The Effect of Laser Heating on the Ductile to Brittle Transition of Si

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Experimental Setup
Testing Parameters

- **# of scratches**: 4
- **cutting speed**: 1 μm/sec
- **scratch length**: 500 μm
- **cutting tool**: 90° conical single crystal diamond tip with 5μm radius spherical end
- **laser wavelength**: 1480 nm *(only applicable for the scratches w/ laser heating)*
- **laser power**: 350 mW *(only applicable for the scratches w/ laser heating)*
- **Work piece**: Si wafer
- **Crystal plane**: (100)
- **Cutting direction**: [110]
**Scratch Matrix**

1A : No Laser
1B : With 350mW Laser

2A : No Laser
2B : With 350mW Laser

* Results comparing scratches 2A and 2B were used for analysis.

**Cutting Direction**

20-90 mN (2-9 g load)

20-70 mN (2-7 g load)
Experimental Setup

Indication of brittle fracture

Cutting Direction

No Laser

With Laser

1000X
Depth of Cut Comparison

Title: Lsr(L) vs No Lsr(R)
Note: 700nm (Duct) vs 480nm (DBT)

Fz ~ 3.2 g or 32 mN
Title: Laser effect on Si
Note: With (left) & Without Laser (right)
Depth of Cut Comparison

Title: Lsr(L) vs No Lsr(R)
Note: 710nm (DBT) vs 540nm (Brittle)

Fz ~ 4.2 g or 42 mN

brittle behavior
severe fracture
## Summary

<table>
<thead>
<tr>
<th>Machining Condition</th>
<th>$F_z$ (mN)</th>
<th>$F_x$ (mN)</th>
<th>DoC (nm)</th>
<th>Scratch Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>no laser</td>
<td>20</td>
<td>5.8</td>
<td>280</td>
<td>Ductile</td>
</tr>
<tr>
<td>with laser</td>
<td>20</td>
<td>5.3</td>
<td>400</td>
<td>Ductile</td>
</tr>
<tr>
<td>no laser</td>
<td>32</td>
<td>9.0*</td>
<td>480</td>
<td>DBT</td>
</tr>
<tr>
<td>with laser</td>
<td>42</td>
<td>11.0*</td>
<td>710</td>
<td>DBT</td>
</tr>
</tbody>
</table>

*Just before DBT occurs.
brittle behavior

Title: Lsr(L) vs No Lsr(R)
Note: 700nm (Duct) vs 480nm (DBT)
THANK YOU

QUESTIONS