



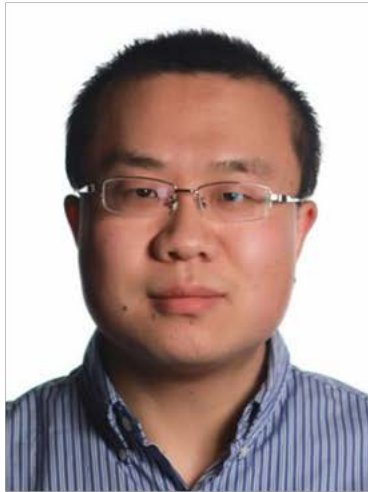
**NANYANG  
TECHNOLOGICAL  
UNIVERSITY**  
**SINGAPORE**

# Advanced Functional Fibers

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*Sep-2017*



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Singapore 639798

### **Research interests**

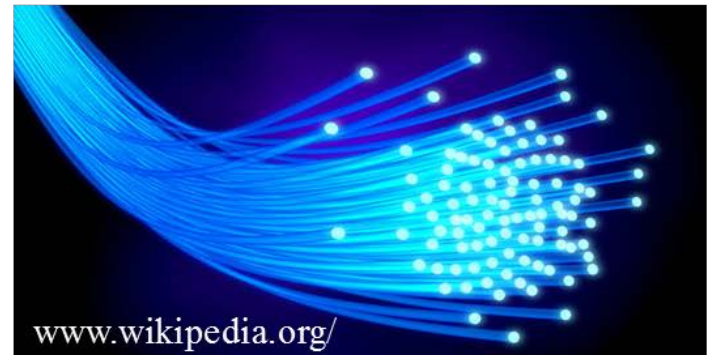
Fiber-based optoelectronic devices, fiber-based wearable devices, multifunctional fiber structures, bio-fiber interfaces, and in-fiber energy generation and storage.

# Vision

Semiconductor  
Devices



Optical Fibers



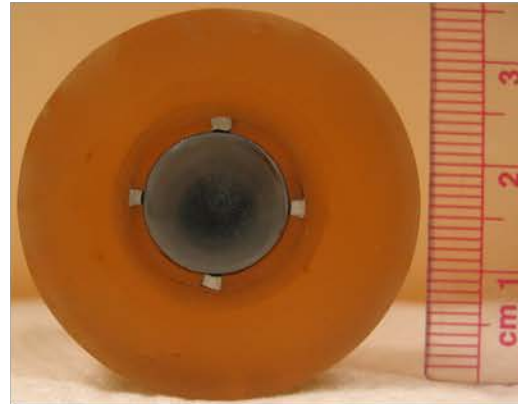
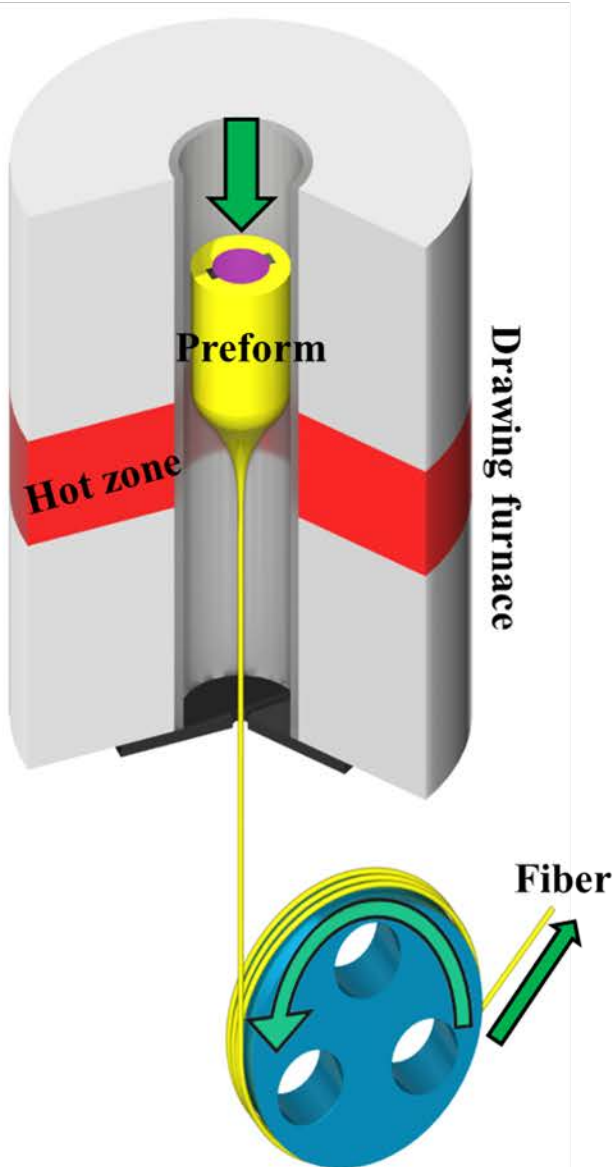
**Fibers that have the functionality of semiconductor devices  
yet are produced at fiber lengths, uniformity and cost.**

