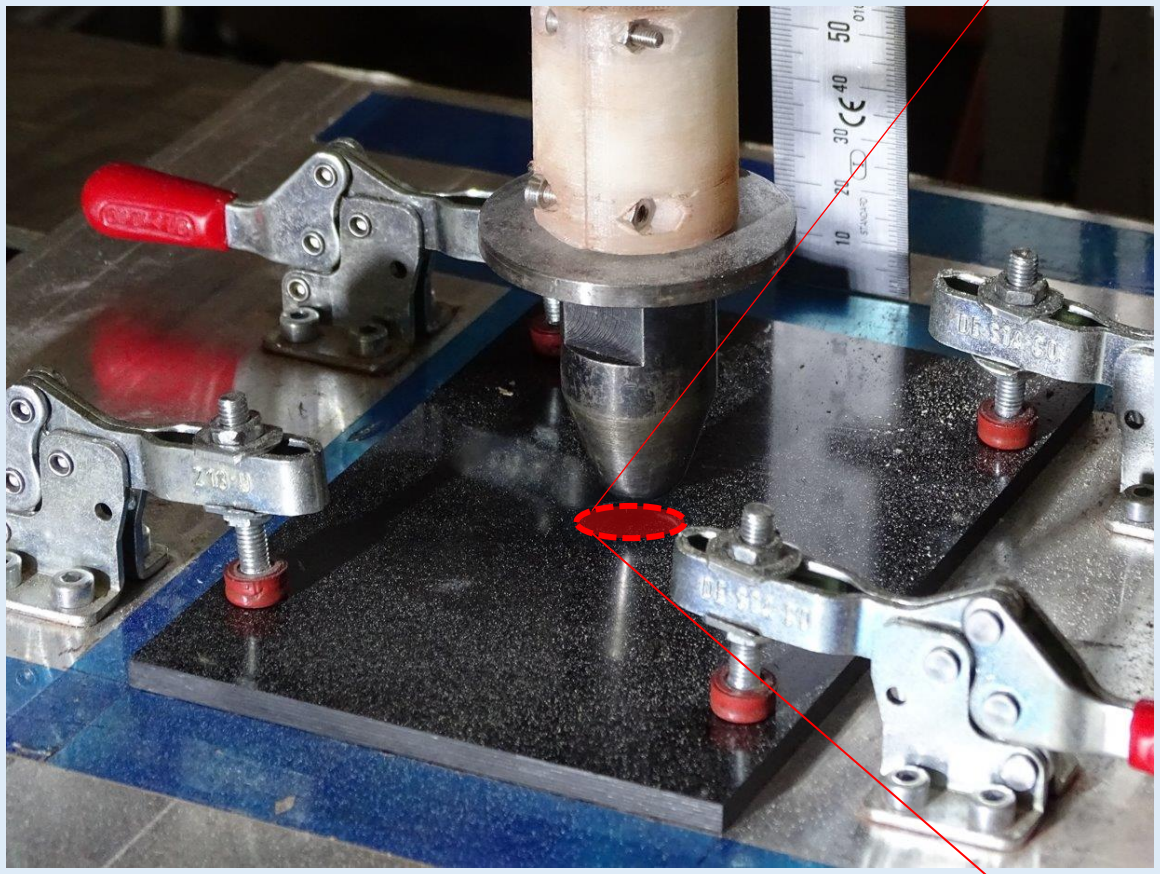


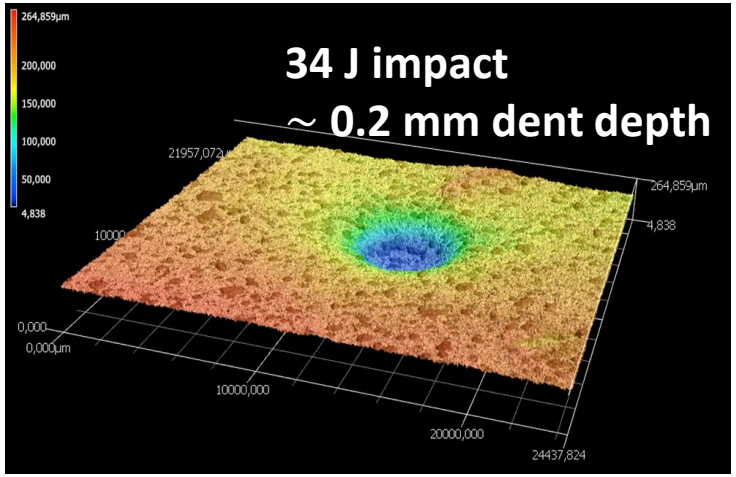
No observed growth ≠ no absolute growth

~~projected delaminated area~~

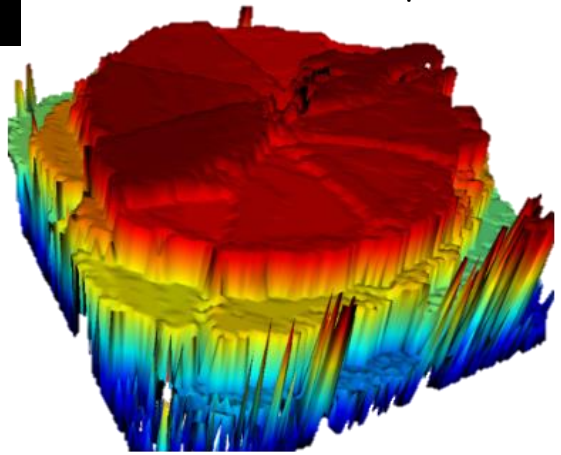
What is growth in CFAI?

