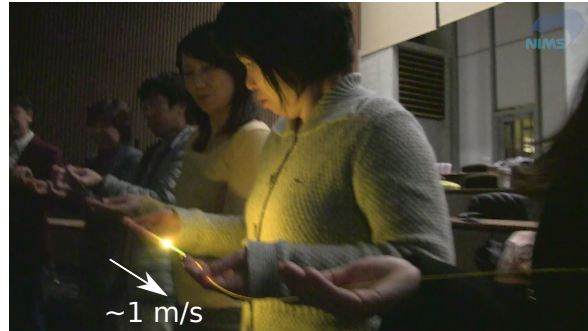


## Fiber fuse behavior

veiled in its strong light emission

Shin-ichi TODOROKI

NIMS, Japan

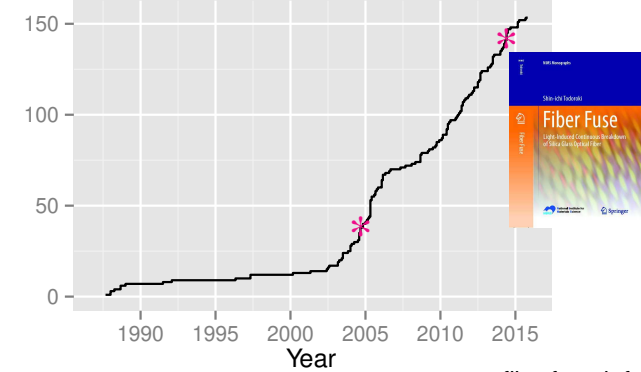


Slide 1

## Introduction

What I've done.

### Talks & Publications on Fiber Fuse



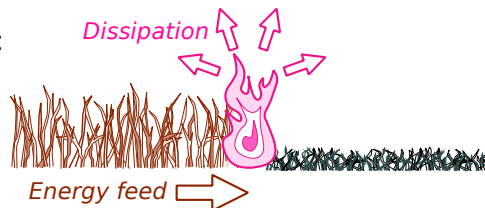
source: fiberfuse.info

Slide 3

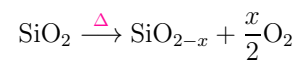
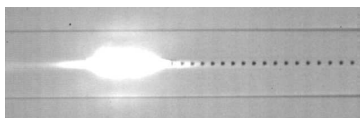
## Introduction

### Dissipative soliton

Grass fire:



Laser (>1W) →  
thru a single-mode fiber



Slide 2

## OVERVIEW

Fiber fuse behavior

### Motivation

*Why should we investigate it?*

### Termination

*How it is trapped at termination devices?*

### Initiation

*What is known about its initiation process?*

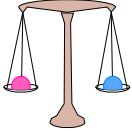
Slide 4

**Motivation** Dilemma of silica glass fibers

**Risk:** high-power light manipulation

**vs. Expected capacity saturation**  
in Optical communication systems

**vs. Required energy**  
in Power-over-Fiber (PoF) applications



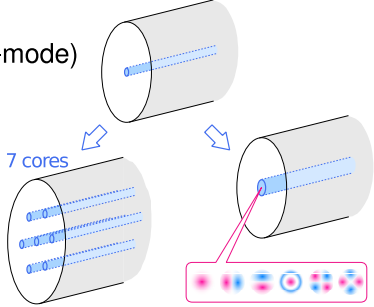
⇒ Submarine sensors

⇒ Ice sheet exploration

Slide 5

**Motivation** Space division multiplexing

- Capacity enhancement w/o power density increase  
⇒ Multi-core  
⇒ Multi-mode (Few-mode)
- Still caught in **the dilemma**



Slide 7

**Motivation** Commun. capacity saturation

D. J. Richardson, *Nature Photonics* (2013)

Slide 6

**OVERVIEW**

Fiber fuse behavior

**Motivation**  
*Better risk management of high power-over-fiber apps.*

---

**Termination**  
*How it is trapped at termination devices?*

**Initiation**  
*What is known about its initiation process?*

Slide 8

**Termination** Proposed technologies for single-mode fibers in opt. commun.

- Remote sensing → Power shutdown
- Local trap → Excess dissipation

The diagram illustrates two termination methods for single-mode fibers. The first, 'Remote sensing', shows a fiber with a starburst at the end, connected to a person using a telescope and a computer. The second, 'Local trap', shows a fiber with a starburst at the end, connected to a person looking at a computer screen displaying a fiber diagram.