# Preform-to-fiber Fabrication

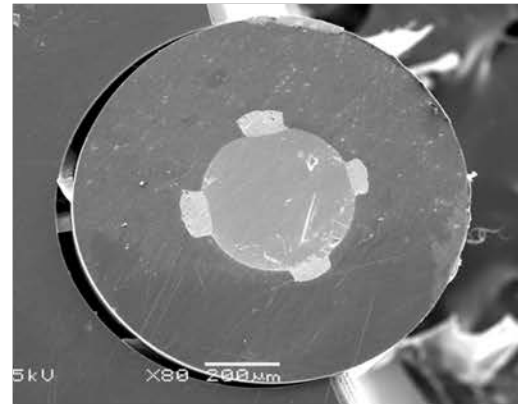
Materials

Geometry

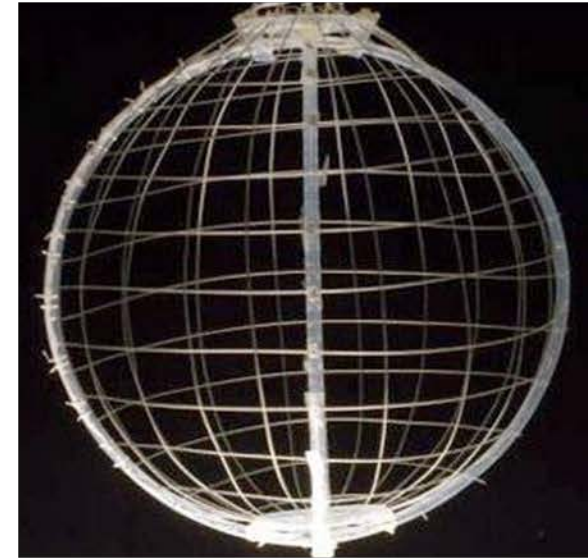
Length scale



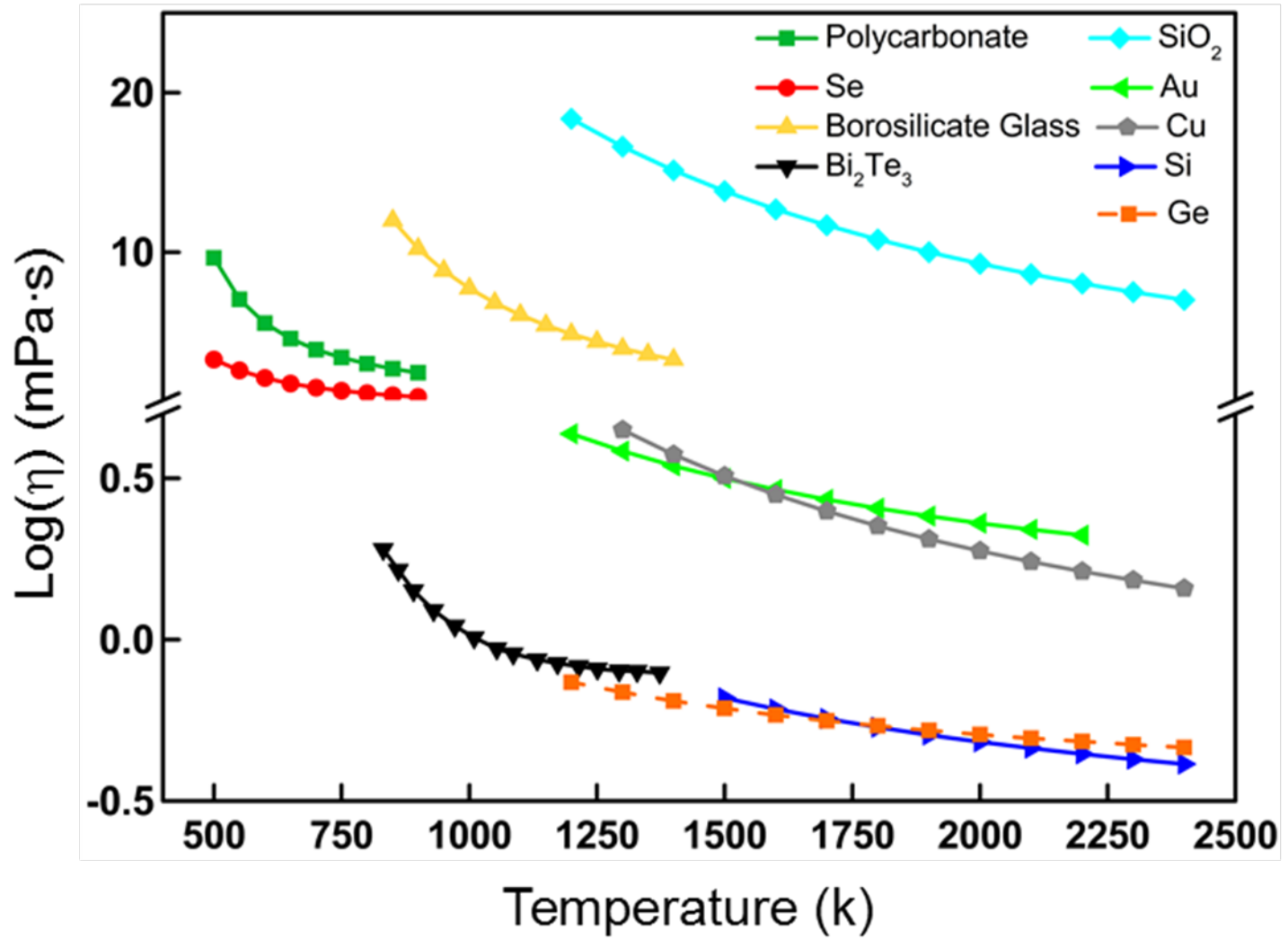
Preform cross section



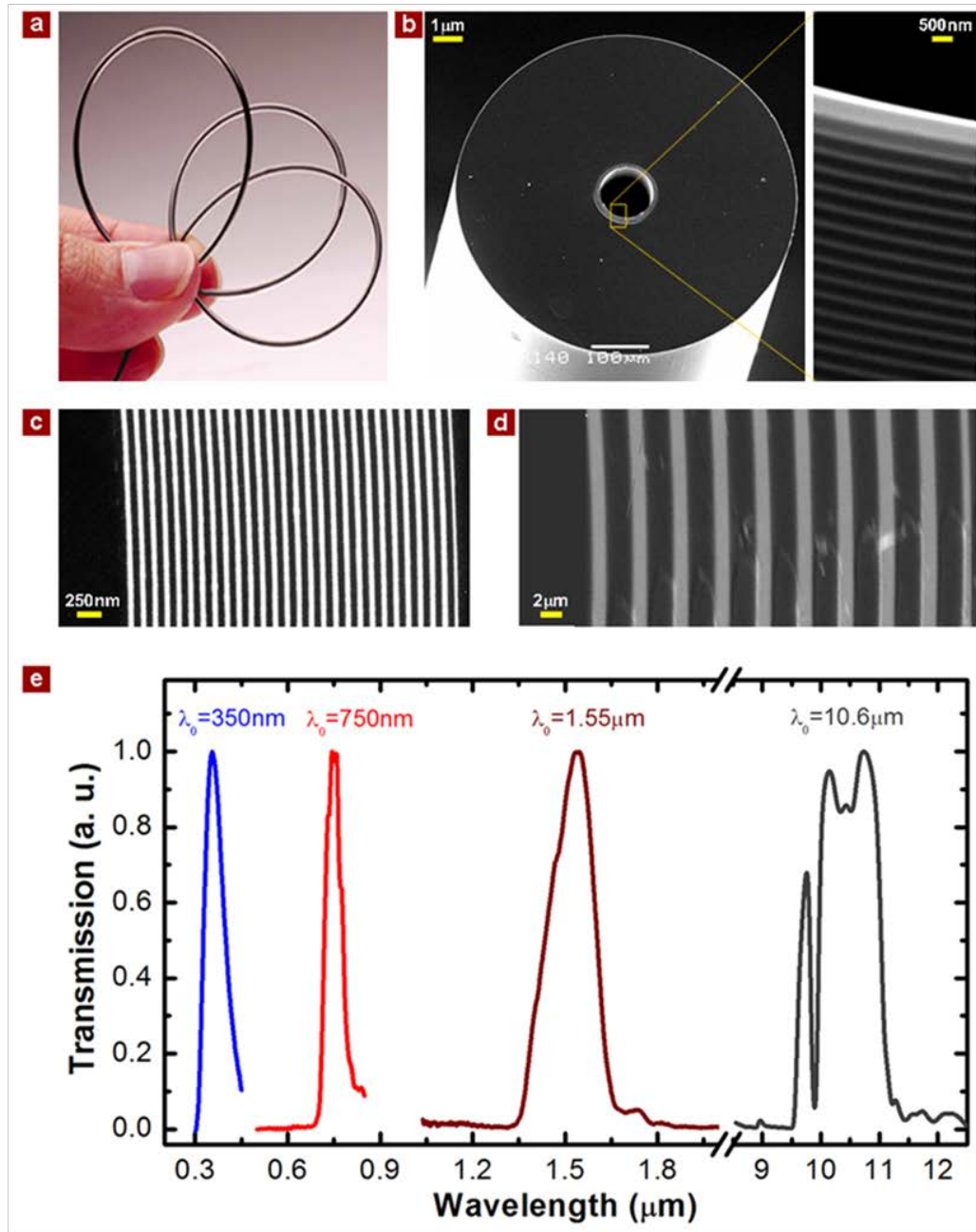
Fiber cross section



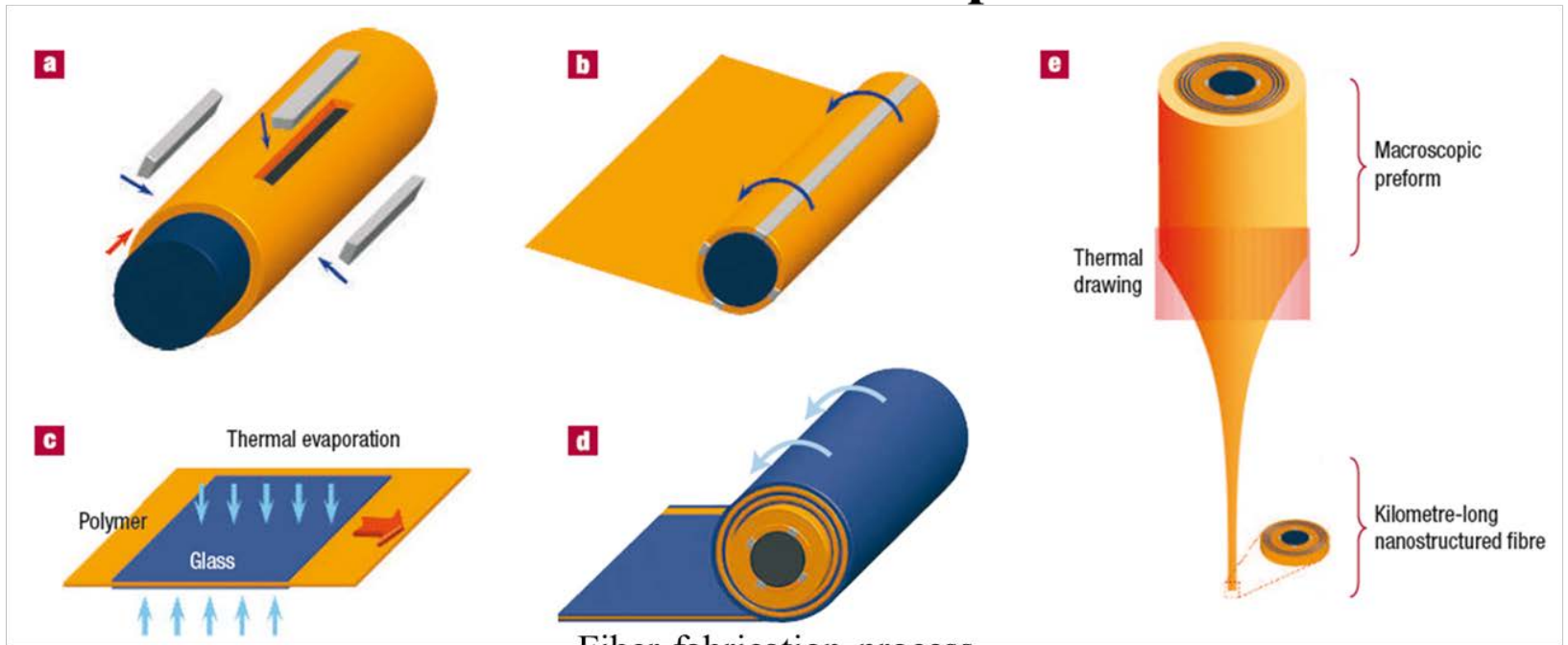
# Material Selection



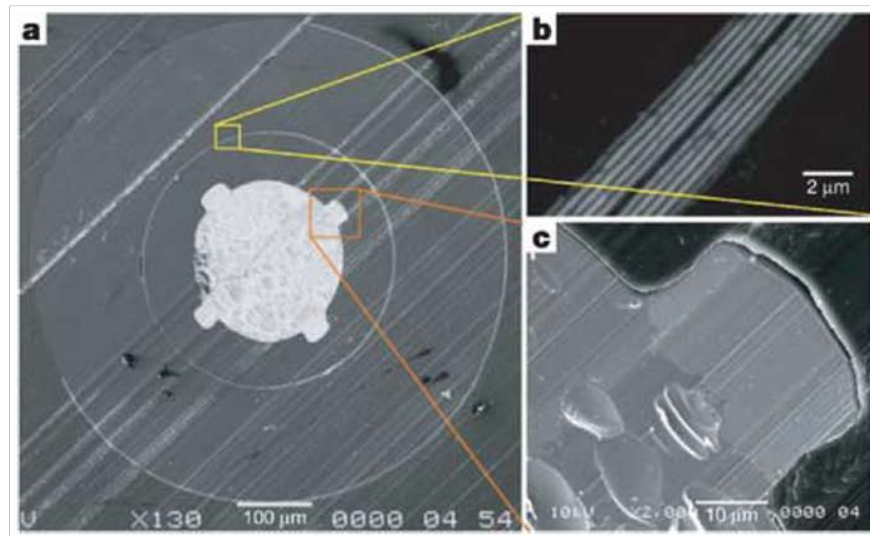
# Omnidirectional Dielectric Mirror Fibers