Barely Visible Impact Damage

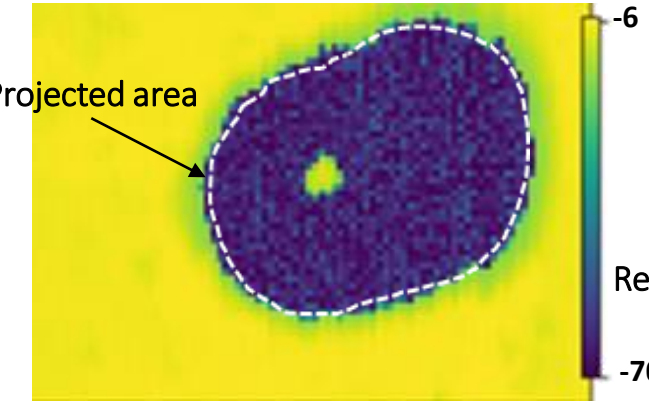




Staircase 3D shape



Non-delaminated
central cone

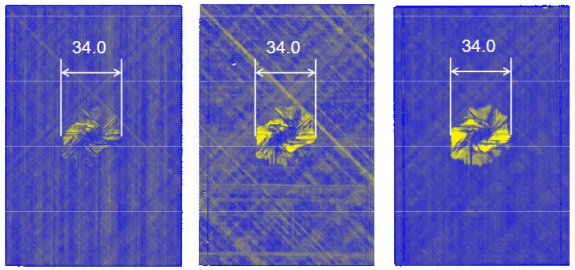


Fatigue after impact: plateau or gradual growth?

1. No-growth of projected area

Fatigue behavior and lifetime distribution of impact-damaged carbon fiber/toughened epoxy composites under compressive loading

Toshio Ogasawara , Sunao Sugimoto , Hisaya Katoh & Takashi Ishikawa



3. Gradual growth projected area

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Effect of loading parameters on the fatigue behavior of impact damaged composite laminates

Milan Mitrovic [a], H. Thomas Hahn [a,*], Greg P. Carman [a], Peter Shyprykevich [b]

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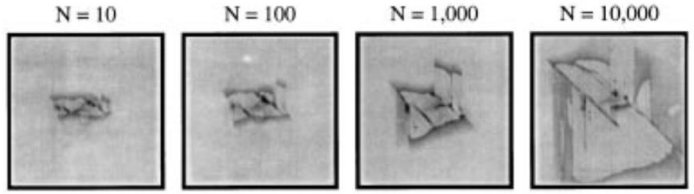
Received 26 July 1998; received in revised form 5 March 1999; accepted 12 April 1999



2. Plateau phase projected area

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International Journal of Fatigue 24 (2002) 257–261

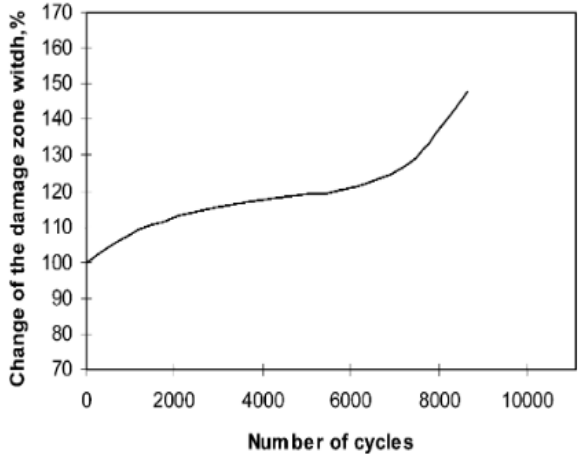
International Journal of Fatigue

www.elsevier.com/locate/ijfatigue

Impact damage growth in composites under fatigue conditions monitored by acoustography

A.S. Chen, D.P. Almond *, B. Harris

Materials Research Centre, Department of Engineering and Applied Science, University of Bath, Bath, BA2 7AY UK