Slide 9

**Termination** (2) Mode field expansion

The diagram shows a fiber with 'Laser light' entering from the left. A starburst indicates a point of mode field expansion. Below, two circular cross-sections show the light spreading out. Further down, two cylindrical cross-sections are labeled 'Larger MFD (Wyatt 2001)' and 'TEC fiber (Hand 1989)'. A coordinate system with axes r, z, and φ is shown. At the bottom, a box contains the equation  $\frac{d}{dz} \int \mathbf{I}(\mathbf{r}, \phi) dS = \text{const.} ?$  with the text '⇒ Need to know its propagation behavior' below it.

Slide 11

**Termination** (1) Pressure leakage

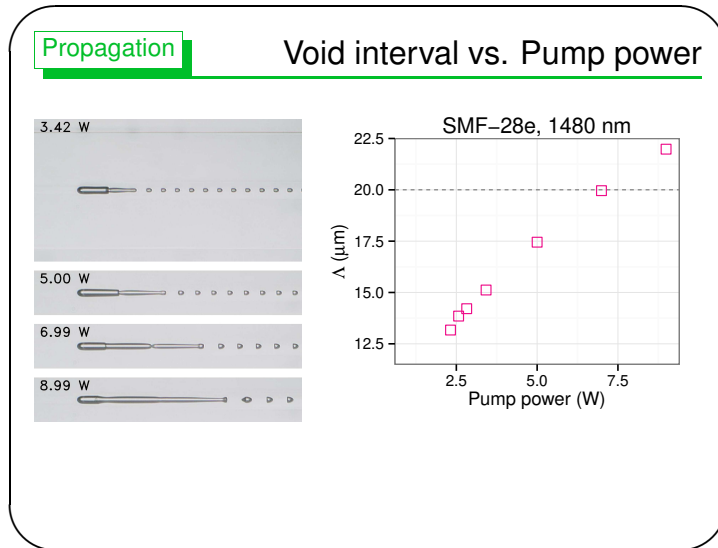
The diagram shows a fiber with 'Laser light' entering from the left and a starburst at the end. Below, three fiber types are shown: 'Hole-assisted fiber (Takenaga 2008)' with a cross-section of three holes, 'Photonic crystal fiber (Hanzawa 2010)' with a cross-section of a lattice of holes, and 'Etched fiber (Dianov 2004)' with a cross-section of a tapered fiber.

Slide 10

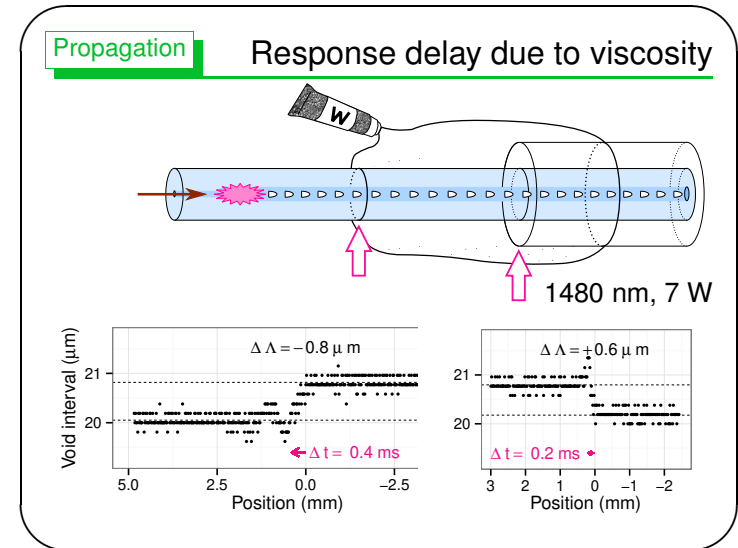
**Propagation** The key is left behind it.

The photograph shows a fiber with a bright spot of light. Below it, a downward arrow is labeled 'Power shutdown'. Below that, a fiber with a series of dots is labeled 'Periodic voids'.