# Metal-Insulator-Semiconductor Optoelectronic Fibers

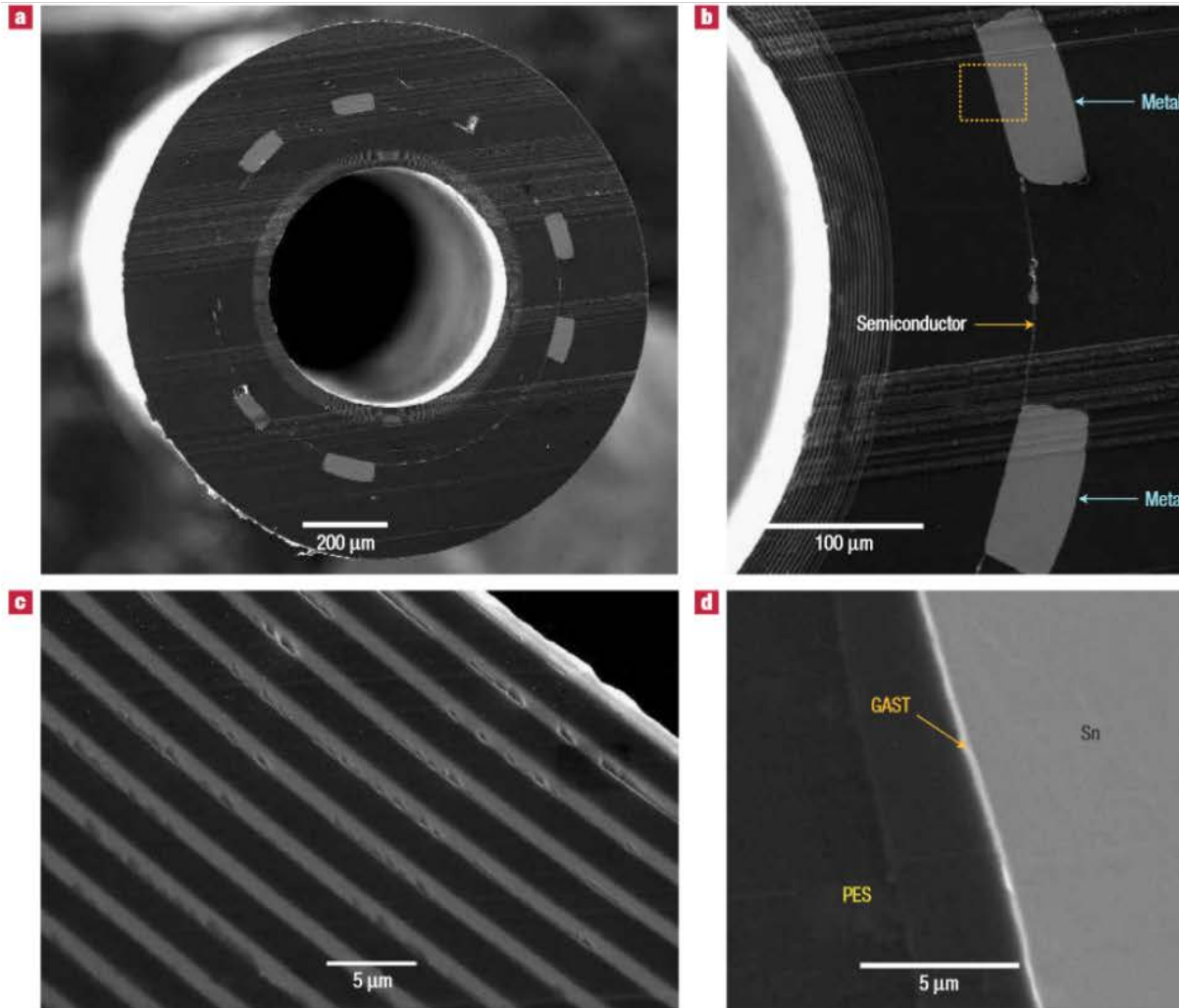


Fiber fabrication process

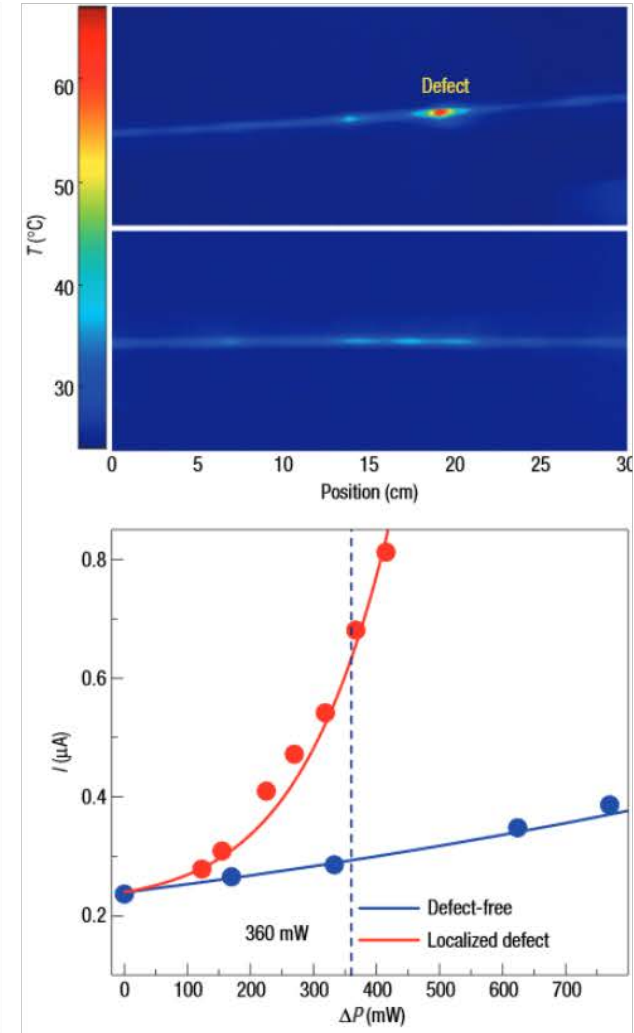


Fiber structure

# Integrated Fibers for Self Monitored Optical Transport



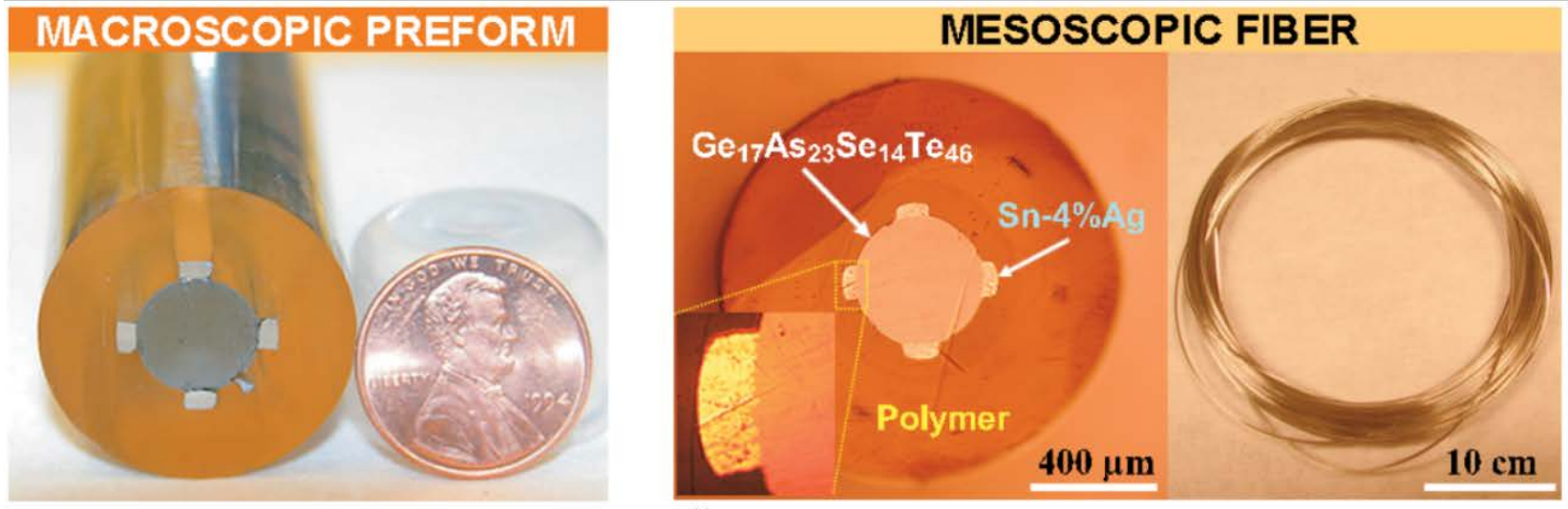
Fiber structure



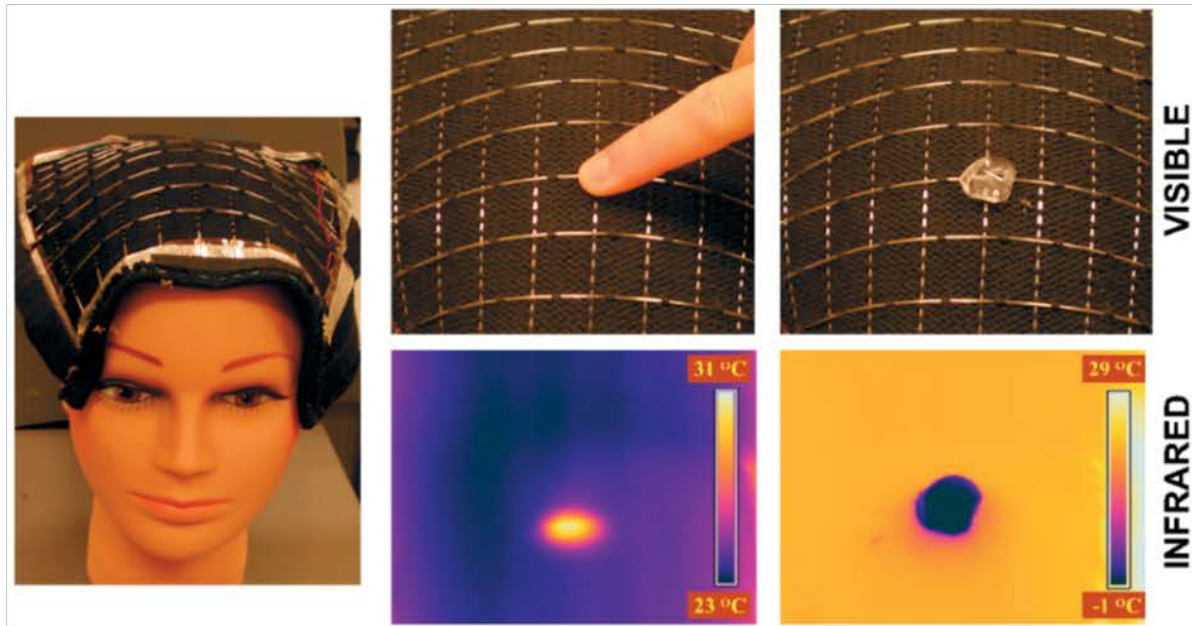
Defect detection



# Thermal-Sensing Fibers

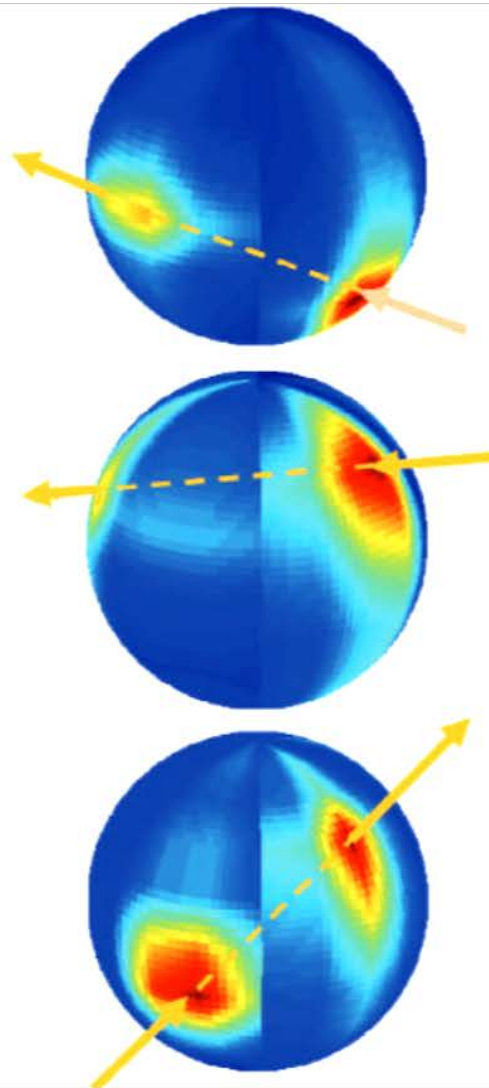
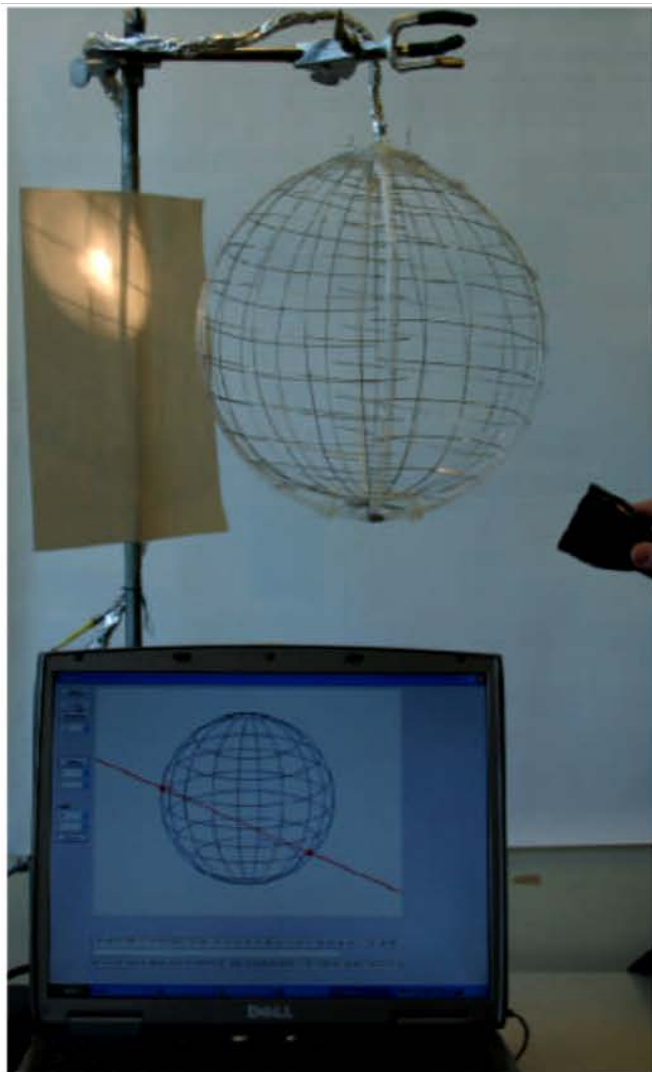


Fiber structure

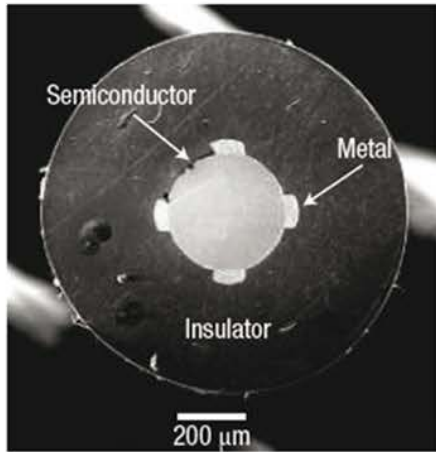
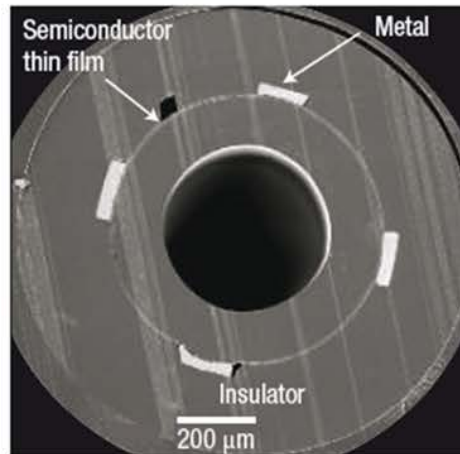
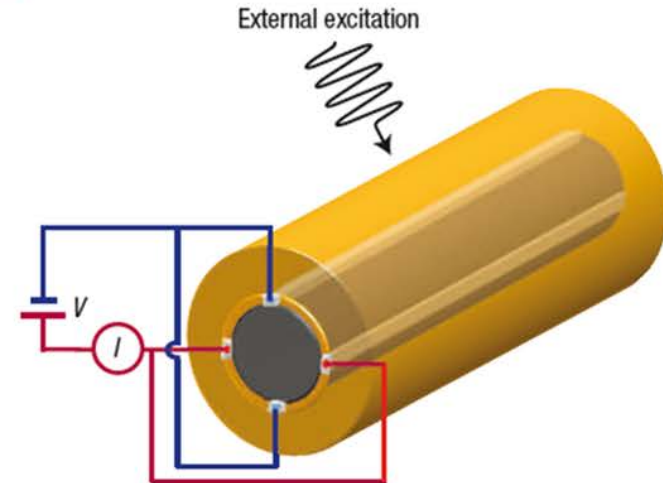
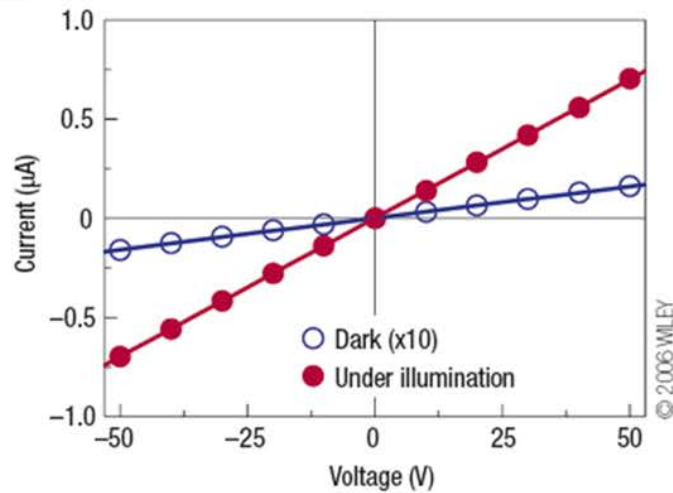
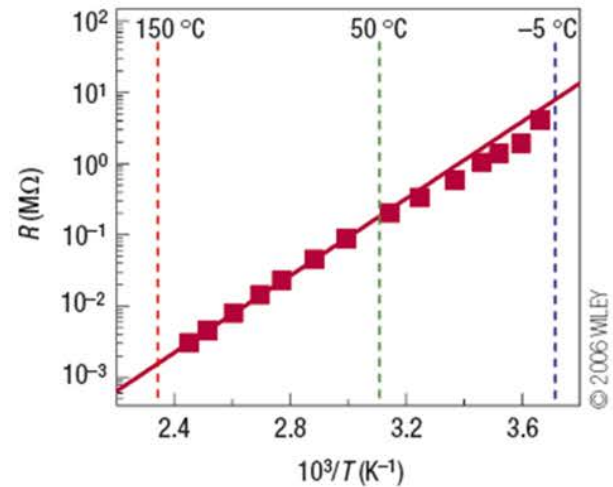


2D thermal sensing

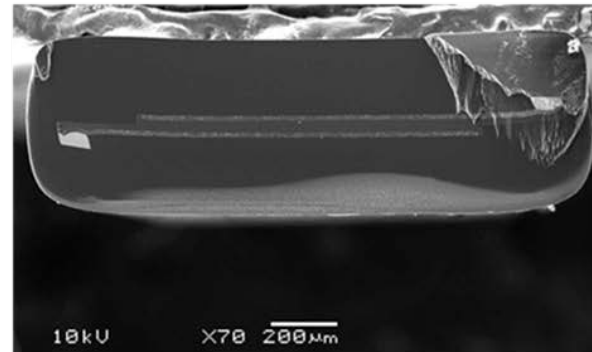
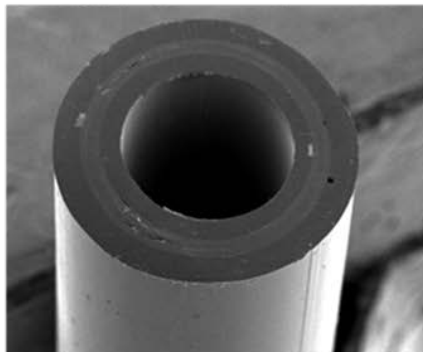
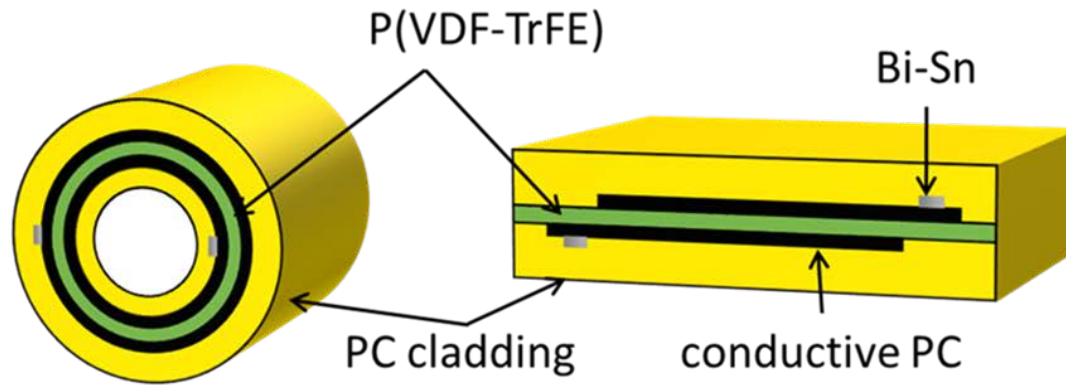
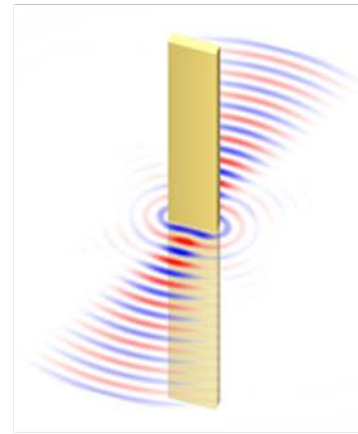
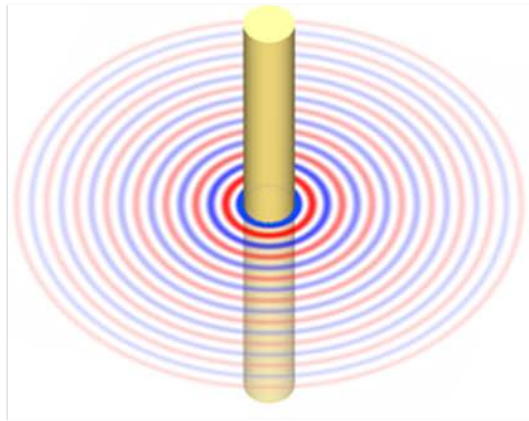
# Geometric Fiber Constructs



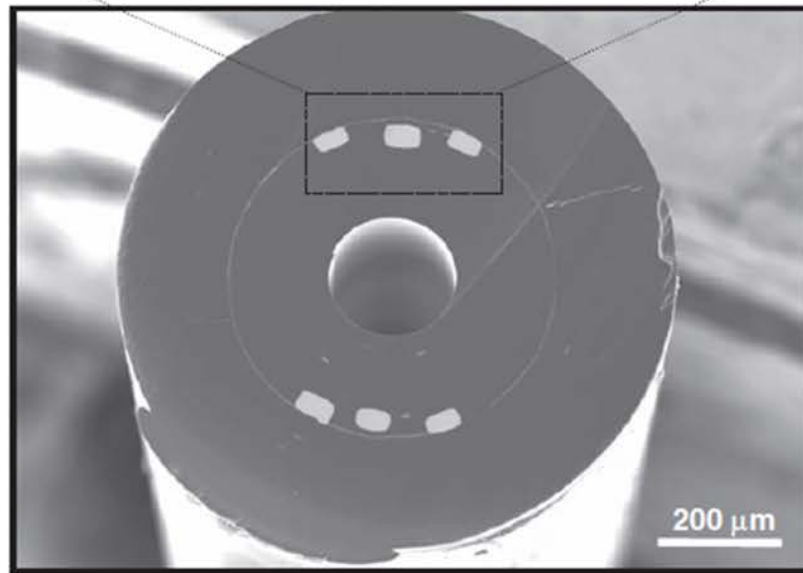
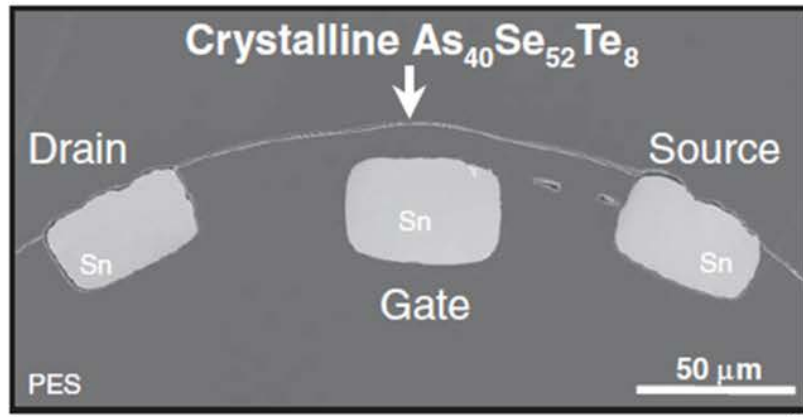
# Multimaterial Photodetecting Fibers