Experimental procedure

1. LVI test

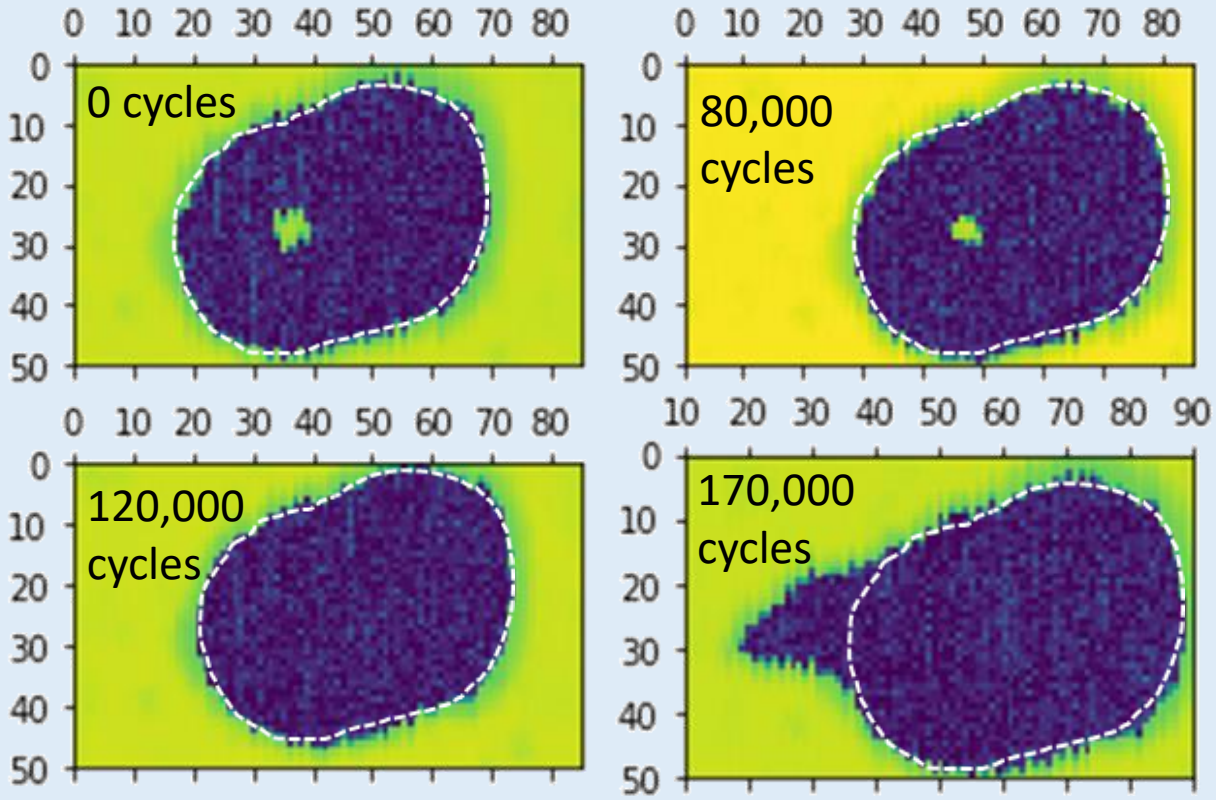
2. CFAI test

Echo-pulse ultrasound scan (Dolphicam 2)

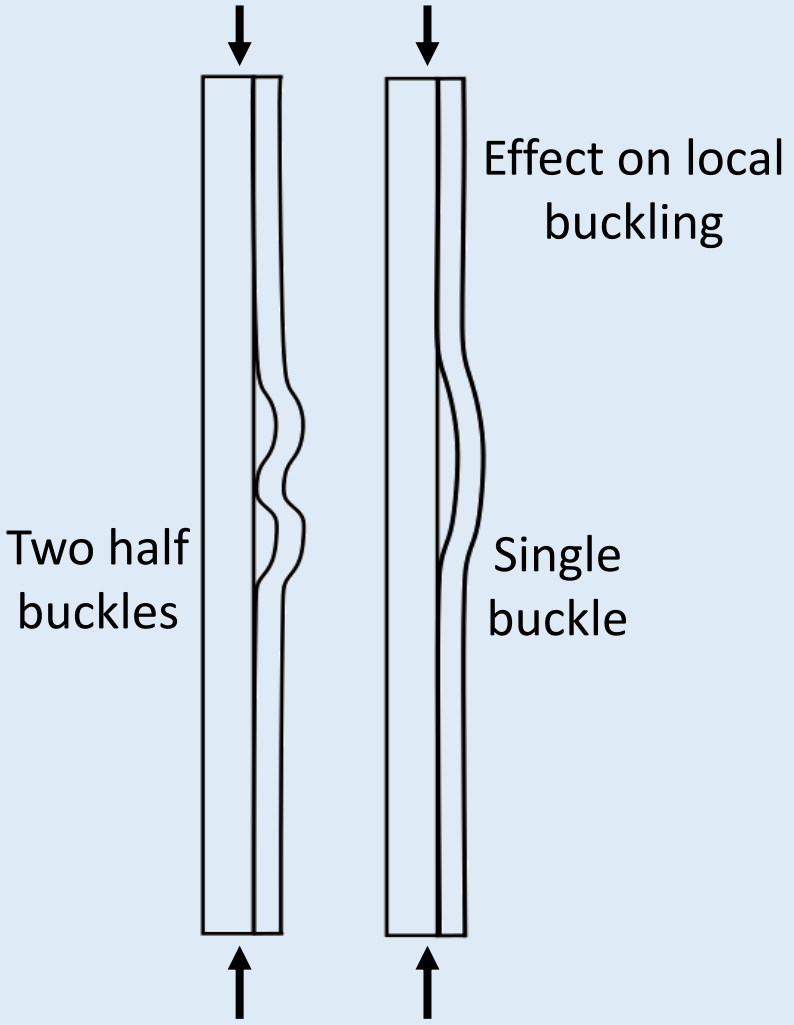
Through thickness transmission ultrasound scan