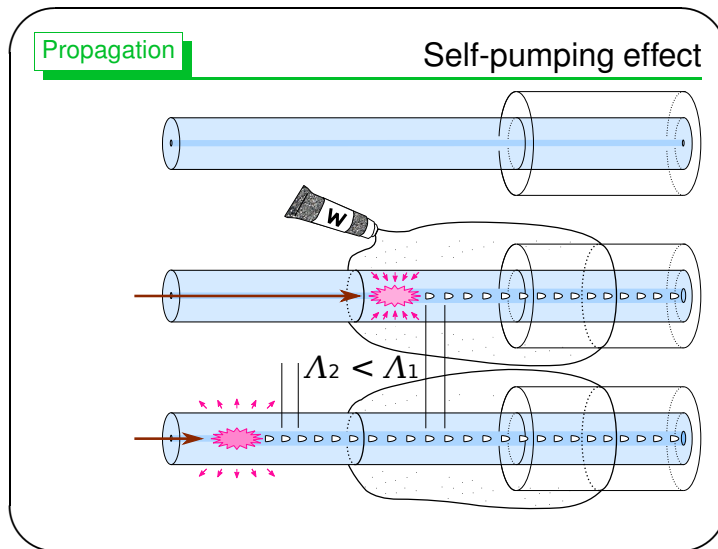
Slide 12



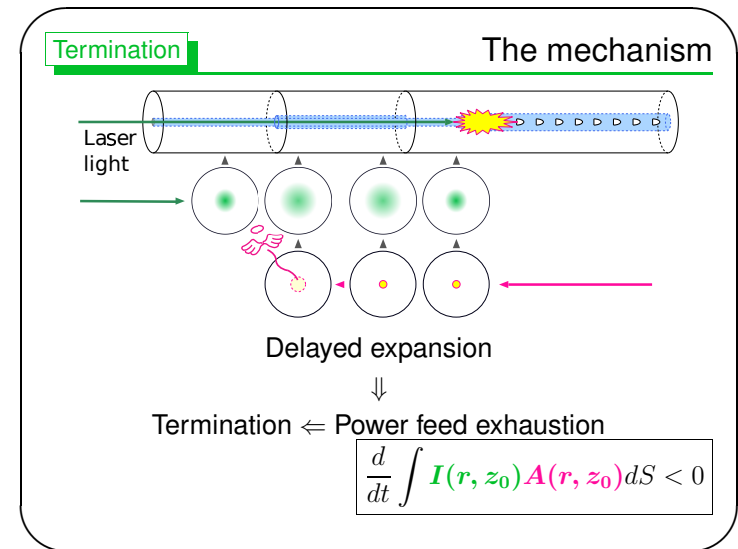
Slide 13



Slide 15



Slide 14



Slide 16

**OVERVIEW**

Fiber fuse behavior

**Motivation**  
Better risk management of high power-over-fiber apps.

**Termination**  
Viscous silica melt causes a delay in response.

---

**Initiation**

**What is known about its initiation process?**

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**Initiation** An alternative criteria

The minimum laser power for propagation

No info about initiation!

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**Initiation** Quantitative evaluation is very hard

$$\text{SiO}_2 \xrightarrow{\Delta} \text{SiO}_{2-x} + \frac{x}{2} \text{O}_2$$

How much is the minimum laser power for initiation?

Slide 18

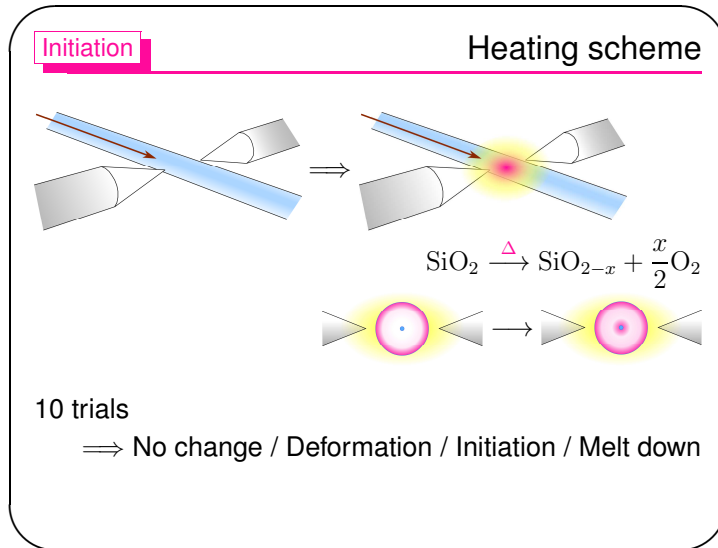
**Initiation** To quantify heat & time,

- Arc discharge in a fusion splicer

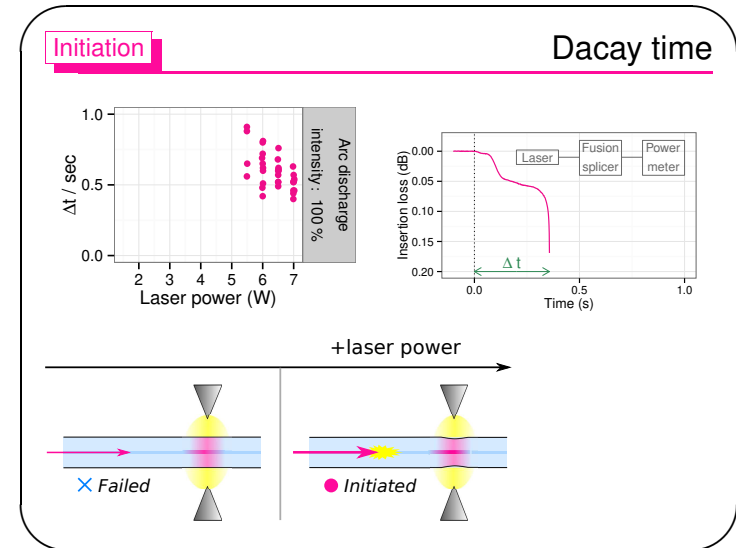
Laser: 1.5 – 7 W

100%,  
130%,  
160% for 1 sec.