**a****b****c****d****e**

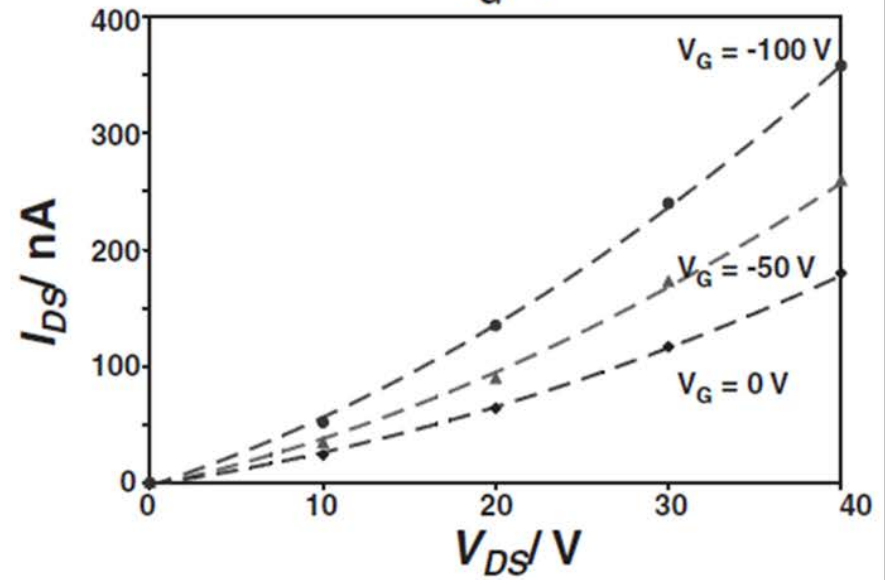
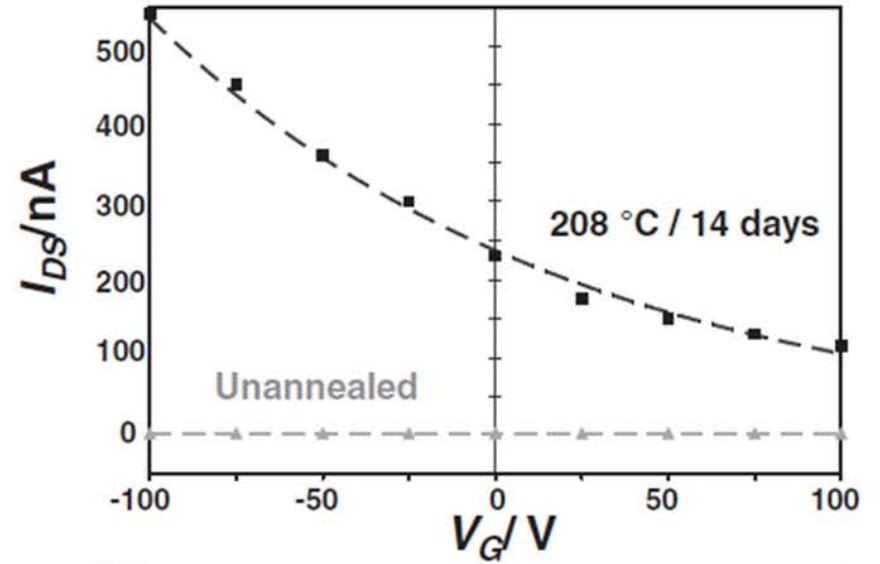
# Piezoelectric Fibers