Acoustic emissions

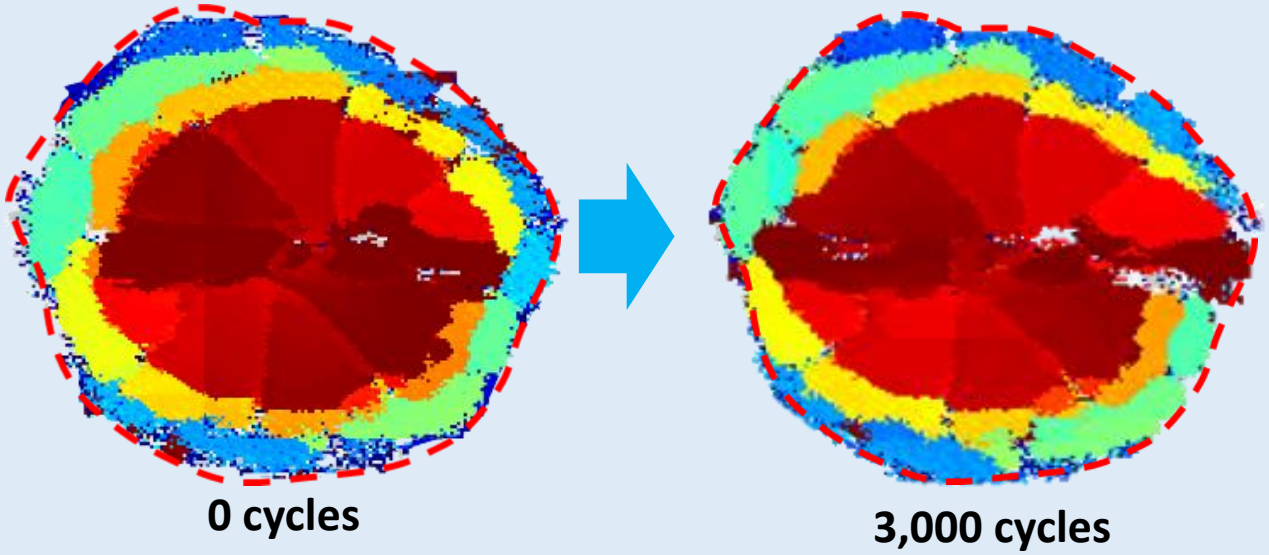
Growth inside the non delaminated cone must be considered