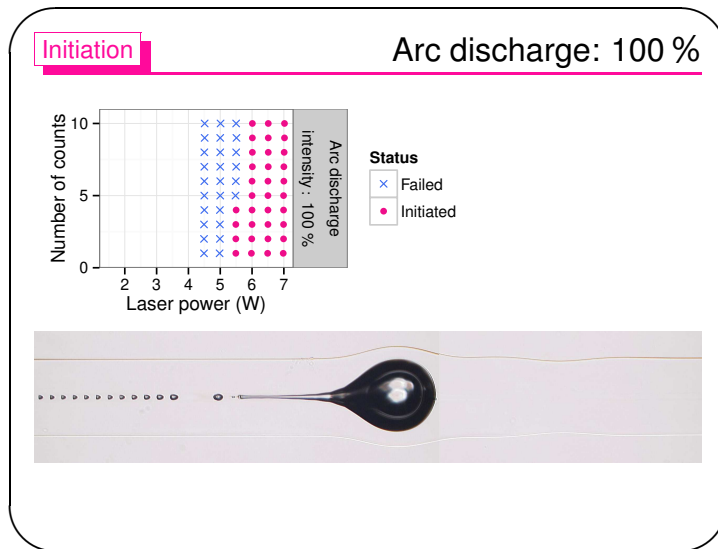
Slide 20



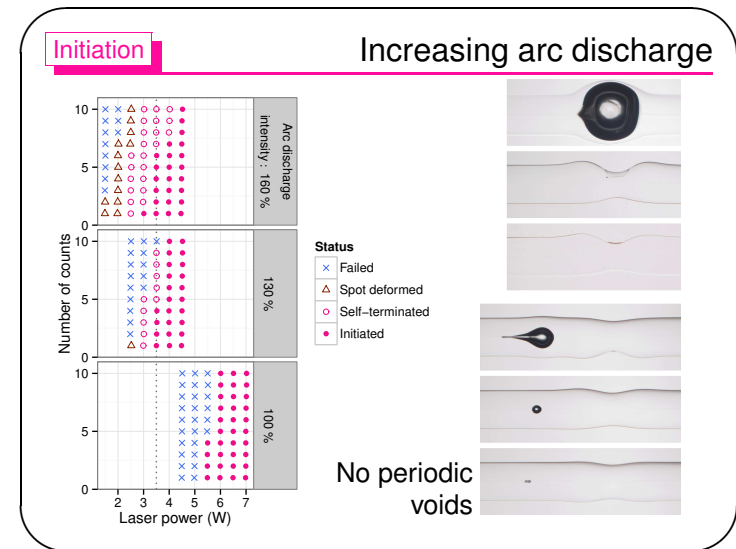
Slide 21



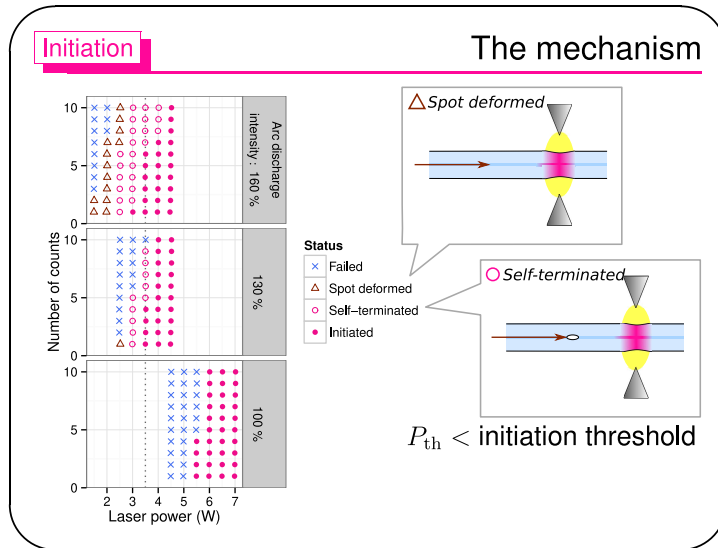
Slide 23



Slide 22



Slide 24



Slide 25

**SUMMARY**

Fiber fuse behavior

**Motivation***Better risk management of high power-over-fiber apps.***Termination***Viscous silica melt causes a delay in response.***Initiation***It requires more than threshold power for propagation.*

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