# Fiber FET

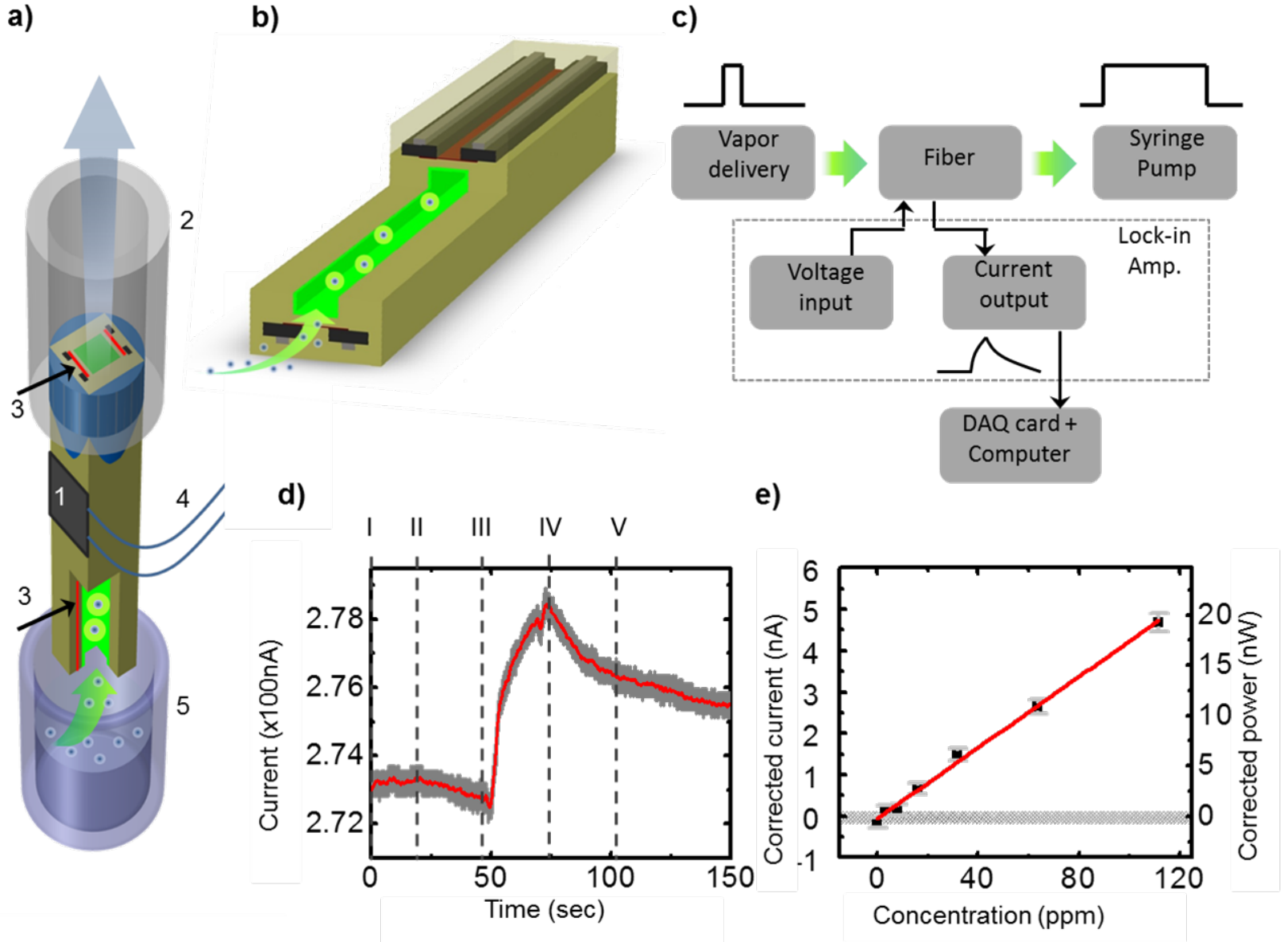


Fiber structure

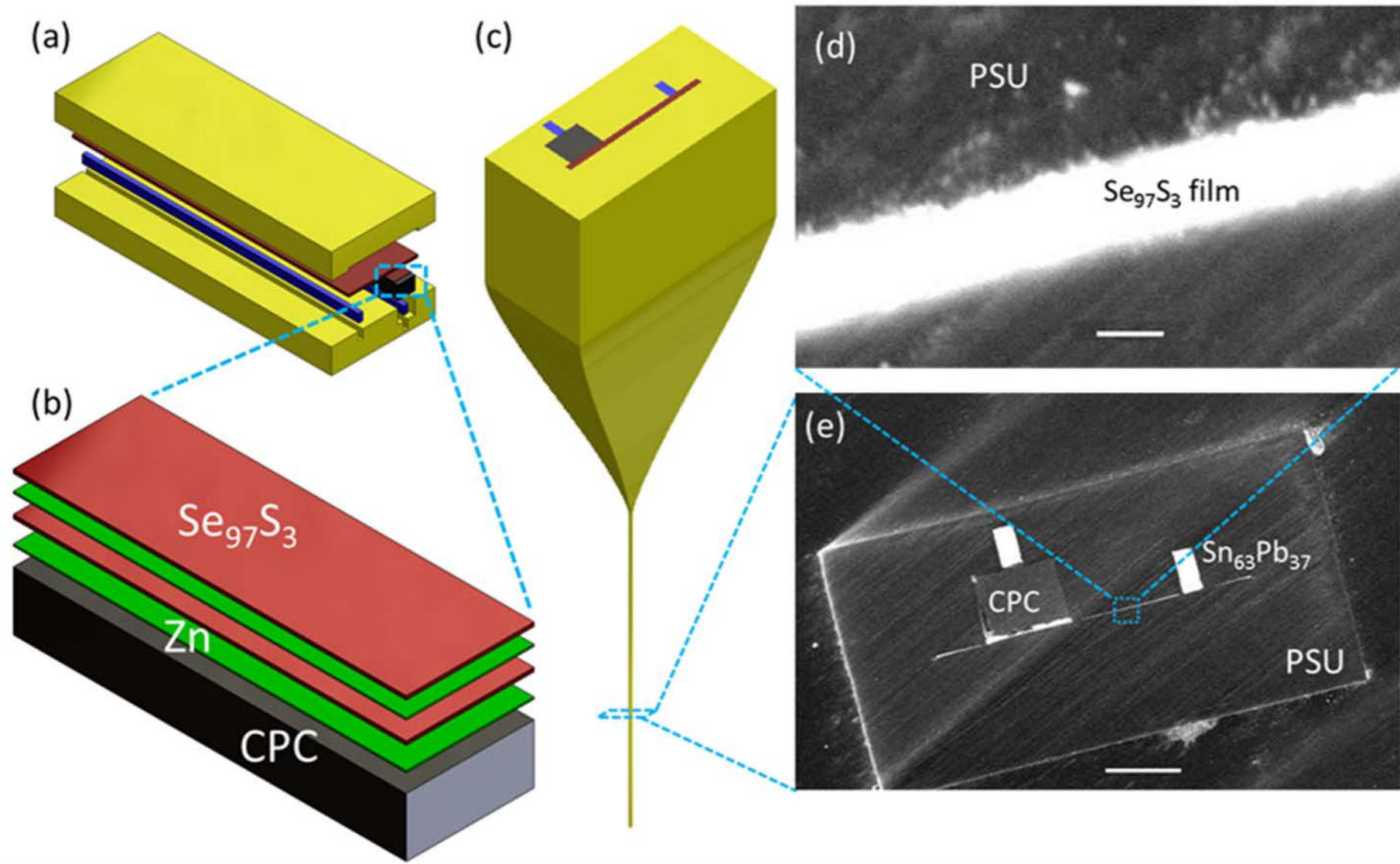


Device performance

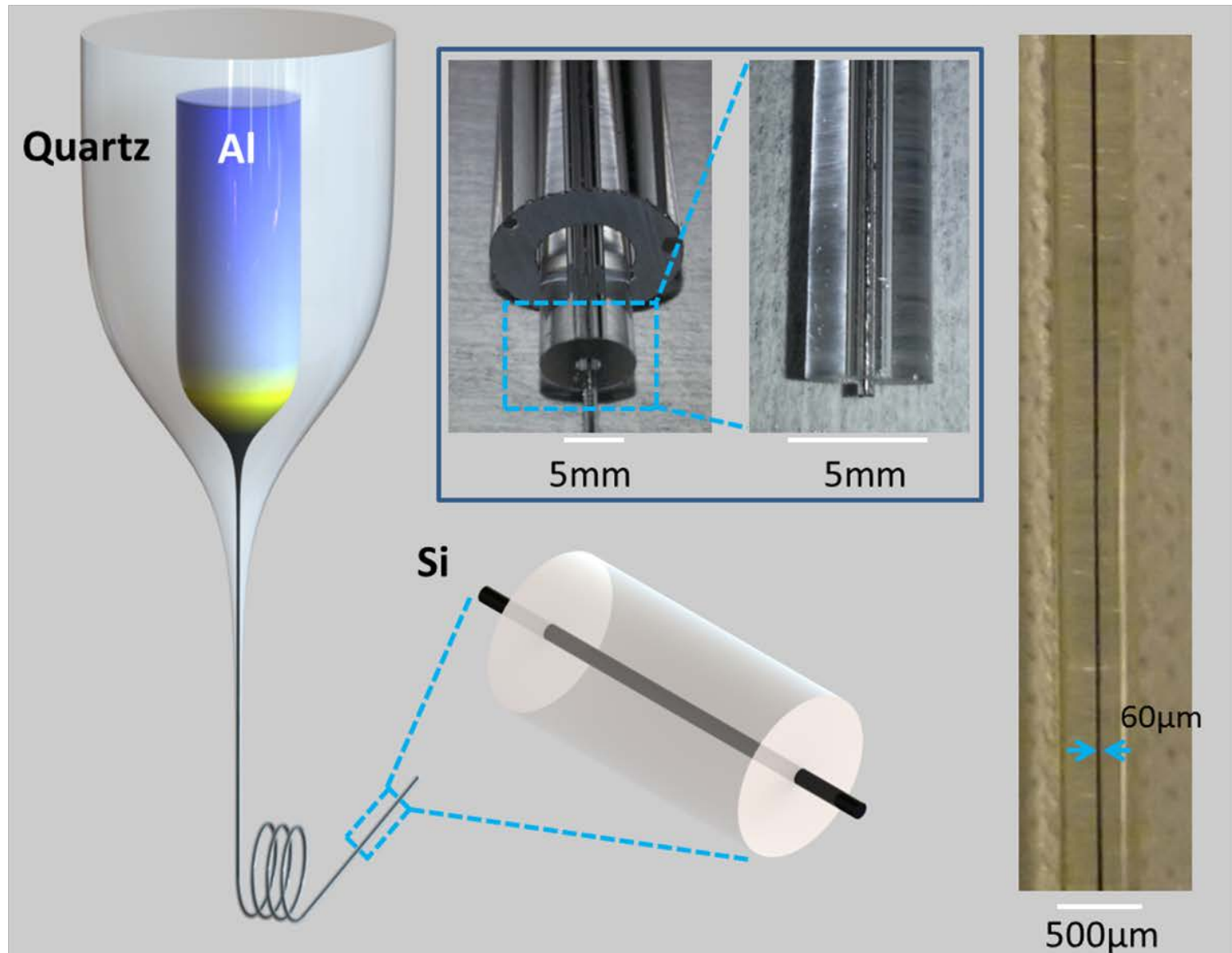
# Chemical Sensing



# Fiber Draw Synthesis

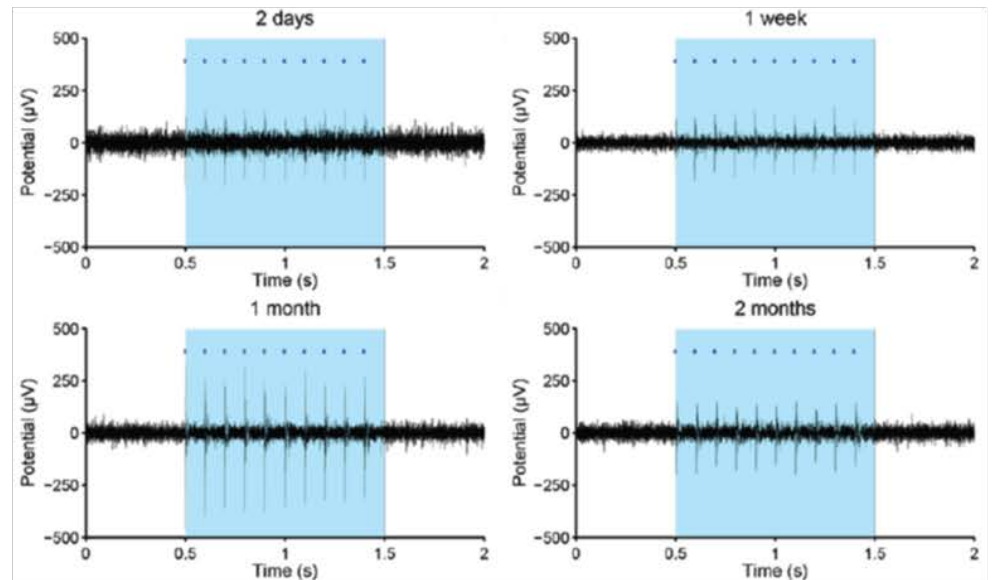
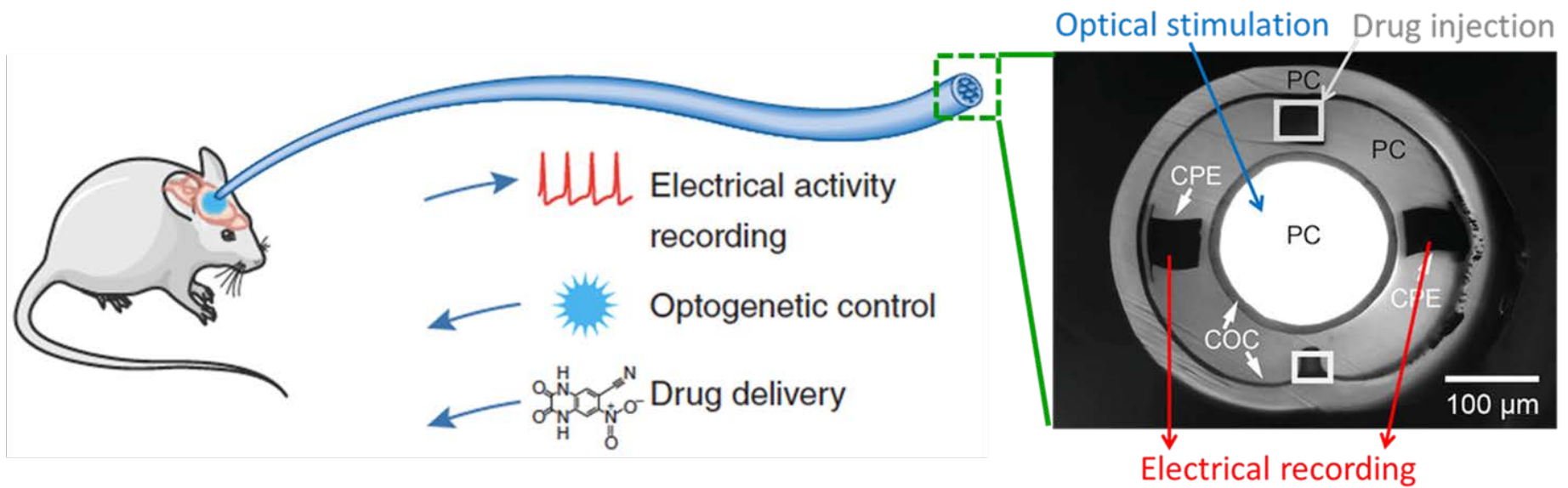


# Silicon Core Fiber via In-Fiber Chemical Reaction



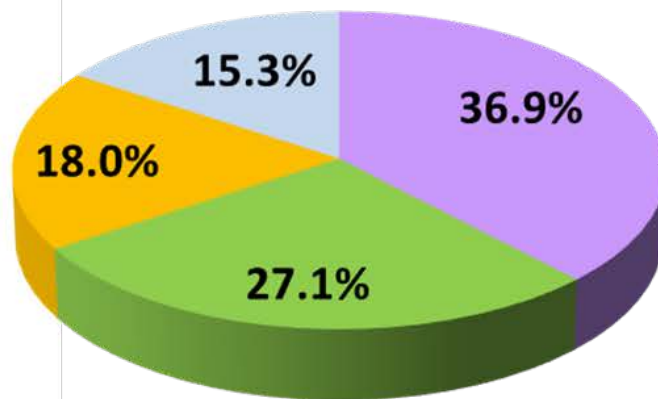


# Flexible Fiber Neural Probes





# High Precision Noninvasive Surgery



- **Otology & Neurotology**
- **Laryngology, Airway Surgery & Pediatric ENT**
- **Head & Neck Surgery**
- **Neurosurgery**

# AFFOA – Advanced Functional Fabrics of America

AFFOA's mission is to enable a manufacturing-based revolution by transforming traditional fibers, yarns, and fabrics into highly sophisticated, integrated and networked devices and systems.

## **New collaboration to accelerate innovations in fibers and fabrics**

April 1, 2016

An independent nonprofit founded by MIT has been selected to run a new, \$317 million public-private partnership announced today by Secretary of Defense Ashton Carter.

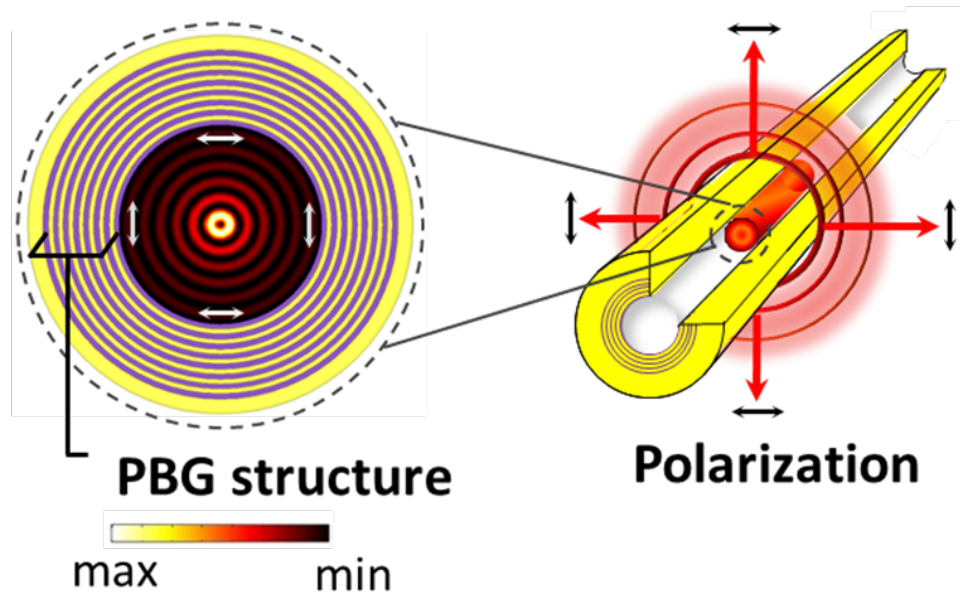
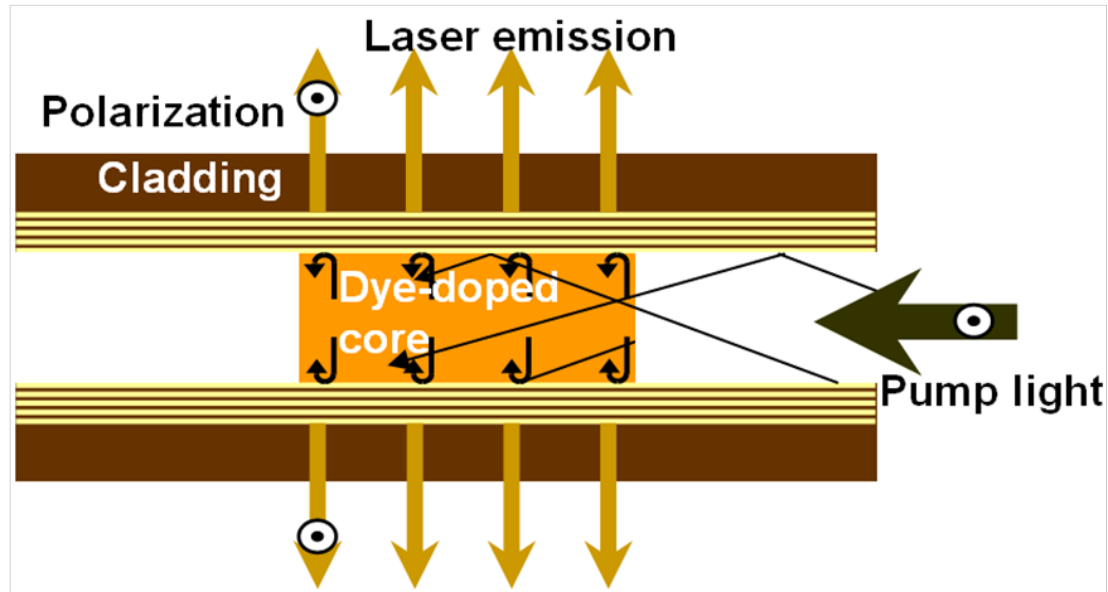
The partnership, named the **Advanced Functional Fibers of America (AFFOA) Institute**, has won a national competition for federal funding to create the latest Manufacturing Innovation Institute. It is designed to accelerate innovation in high-tech, U.S.-based manufacturing involving fibers and textiles.

The proposal for the institute was led by Professor Yoel Fink, director of MIT's Research Laboratory of Electronics (RLE). The partnership includes 32 universities, 16 industry members, 72 manufacturing entities, and 26 startup incubators, spread across 27 states and Puerto Rico.