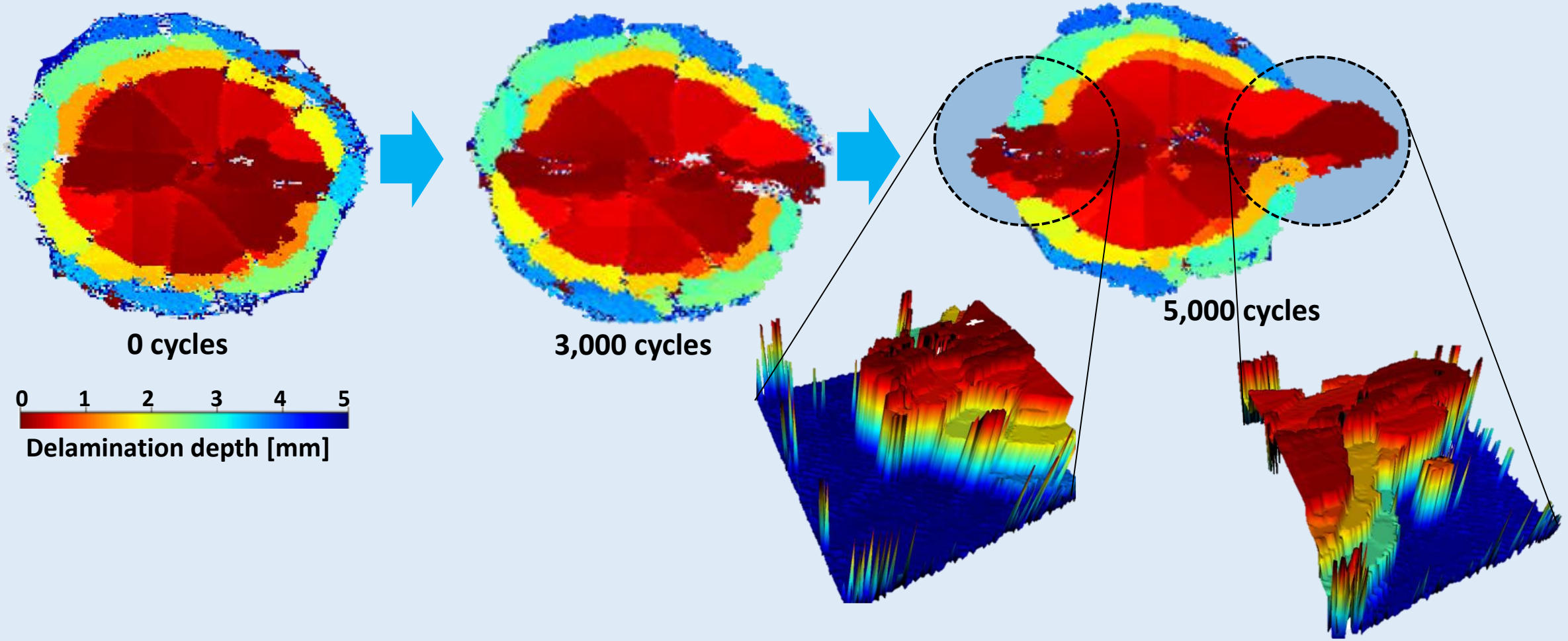
Through thickness transmission scan



Preferential growth of short delamination

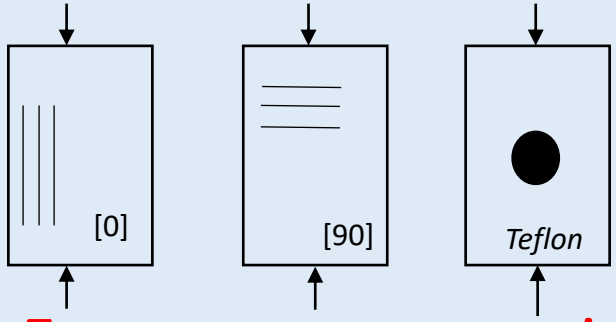


Preferential growth of short delamination

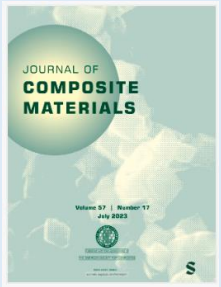


Growth of projected delaminated area is not sufficient

Preliminary tests



Frequency separation between *damage modes*

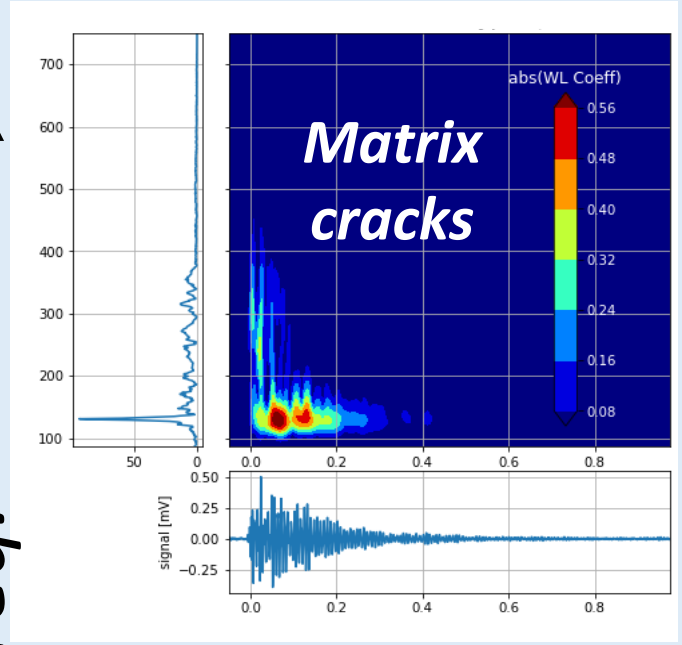


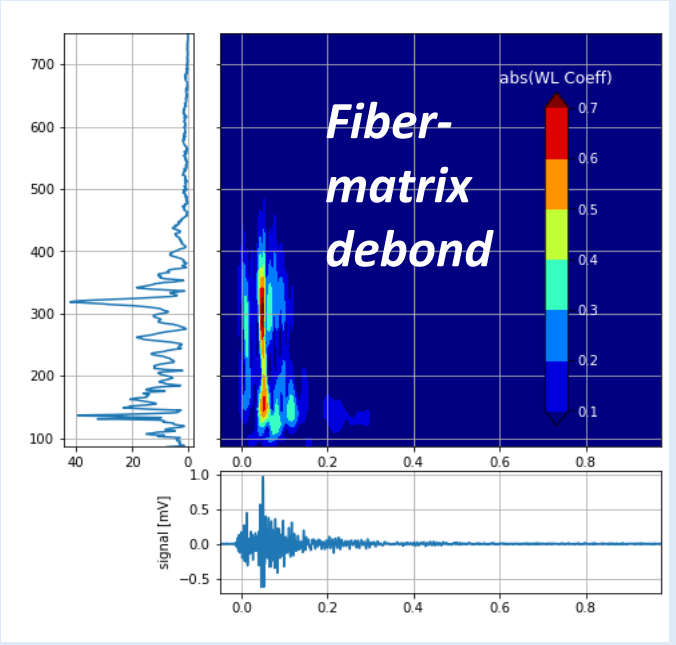
Article

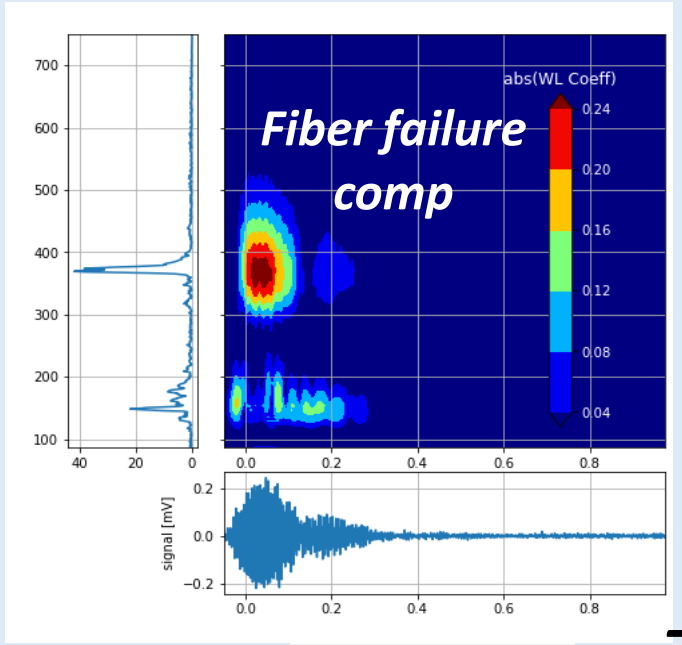
Investigation of compression after impact failure in carbon fiber reinforced polymers using acoustic emission

