Ultrahigh-speed videography of fiber fuse propagation: a tool for studying void formation

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Slide 1

Introduction

• Found in 1987 (R.Kashyap & K.J.Blow)
• Optical discharge runs toward the light source leaving periodic voids

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Fiber fuse

Videography

How was the fire-ball captured?

Setup

What is the trap like?

Movie

How its behavior changed with the pumping power?

Analysis

What is found out?

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OVERVIEW

Ultrahigh-speed videography of fiber fuse propagation

How was the fire-ball captured?

Setup

What is the trap like?

Movie

How its behavior changed with the pumping power?

Analysis

What is found out?

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Setup

- 4 µs/frame
- 1 µs-exposure with ND filters (×16)
- 128×16 pixels

Movie

- 4 µs/frame
- 1 µs-exposure with ND filters (×16)
- 128×16 pixels

FYI

Current status of high-speed videography

Todoroki (ECOC 2004 PD)
Bufetov et al. (OFC 2005)

<table>
<thead>
<tr>
<th>Interval</th>
<th>Exposure</th>
<th>Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>128 or 70 µs/frame</td>
<td>10 µs + ND filters</td>
<td>1024×128</td>
</tr>
<tr>
<td>1 µs</td>
<td>+ black illumination</td>
<td></td>
</tr>
<tr>
<td>128×16 pixels</td>
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</tbody>
</table>

Analysis

Distance, z/µm

- 500 µm
- 0.77 m/s
- 0.61 m/s
- 0.41 m/s
- 0.33 m/s
- 1.5 W
- 2 W
### Slide 9

**Analysis**

Fusing speed & Void interval

![Graph showing fusing speed and void interval](image)

### Slide 10

**Videography**

How was the fire-ball captured?

**Setup**

1 µs-exposure & x16 ND filters helped to catch it.

**Movie**

Pumping with >2W makes intensity profile asymmetric.

**Analysis**

Asymmetric optical discharge leaves periodic voids.

### Slide 11

**Front void**

What is left behind at the fire-ball’s position?

**Photography**

How the samples were prepared?

**Comparison**

What is related with the asymmetry of the discharge?

**Cavity size**

How it changes with increasing the pumping power?

### Slide 12

**Photography**

Sample preparation

- observed as it is focused inside

- 1480nm Fiber Laser
  
  - 9W
  
  - 1.5W
  
  - <100µs

- SMF-28
Comparison

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Comparison

What we can say during quenching

- Decay time of laser:
  $\Rightarrow < 100 \mu s$ (observed)
  $\Rightarrow < \text{one-void-formation}(\sim 20 \mu s)$

- Structural relaxation may occur, but expected to be small.
  $\Rightarrow \text{large } \frac{\partial \eta}{\partial T}\text{ of silica glass}$

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Comparison

Slide 14

Comparison

Cavity size

Slide 16
Front void

What is left behind at the fire-ball’s position?

Photography
Prepared by sudden power cut after fiber-fusing.

Comparison
Asymmetric discharge leaves a tailed void.

Cavity size
Void radius is constant & independent of input power.

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Archaeology

What is told from the photos of left behind?

Periodicity
What comes into view considering periodicity?

Reconstruction
What is extracted from a series of photographs?

Mechanism
Why the regular voids look like bullets?

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Periodicity

7W
1480nm

Periodic voids
One per 20 µs

Uniform velocity

Reconstruction

• These are NOT in-situ

• but seem that the void casts off its tail → one of regular voids

• Assuming that each structure is sufficiently the same as that before quenching
**Mechanism**

Formation of a bullet

- Distance from the top
- Temperature
- Viscosity

**Archaeology**

What is told from the photos of left behind?

- Periodicity
  - Normalized position is the key for sorting by time.

- Reconstruction
  - Extended tail is casted off to be one of regular voids.

- Mechanism
  - Optical discharge pushes casted tail to make a bullet.

**SUMMARY**

Ultrahigh-speed videography of fiber fuse propagation

- Videography
  - >2W-pump $\Rightarrow$ asymmetric discharge & periodic voids

- Front void
  - Asymmetric discharge leaves a tailed void.

- Archaeology
  - Extended tail is casted off to be one of periodic voids.
  - Optical discharge pushes casted tail to make a bullet.
Acknowledgement

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