# Lighthouse Inside Fiber ?

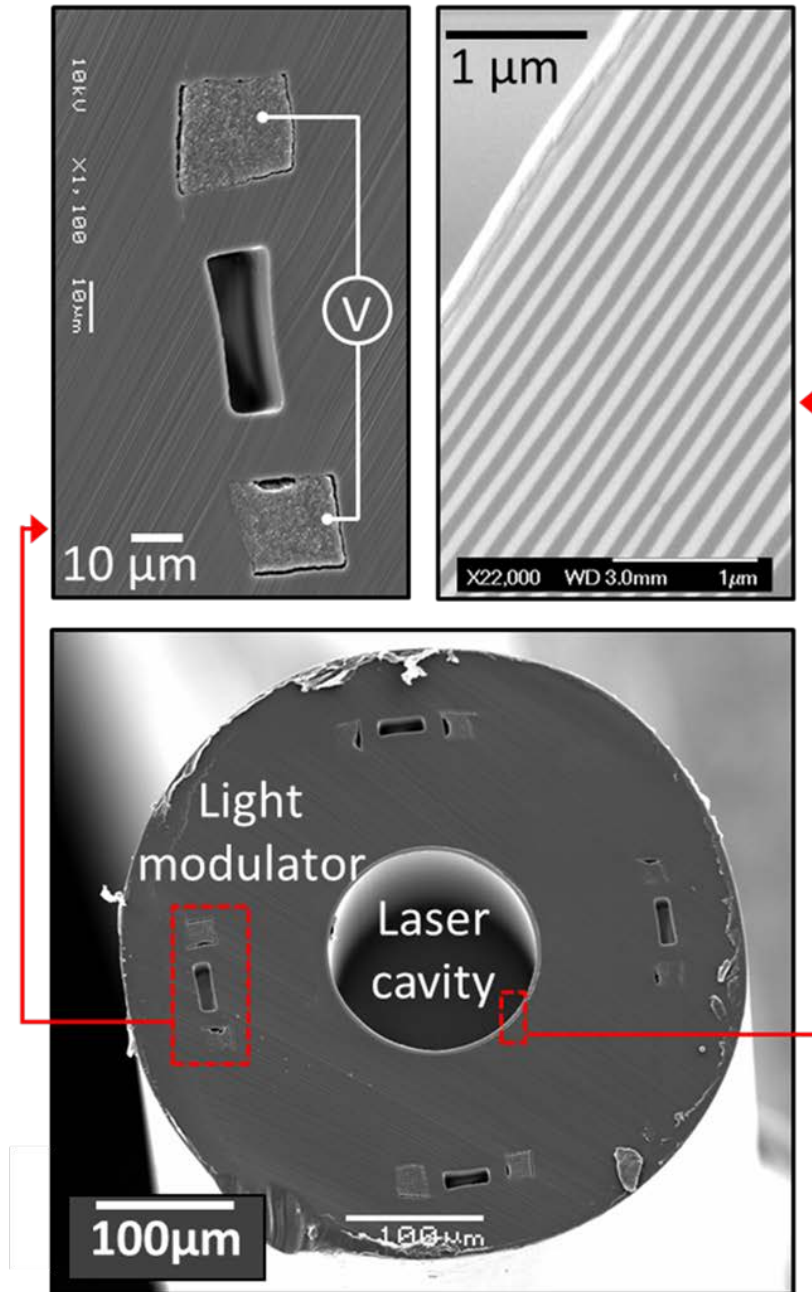


# Surface Emitting Fiber Laser

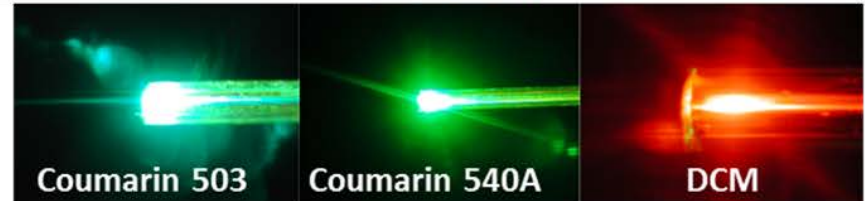
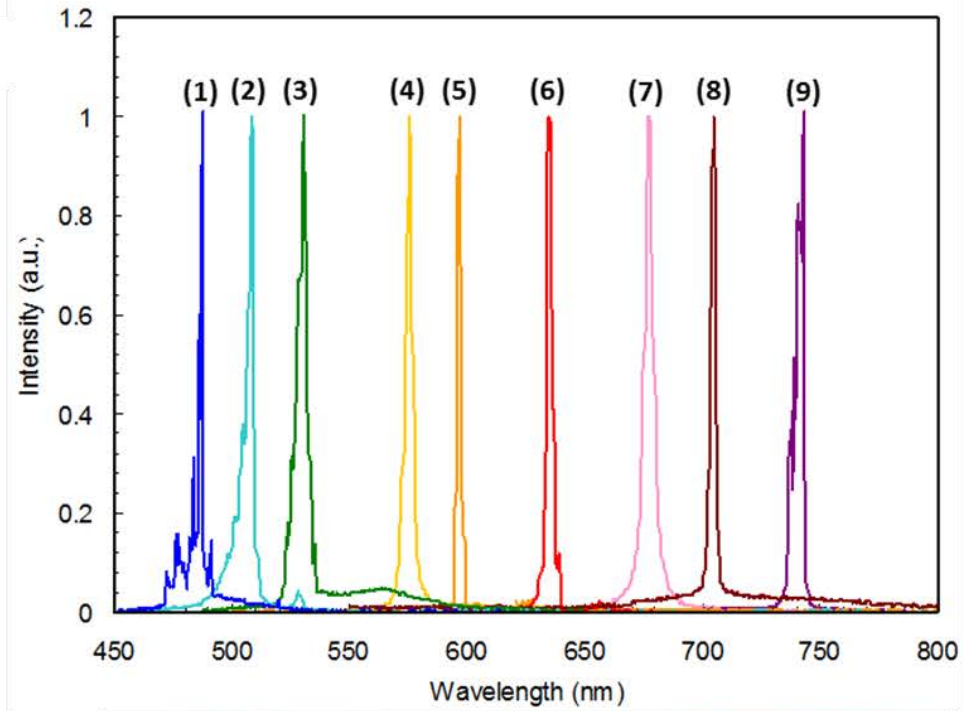
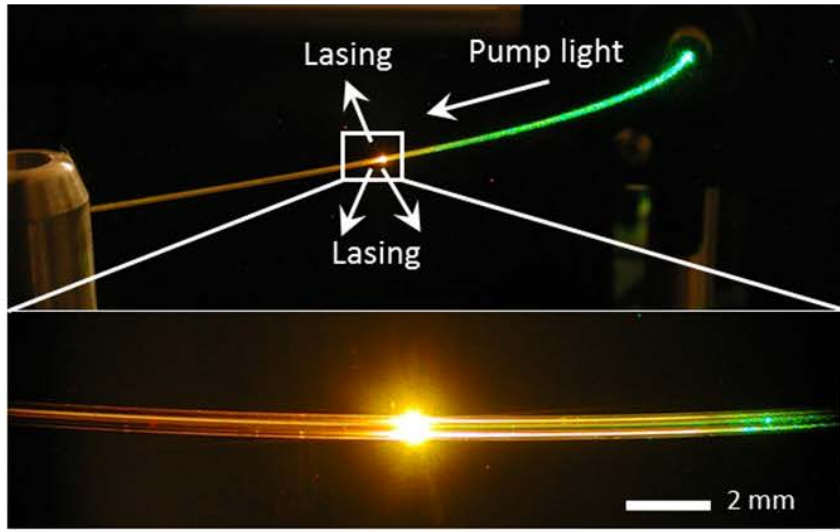


Azimuthally polarized radial fiber laser

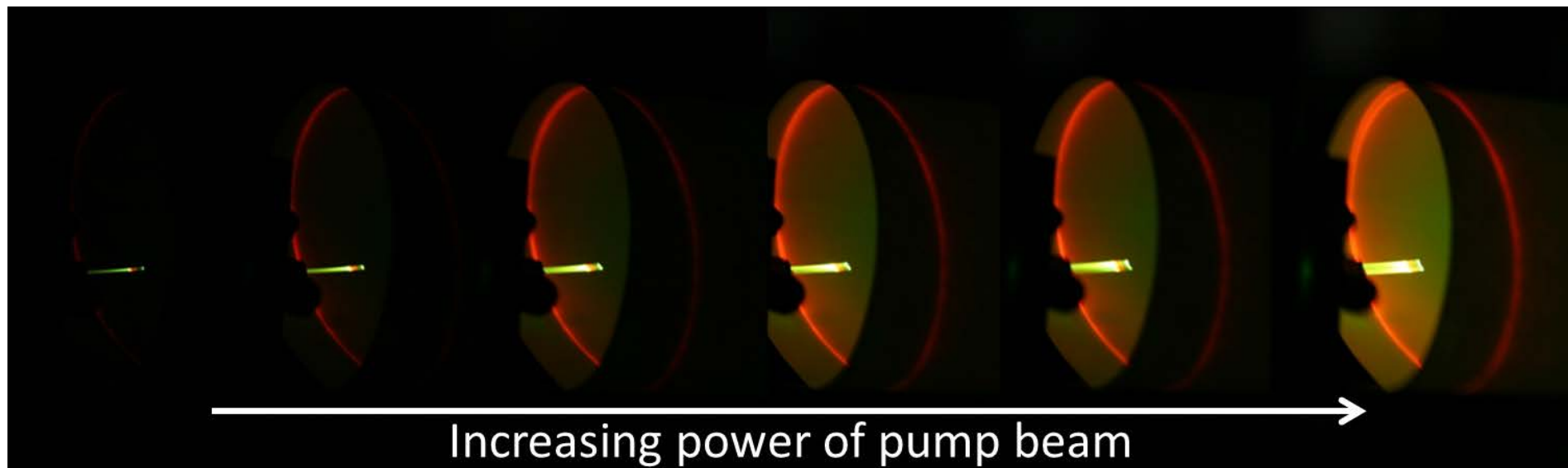
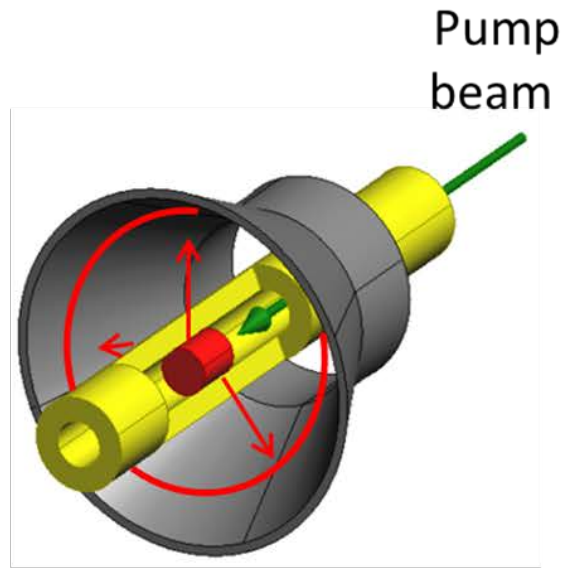
# Fiber Structure



# Surface Emitting Fiber Laser

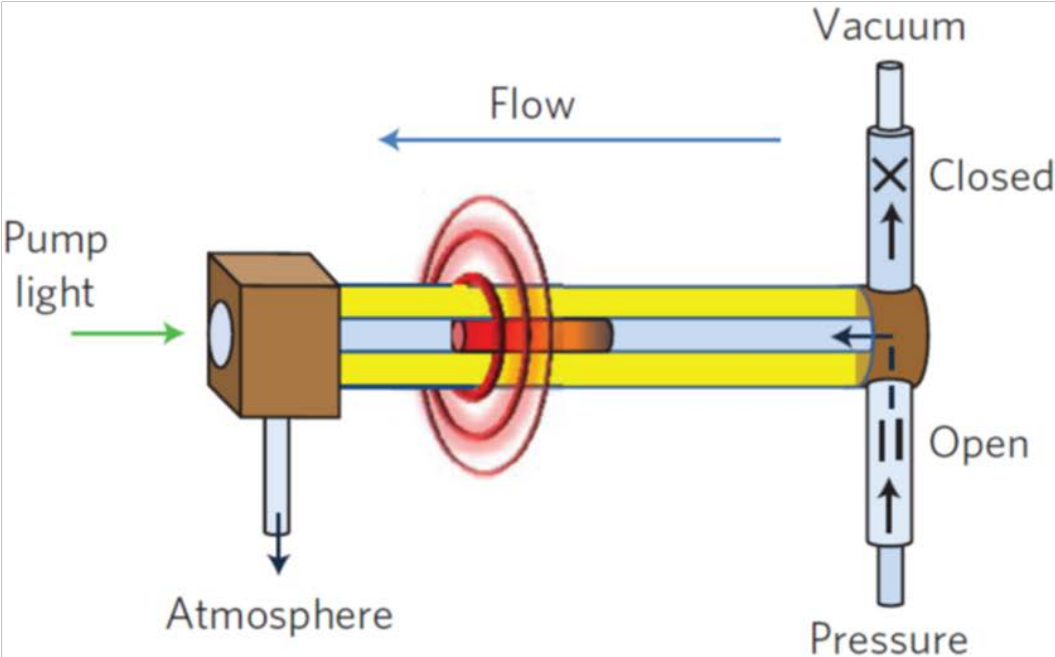


# Perfect Radial Emission

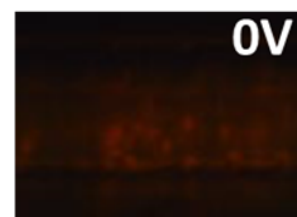
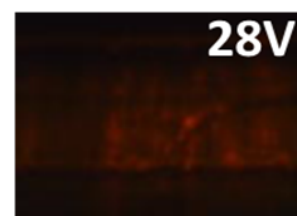
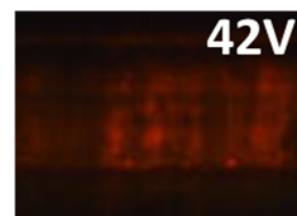
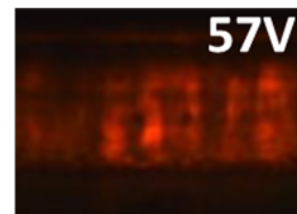
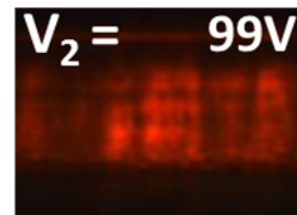
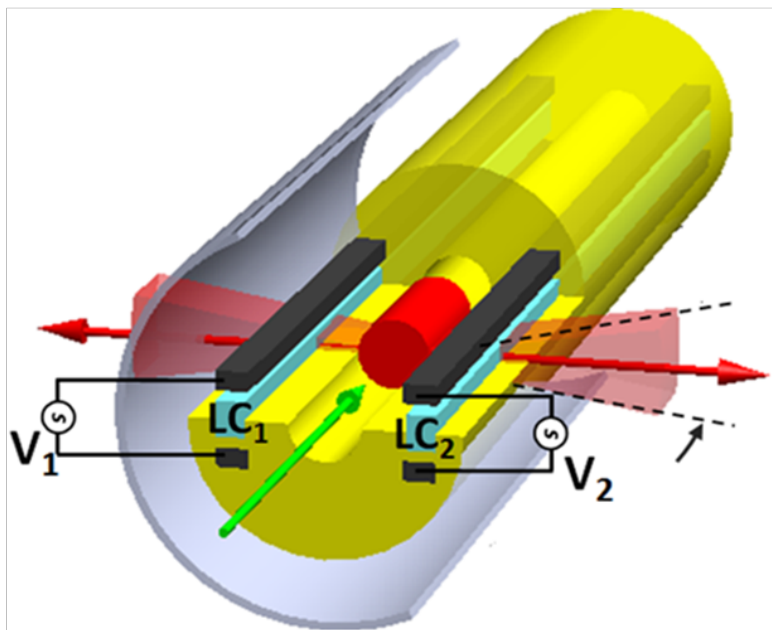




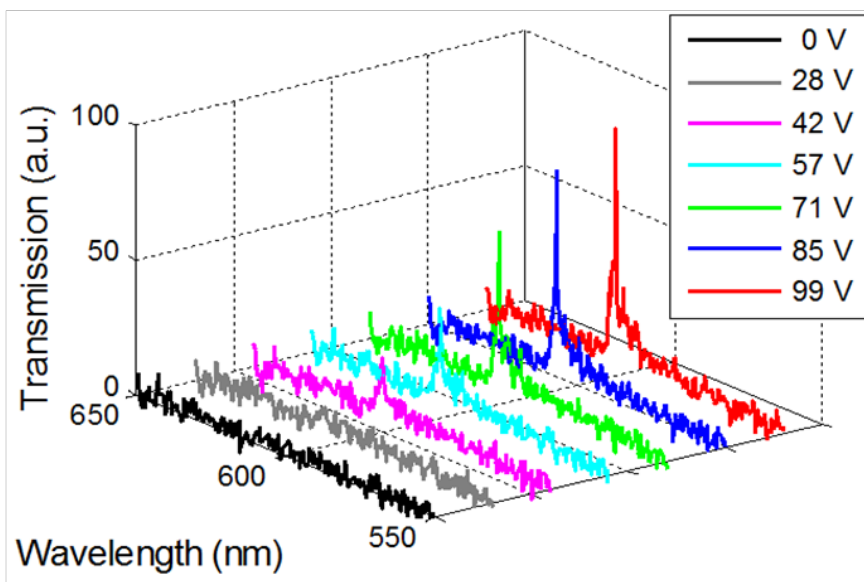
# Microfluidic Surface Emitting Fiber Laser