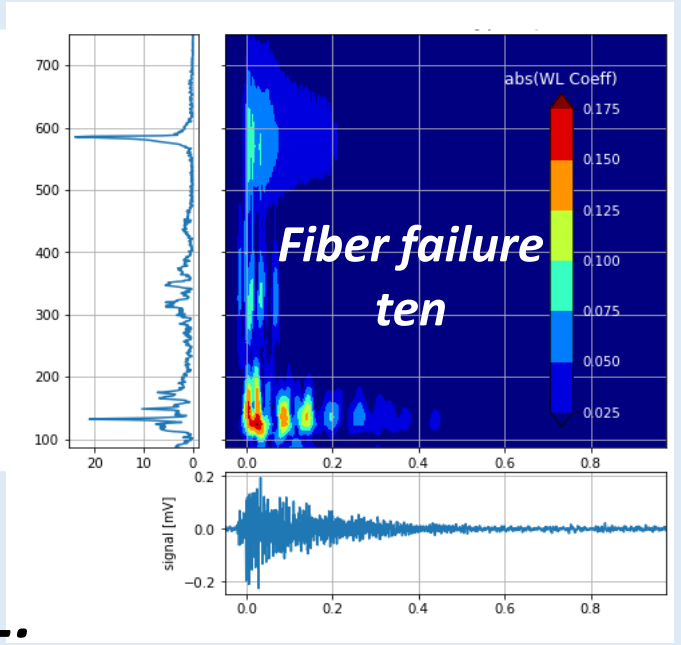
Davide Biagini, John-Alan Pascoe, and René Alderliesten

Freq.



