

# Fiber fuse propagation modes for typical single-mode fibers

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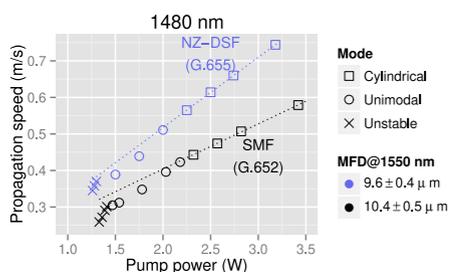
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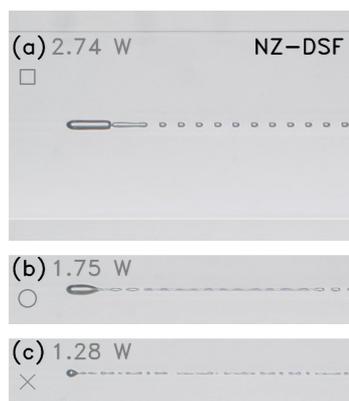
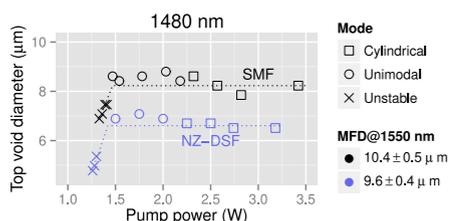
## Abstract

The precise measurement of fusing speed revealed that its behavior varies depending on the plasma volume per pump beam diameter. Irregular void patterns appear when the pump power changes faster than the surrounding melt relaxes.

## 3. The results



## 4. Corresponding void shapes



## Speed vs. Pump power

Already known as linear. What's new?

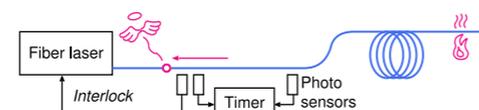
### 1. Earlier studies

$\lambda$ : $\sim 1.5 \mu\text{m}$	$\sim 1064 \text{ nm}$	514 nm
Atkins '03	Kashyap '87	Kashyap '87
Todoroki '05	Davis '96	Hand '88
Lee '06	Bufetov '05	
André '10	Dianov '06	
Abedin '10		
Domingues '12		

They all said

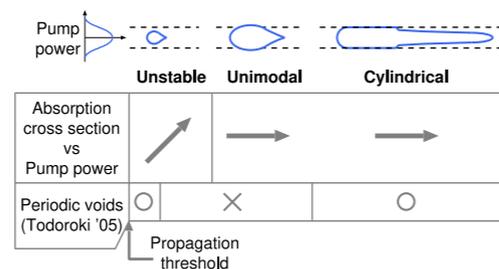
"Roughly linear!"

### 2. More precise measurement



- Lap time of **80 mm** dash with a precision of **0.1 ms**.
- Pump power was 7 W for fuse initiation and reduced to a certain value.
- The power was calibrated with a precision of **0.01 W** based on the test runs.

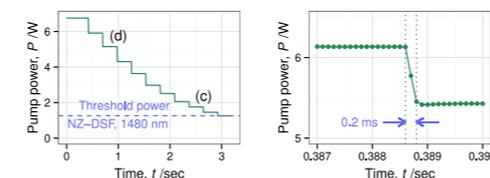
### 5. Three propagation modes



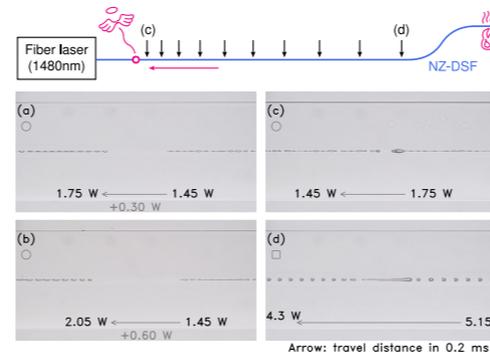
## Sudden power change

What happens and what is left?

### 1. Pump power vs Time

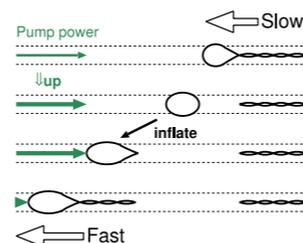


### 2. The results



### 3. Sudden power increase

1. Quick rise in plasma temperature
2. **Delayed void inflation** due to high viscosity of the surrounding melt
3. Void formation is suspended until the recovery of equilibrium state

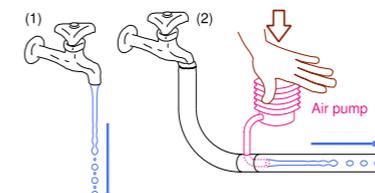


## Enigmatic long voids

Were those really due to Rayleigh instability?

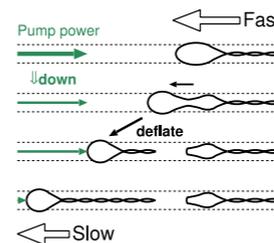
### 1. Long non-periodic filaments

- Davis '96
- Atkins '03
- +3 more (Hand '88, Driscoll '91, Dianov '92)
- The void is a capture of "incipient process" ⇒ "bubbles in optical fibers ... are compatible with" **Rayleigh instability** — Atkins '03



### 4. Sudden power decrease

1. Quick drop in plasma temperature
2. **Delayed void deflation** makes its tail frozen to extend the whole void.
3. (Same as the left)



## Summary

Speed vs. Pump power

*Out-of-linearity comes from plasma shape variation with the pump power.*

Sudden power change

*Delayed response of surrounding melt brings an irregularity into the void train.*

Enigmatic long voids

*Reported voids must be formed by sudden pump power reduction.*

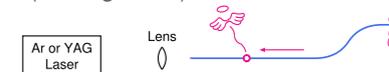
### 2. Counterarguments

- Viscosity of the melt is too high (Yakovlenko '04)
- Can't explain why O<sub>2</sub> is in the voids (Kashyap '13)
- Similar void appears at a sudden pump power drop (**this study**)



⇒ Launched light in the past experiments must be modulated w/o knowing it.

(floating dust?)



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