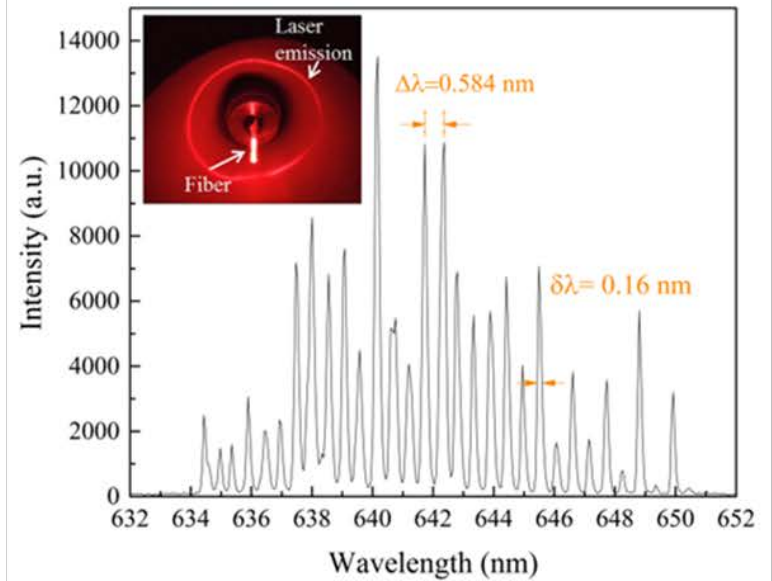
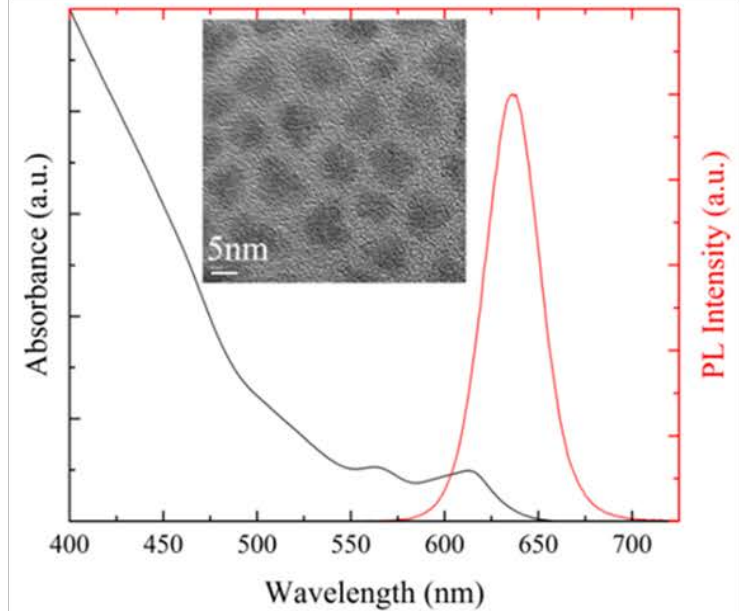
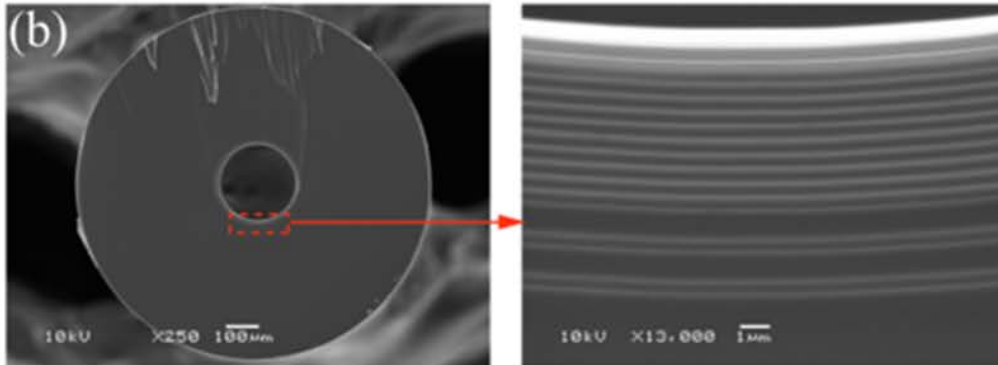
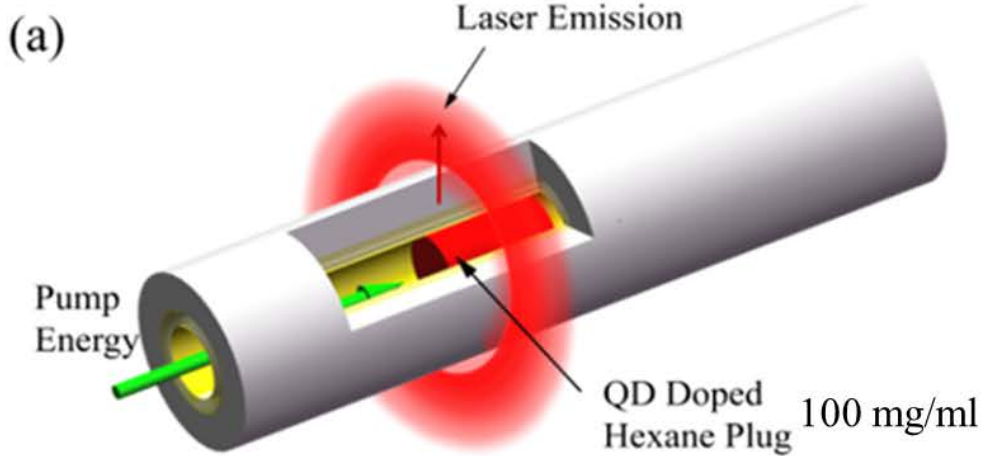
# Light Modulation via Side Channels



Light modulation



# Optofluidic QD Fiber Laser



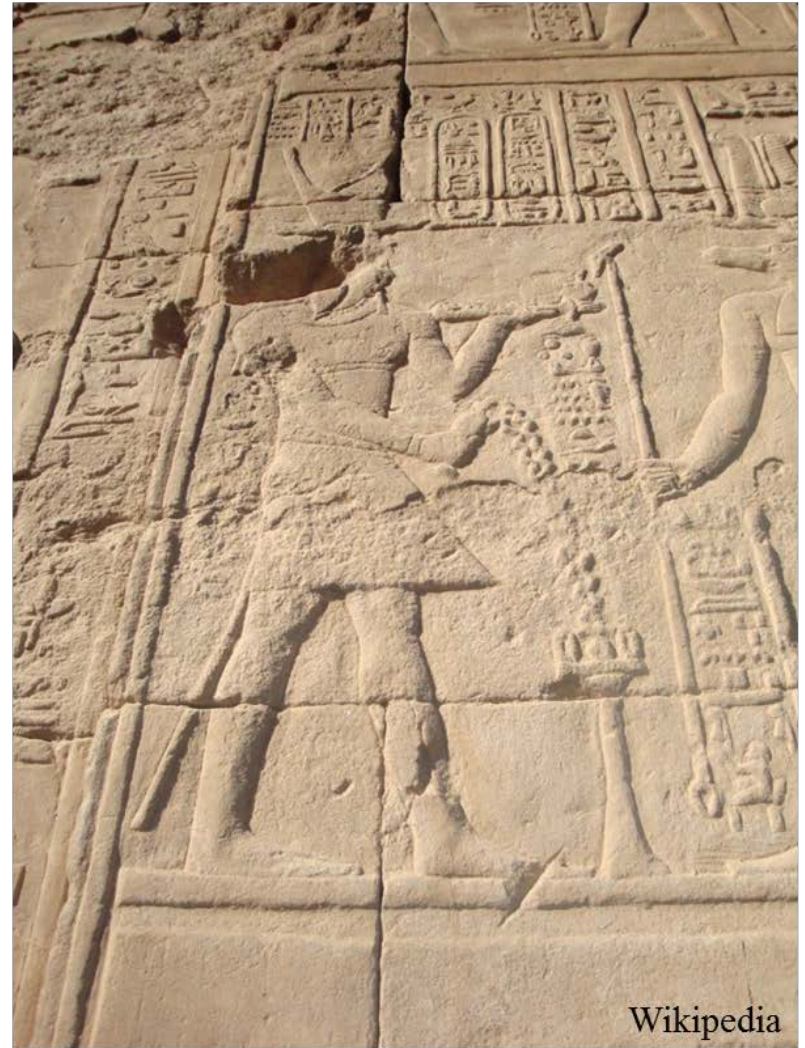
# Fluid Instability: Judo Inside Fiber



# Fluid Instability

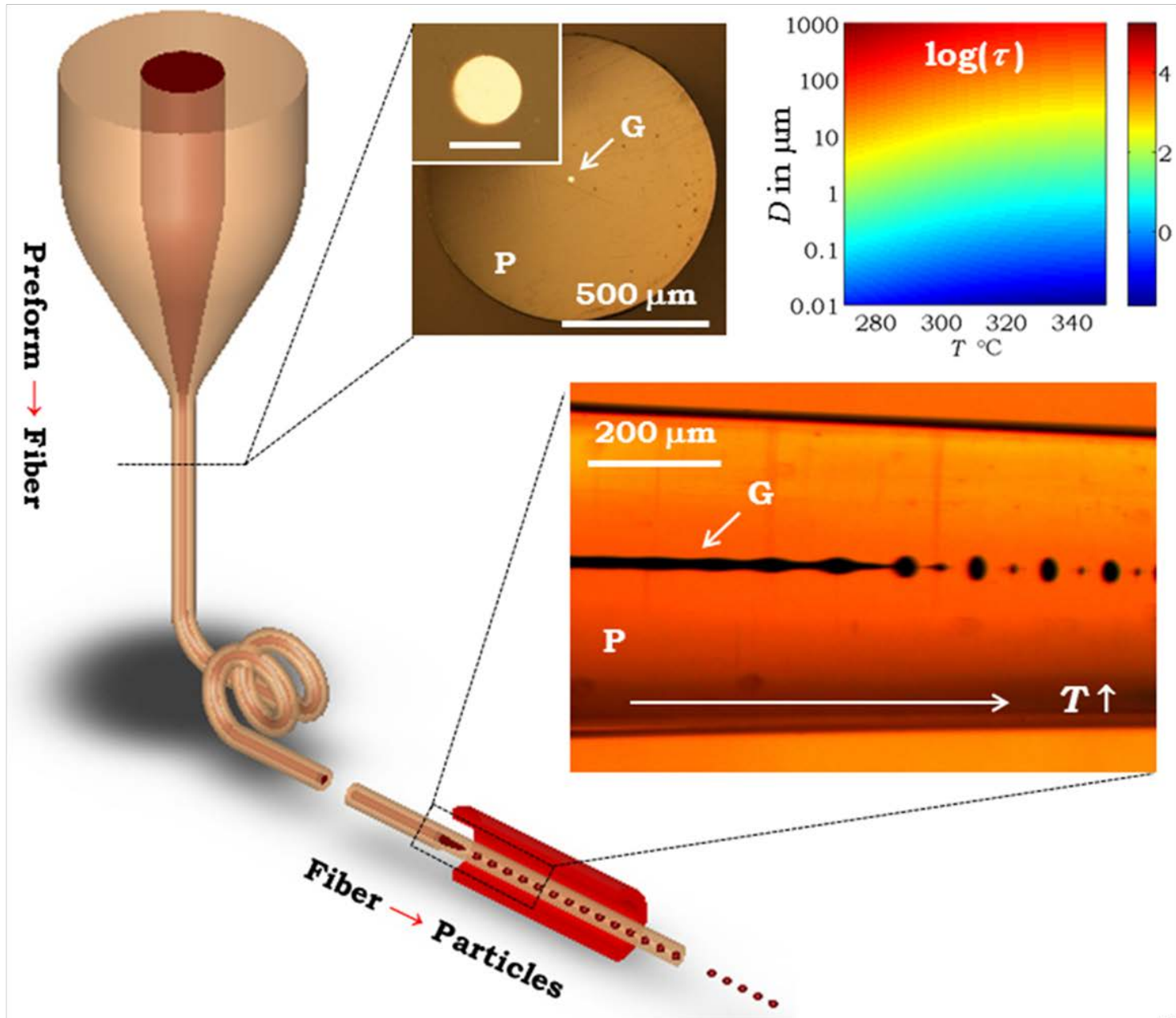


Plateau and Lord Raleigh's groundbreaking analysis

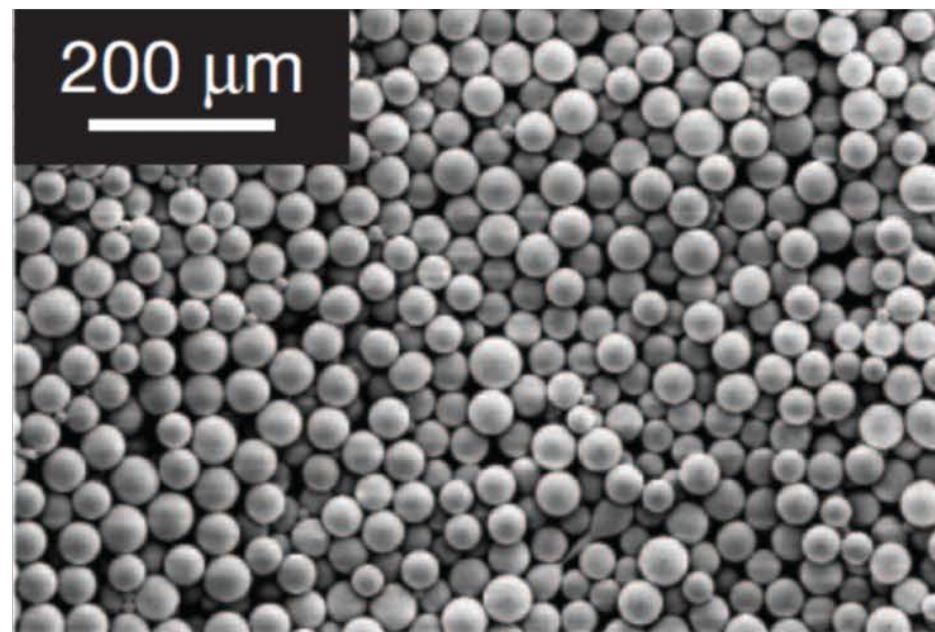
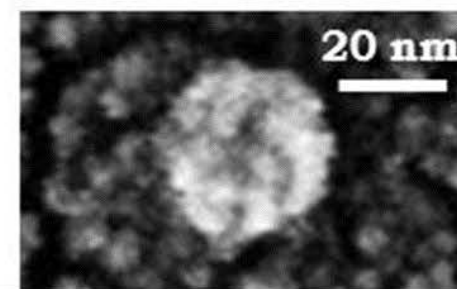
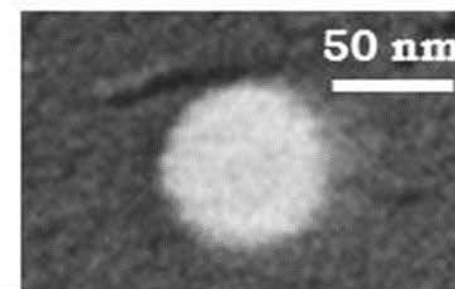
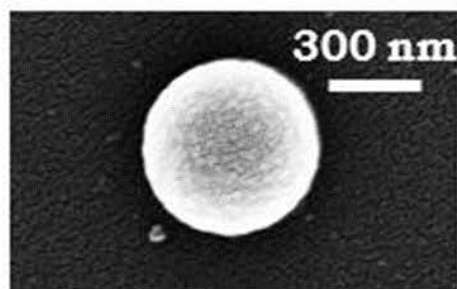
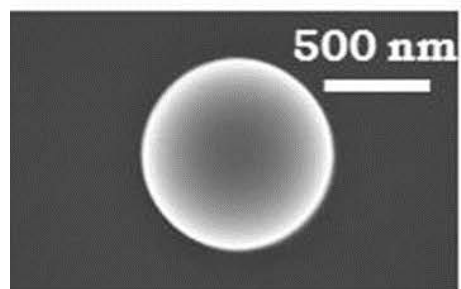
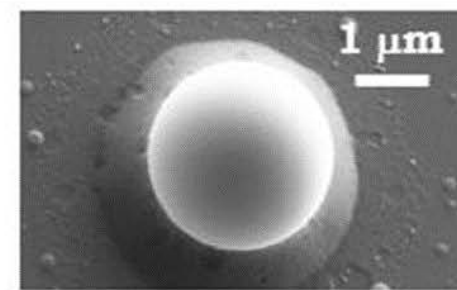
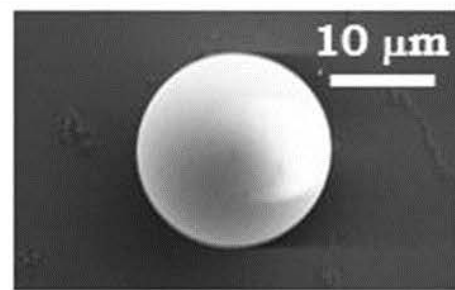
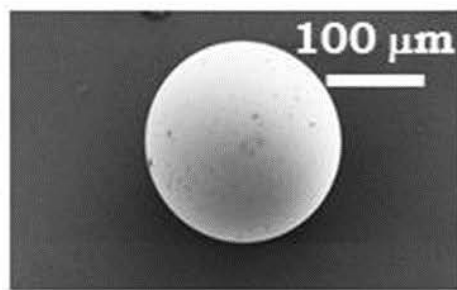
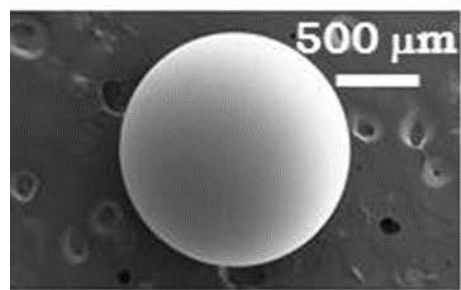