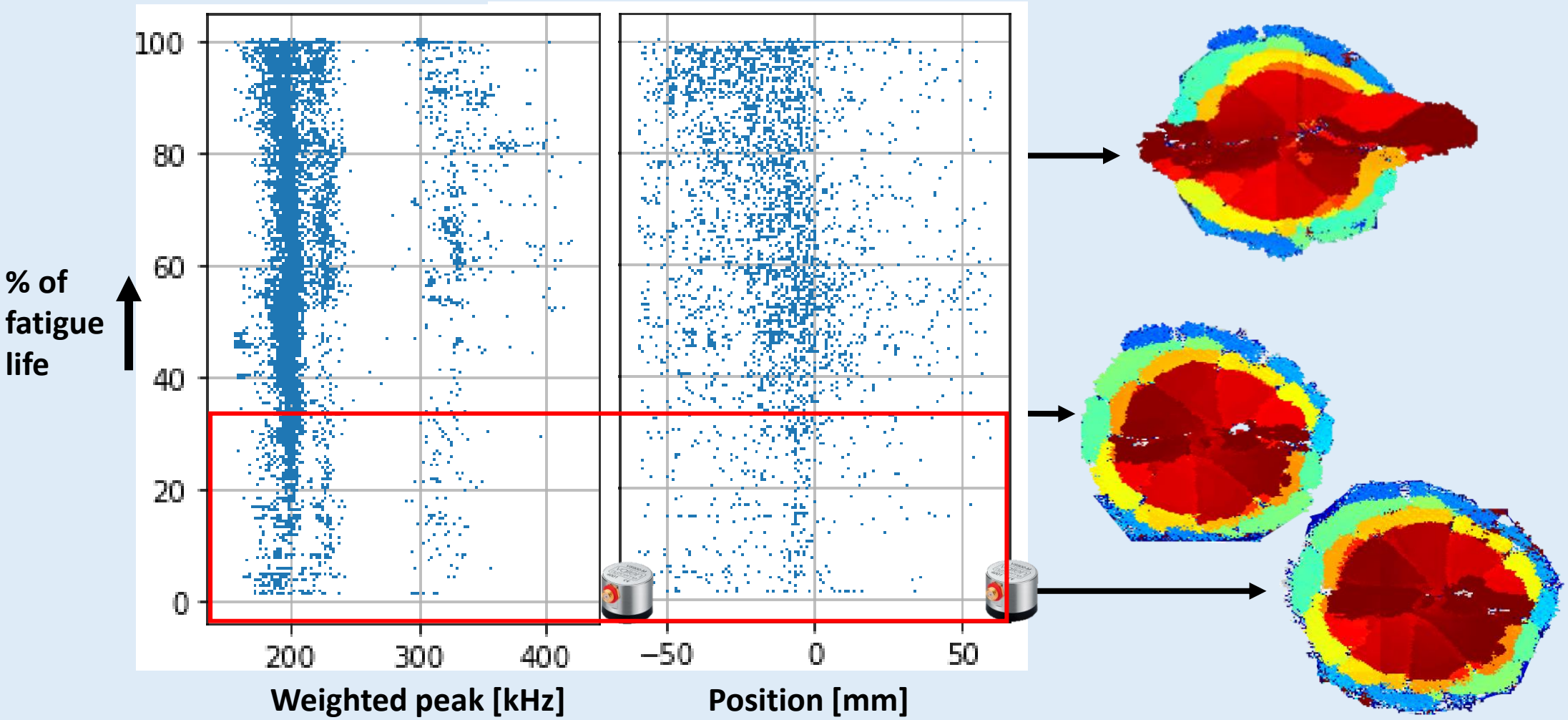




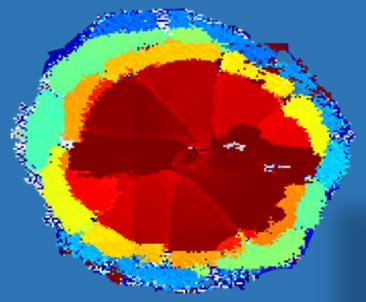


Time

Acoustic emissions monitoring



no growth in the C scan ≠ no damage growth



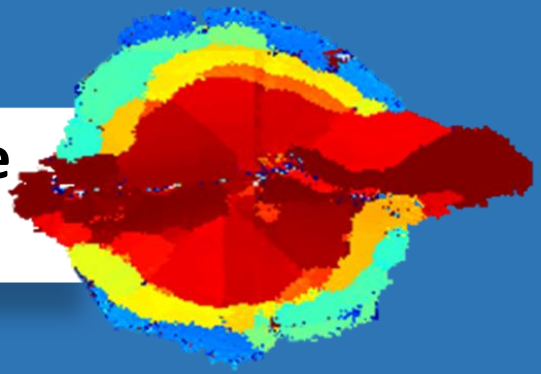
‘Plateau’ of projected delamination growth

Intralaminar matrix cracking/shadowed delamination

Short delamination growth

Growth inside the impact cone

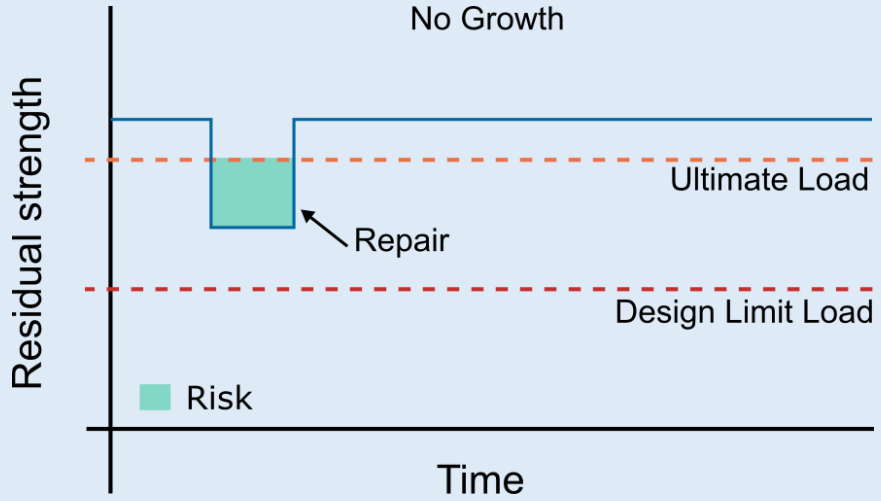
Growth outside projected area



No observed growth ≠ no absolute growth

~~**Projected delaminated area**~~

NO-growth design philosophy



- ✓ Ultimate load capability maintained after BVID
- ✓ No **growth** allowed between inspections

Testing campaign to ensure that BVID will not grow due to fatigue

The growth/no-growth is evaluated using ultrasounds

Conclusions

Combining multiple techniques ⟶ better understanding

No-growth phase could be an artefact of unprecise damage description

- *growth in the non delaminate cone*
- *growth of short delamination*
- *low frequency AE during early stages of fatigue*

CAI fatigue growth definition should consider damage in its entire complexity

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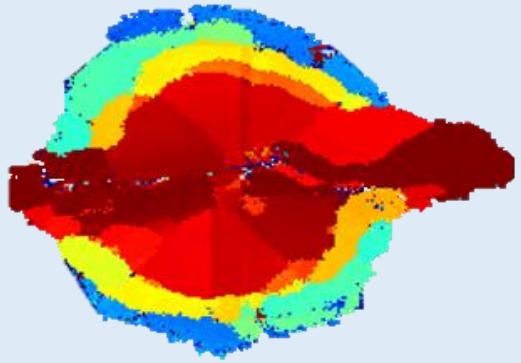
Thank you

= Setup

≠ Impact energy

≠ Layups



Final growth 90 deg direction

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Buckling behaviour and delamination growth in impacted composite specimens under fatigue load: an experimental study

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FATIGUE LIFE AND FAILURE OF IMPACT-DAMAGED CARBON FIBRE COMPOSITES UNDER COMPRESSIVE CYCLIC LOADS

