Inducing Damage by Laser Shock Plasma: Application for Dismantling Laminated Composites for Reuse

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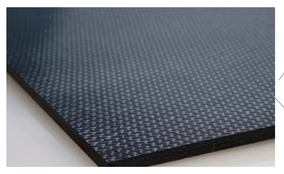
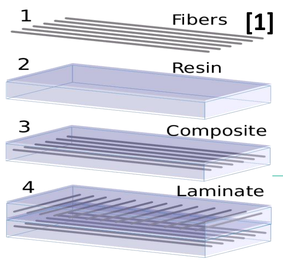
Introduction



Carbon fiber-reinforced composites [2]



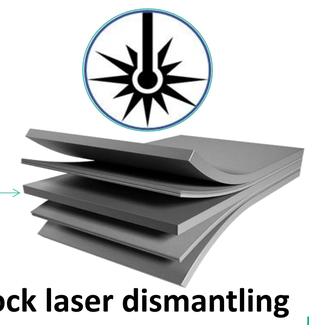
Waste of composite materials [3, 4]

Traditional recycling and reuse methods

Struggling to meet quality requirements and ecological standards

Operating slowly, generating noise, dust, and debris

Limitations of traditional methods [5, 6]

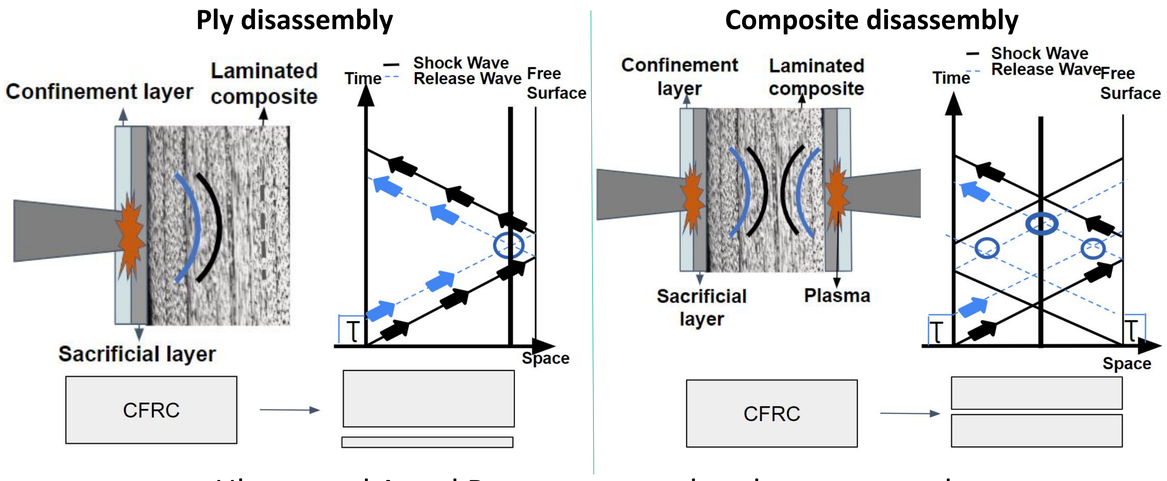


Shock laser dismantling

Objective: dismantle composites using laser shock, retaining reuse properties, explore reassembly and ageing effects, enabling waste reduction and environmental progress.

Laser Shock

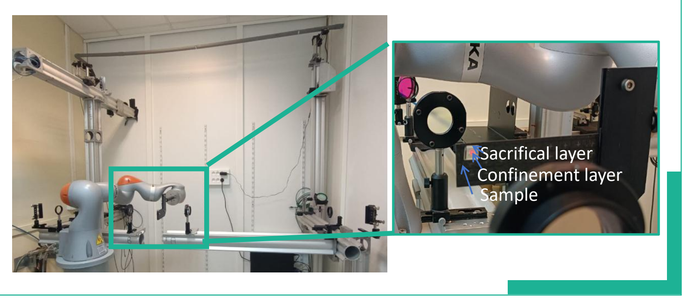
Principle [7, 8]



Ultrasound A and B scans are used to detect or not damage

Experimental Setup

- Laser System: Nd: YAG
- Beams: Two Separate Beams, up to 7 Joules per Beam
- Pulse Duration: 7 ns
- Wavelength: 532 nm
- Spot Diameter: 4 mm



Results: Delamination and disassembly

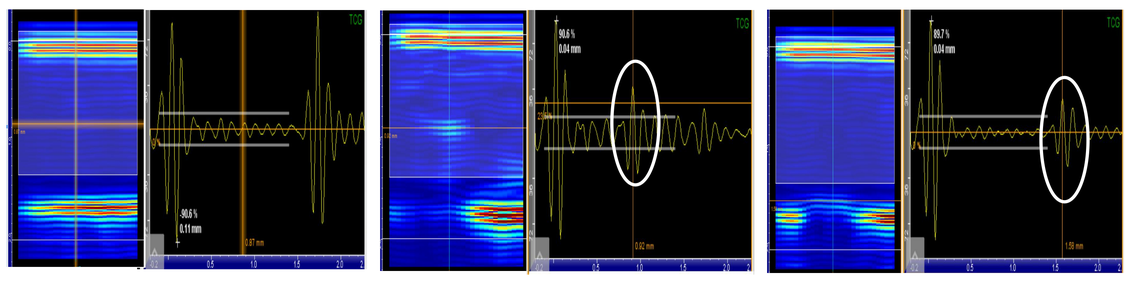
Delamination initiation:

Symmetric **2.69 GW/cm²**, Mono-shots: **1.74 GW/cm²**

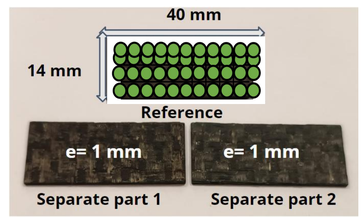
Ultrasound Scans (Clear Delamination):

Purpose: Facilitating Composite Disassembly

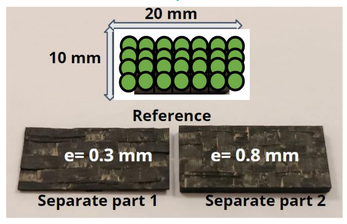
Symmetric: **9.51 GW/cm²**, Mono-shots: **4.61 GW/cm²**



Reference: No damage



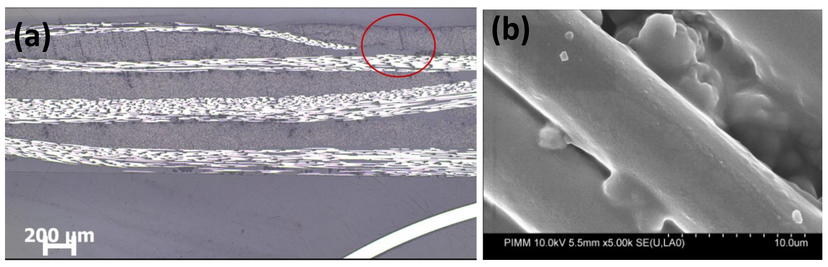
Composite disassembly



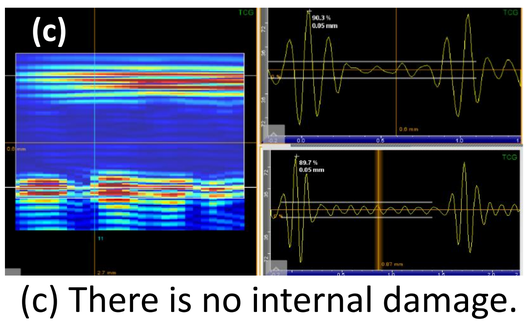
Ply disassembly

Results: Study of material properties after disassembly

Physical integrity of material at its surface



(a) Micro-cracks found in the first internal ply, (b) along with minor fiber breakage and residual resin around them.



(c) There is no internal damage.

Mechanical properties

DMA test

	Reference sample	Dismantled sample
E* [GPa]	69 ± 8.43	69 ± 0.59
Tg [°C]	167 ± 0.18	170 ± 7.80

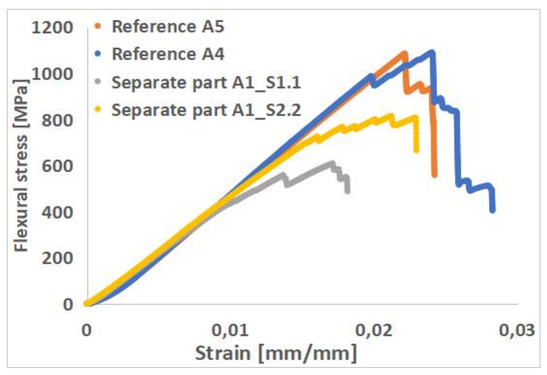
Tg: Glass transition temperature

E*: The complex modulus is usually represented as a complex number in the form E* = E' + iE'', where E' is the storage modulus (the elastic component) and E'' is the loss modulus (the dissipative component).

- Laser-shock dismantling had minimal impact on mechanical performance.
- Matrix's chemical properties remained largely unaffected.

Flexural mechanical test

	Reference sample	Dismantled sample
Flexural modulus [GPa]	52 ± 1	49 ± 1
Ultimate stress [MPa]	1088 ± 4	712 ± 144
Ultimate strain [mm/mm]	0.023 ±0.001	0.019 ± 0.003



Slight reduction in ultimate stress and strain, with unchanged flexural modulus.

Conclusion and Perspectives

Conclusion

Laser shock demonstrates great promise as a technique for composite material dismantling.

Perspectives

- Assessing the feasibility of reusing materials through bonding after disassembly,
- Study thermal/UV ageing effects to simulate end-of-life conditions,
- Using laser shock to eliminate oxide layers, followed by disassembly and analysis of undamaged materials.

References

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