Quantitative evaluation of fiber fuse initiation probability in typical single-mode fibers

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Abstract

5.5W@1480nm five-second-long light irradiation through a SMF-28e+ fiber on a highly Co-doped borosilicate glass surface gave 10% probability of fiber fuse initiation. This method is useful to evaluate relative fiber fuse tolerance for various fibers.

Conclusions

Method *An adaptive glass melt absorber helps to evaluate relative probability of fiber fuse initiation.*

Results *Initiation was enhanced by MFD reduction but not by external heating.*

Discussion *Confinement of heated area promotes fiber fuse initiation.*

FAQ

Q: *Can we use 5 W light w/o any fiber fuse initiation?*

A: No!!!

Metal with 1+ W light brings about initiation but it's hard to evaluate the probability quantitatively.

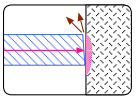
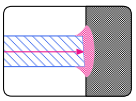
Background

Only two qualitative studies before [1,2]

We should normalize

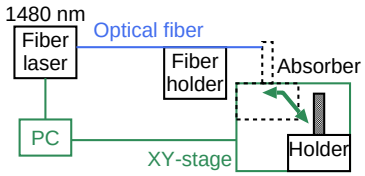
- geometry btw fiber & heat source
- irradiation time & power

Method — Heat source (Absorber)

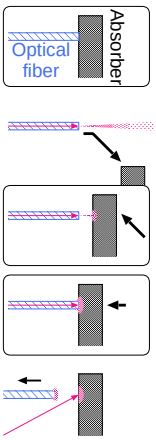
	Geometry	Probability
Metal:		Inevitable gap ⇒ Small ✗
Highly Co-doped borosilicate glass*:		Adaptive ⇒ Measurable ✌

* Cobalt-6 #516 (Glass Alchemy)

Method — Reproducible positioning



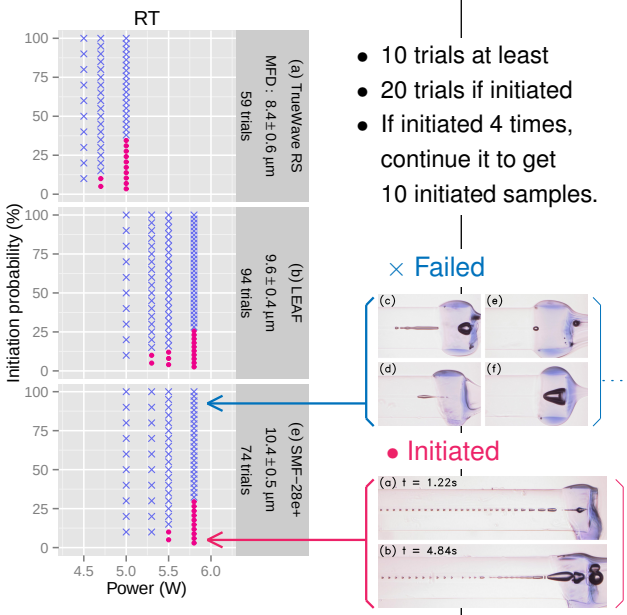
Method — Initiation procedure



- Position the absorber w/ minimum tension
- Shift it away & Let the laser ON
- Shift it back to melt it before the contact.
- The melt expands & wraps the fiber tip.
- Stop the laser **5 s** later.
- Remove the fiber w/ the aid of spot heating.

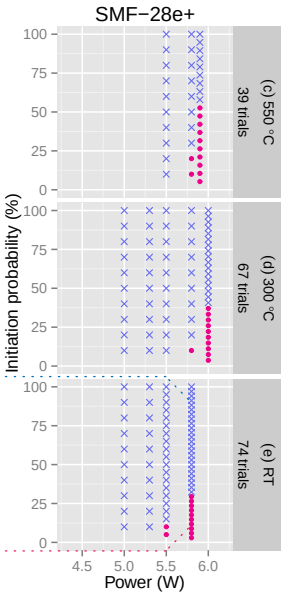
Watch YouTube @ youtu.be/wmM5JLUbf4w

Results — MFD dependence



- 10 trials at least
- 20 trials if initiated
- If initiated 4 times, continue it to get 10 initiated samples.

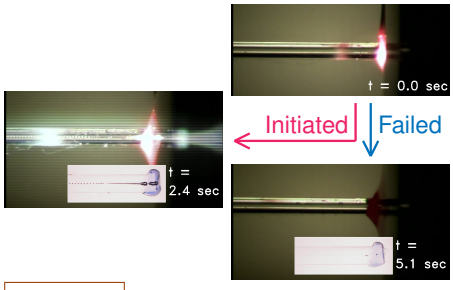
Results — Temp. dependence



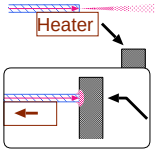
Discussion — Initiation probability

- MFD reduction promoted initiation with lower power.
- However, external heating did not because it disturbs thermal confinement at the core.

Method — Reaction zone



Method — How to heat the fiber tip



- w/ a micro ceramic heater (5×5×1.7 mm)
- It slides along the fiber if the absorber comes.

Discussion — Reason for failures

Poor confinement of

- Heated area
- Plasma / Optical discharge

Namely, **dissipation** > **absorption** from / in the core

Results — Time for initiation

- Minimum: 0.18 sec
- Average: 2.40 sec (62 samples)

No apparent trend with the variation of MFD & temperature.

Reference

[1] D.D.Davis *et al.*, SPIE **2714** 202–210 (1996)

[2] S. Yanagi *et al.*, Electron. Lett. **38** 977–978 (2002)