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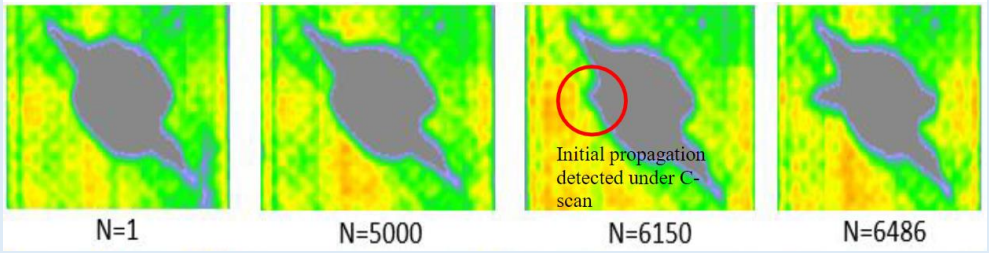
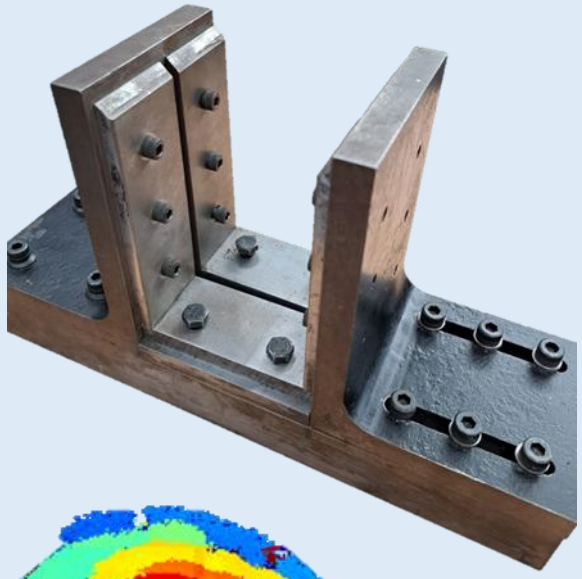
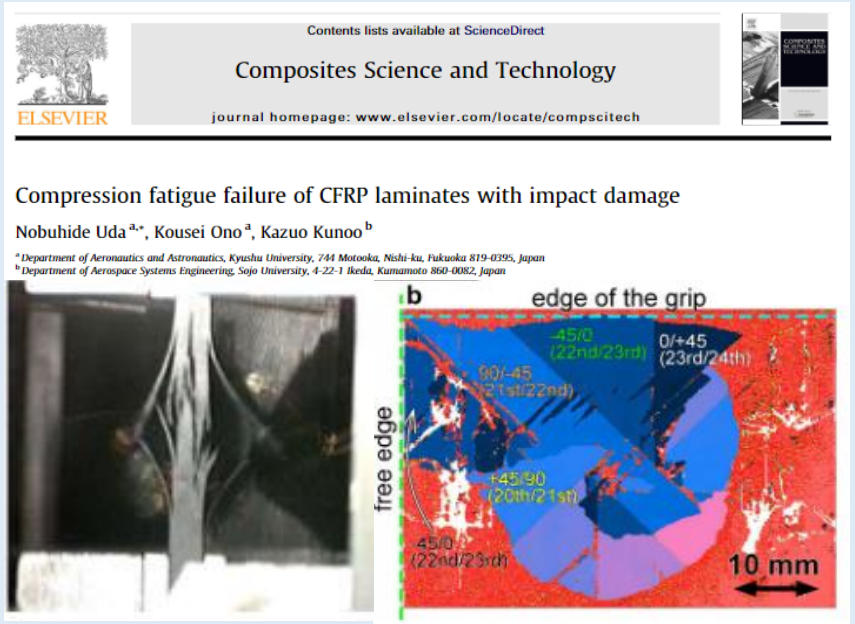
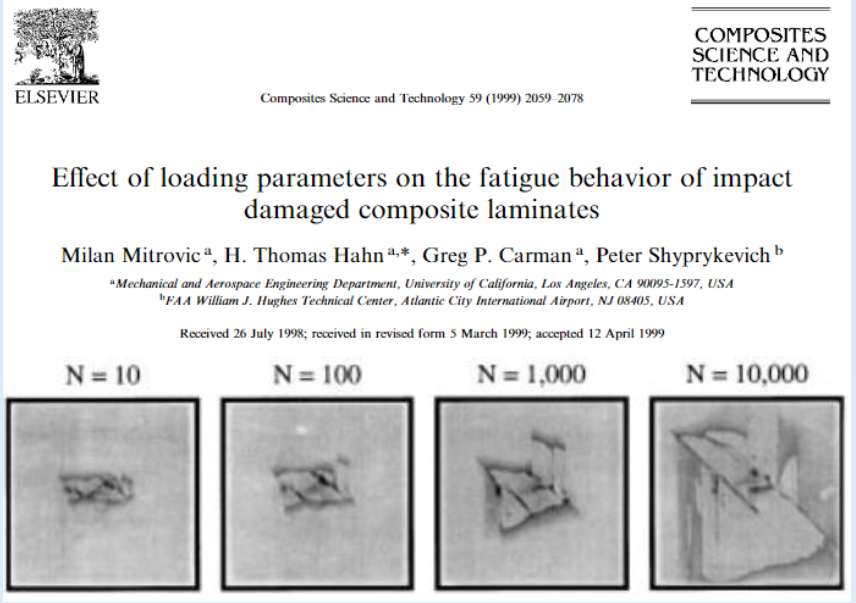




≠ Setup





✗ Final growth 90 deg direction