Laser Cutting composites

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Some Basics..

Low $F_T \rightarrow$ low thermal loading

$F_T \rightarrow fn(1/\alpha, 1/\tau)$
Some Basics...

\[ F_T \rightarrow fn\left(\frac{1}{\alpha}, \frac{1}{\tau}\right) \]

- Expect best results in the UV where the absorption coefficients of the two materials are similar
- High absorption
- Short pulse

- BAES activities concentrated on excimer
- \( \lambda: 308\text{nm} \) (XeCl)
- \( \tau: 20\text{ns}, 160\text{ns} \)
- Prf: 150Hz -1kHz
- Energies: 500mJ -1J
Results with XeCl laser

- Trepanning gave the best results
- Laser energies -10-20mJ

Serial Trepanning using a diffractive lens array

1mm Parallel Trepanned Holes in 1mm Thick CFC

7 and 16mm Holes
SEM Image of Excimer Laser Cut CFC
Excellent cuts...

8mm thick

30mm
Chamfers, angled cuts....

Angled intersecting cuts in 10mm CFC - macroscopic view

Angled intersecting cuts in 10mm CFC - edge details
CFC Cutting and Drilling Demonstrator

800mm
CFC Cutting and Drilling Demonstrator

Holes and Cut Outs cut in CFC stringer
Cuts in thick material

Top

- Cut made with 0.2mm/s scan speeds (14 scans to cut through), 8mm aperture.
- Lens focal length=100mm. Effective cutting speed=0.85mm/min.

Note ‘0’ wall angle

Normally $\phi \propto \frac{F}{F_T}$

‘wave-guiding’?
Trial Rivet holes

Black deposit
- soot
- Can be wiped away or eliminated during processing

Copper mesh on top
A lot of research into optimising process

Etch rate as function of thickness

Active focus (for thick materials)
Mechanical Characteristics of CFC Cut using Various Processes

![Graph showing the mechanical characteristics of CFC cut using various processes. The graph compares 5% yield, fracture, and high-speed mechanical strengths. The processes compared are cw CO2 laser, water jet, mechanical, high-speed mechanical, and excimer laser.]
Other Laser wavelengths?

Q-switched Nd:YAG

Single ply  Looking along the fibres  Multi-ply

1.06 µm
Results variable
Air breakdown an issue
Cut speed ≤6 mm/min
Other Laser wavelengths?

• 531nm
• Results still variable
• A little better than IR (?)
• Air breakdown an issue
• Cut speed ≤1mm/min
Other Laser wavelengths?

- 353nm
- Better than IR and vis.
- Air breakdown an issue
- Cut speed \( \leq 0.75\text{mm/min} \)
Excimer Laser Cutting of Kevlar
Excimer Laser Drilling in Kevlar

Entrance Holes  Exit Holes
Other composite processing - 2D Riblets in CFC
Other composite processing - Random Polarisation Surfaces

(a) 0.05 J/cm²  (b) 0.10 J/cm²

(a) 0.15 J/cm²  (a) 0.20 J/cm²
Excimer Laser Demetalisation of Kevlar Honeycomb

200µm Film Thickness 0.5µm

Used for patterning of 2m diameter satellite microwave reflector dishes.
Demetallisation of Kevlar Honeycomb

Used for patterning of 2m diameter satellite microwave reflector dishes.
Suitable laser?

- UV (<308nm)
- Pulse length (<150ns)
- High average power/prf
- Small beam
- Excimer laser meet most of these
- But, generally beam too large and pulse energy too much.
- Towards latter end of our study suitable lasers becoming available
- Tui lasers (now part of coherent)
- GAM lasers
- Prf still too low