Inscription on an ancient Egyptian temple, circa 1500 BCE

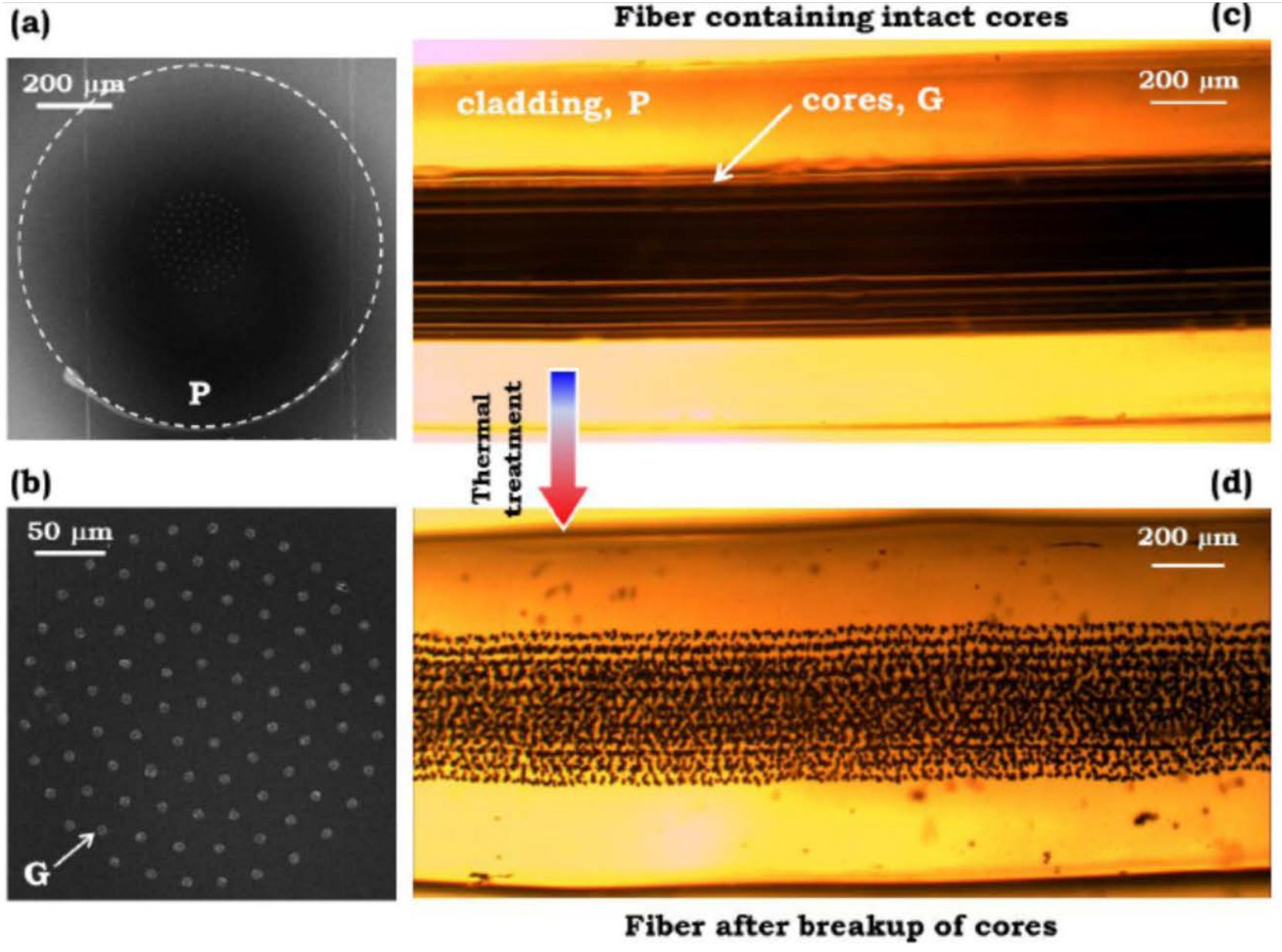
# In-Fiber Fluid Instability



# Spheres!

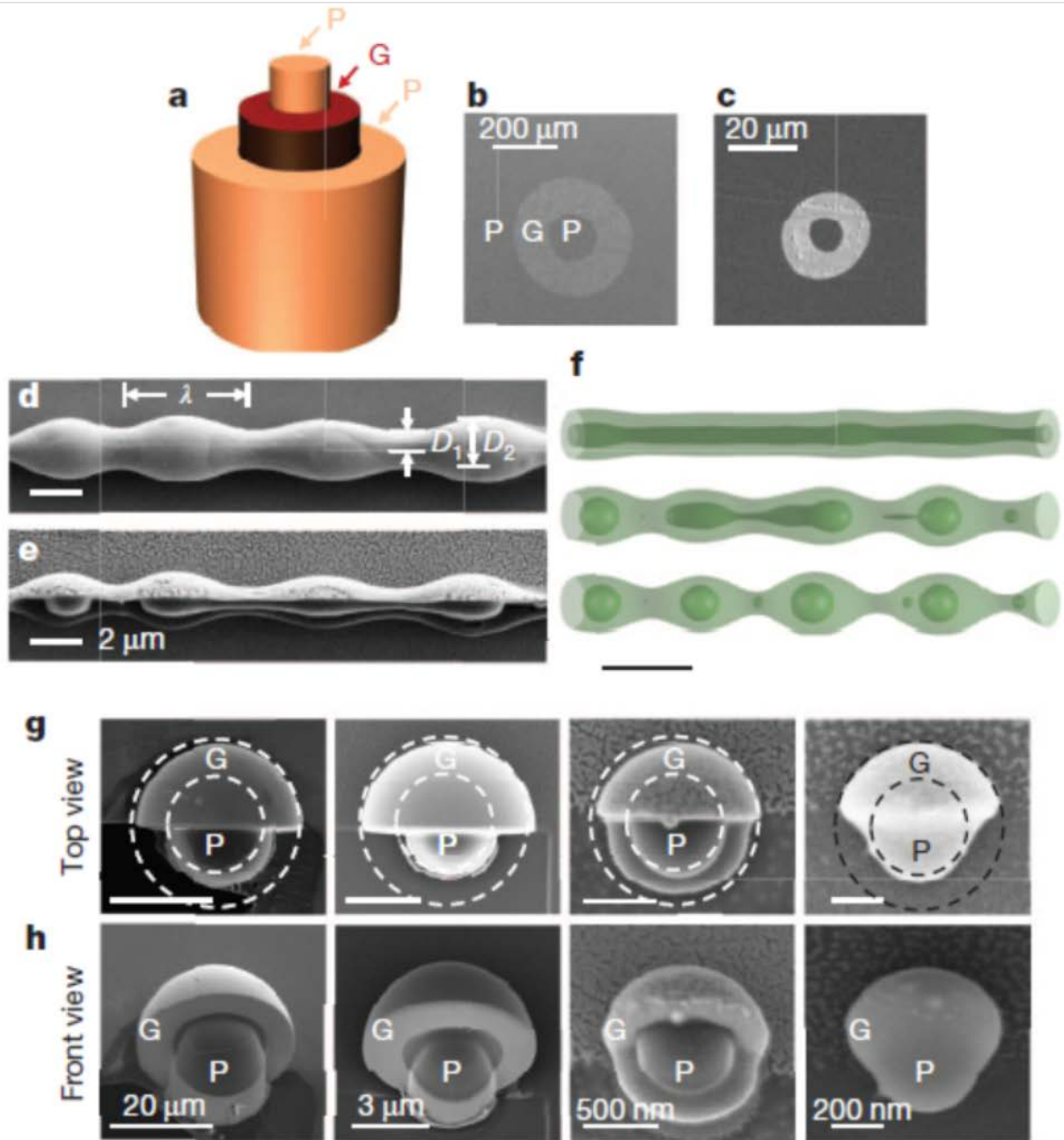


# Multi-Core Breakups

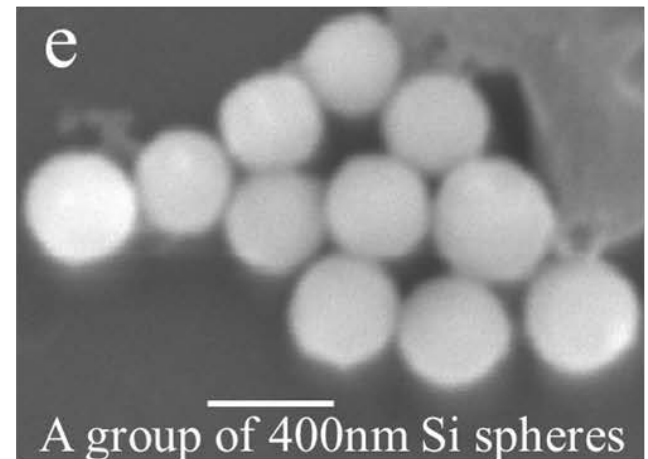
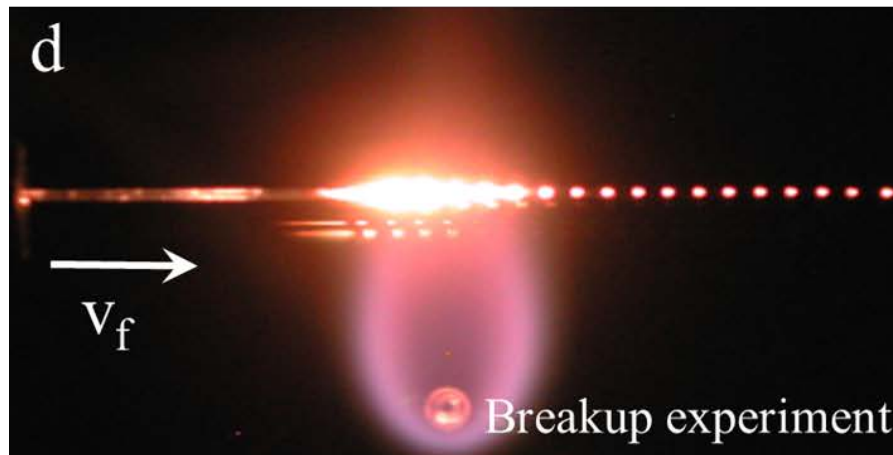
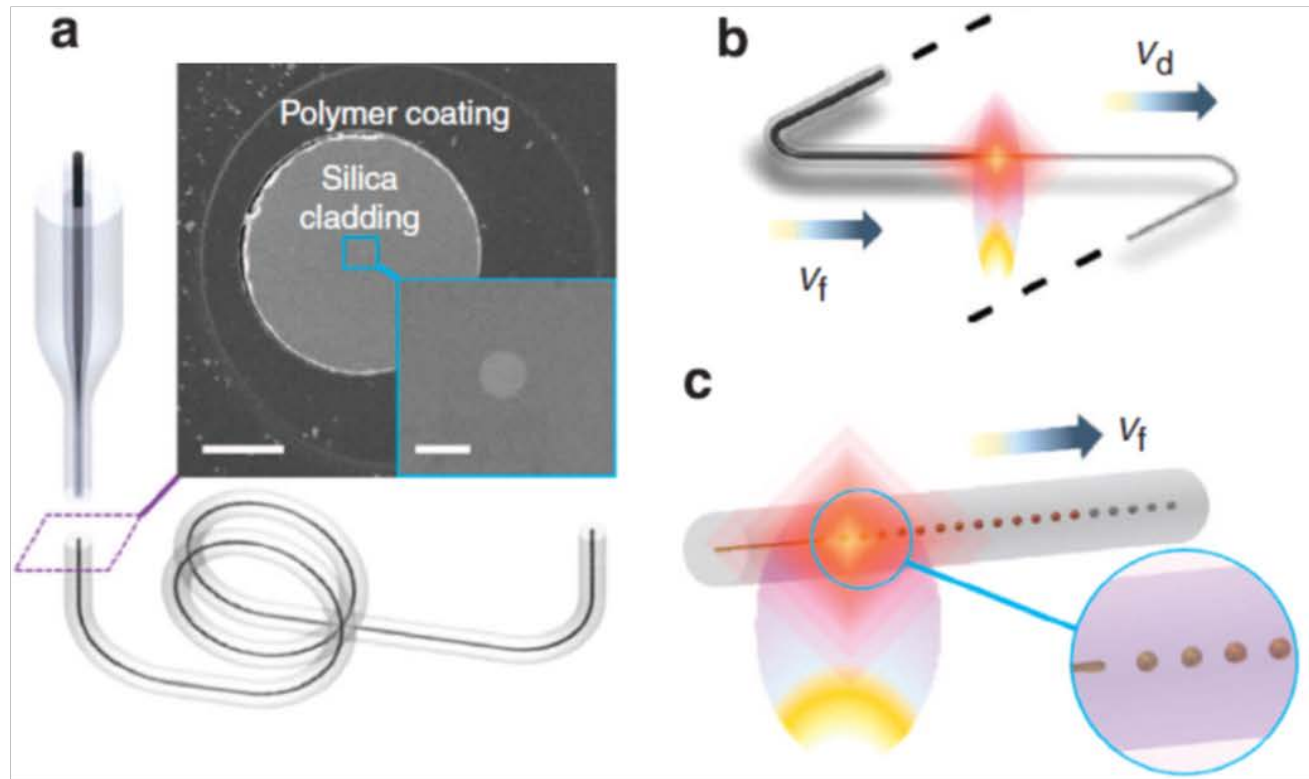




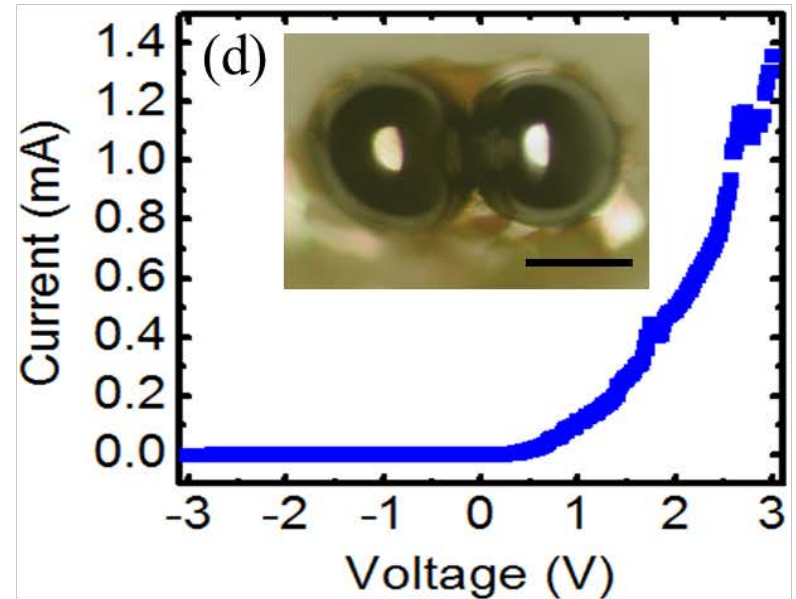
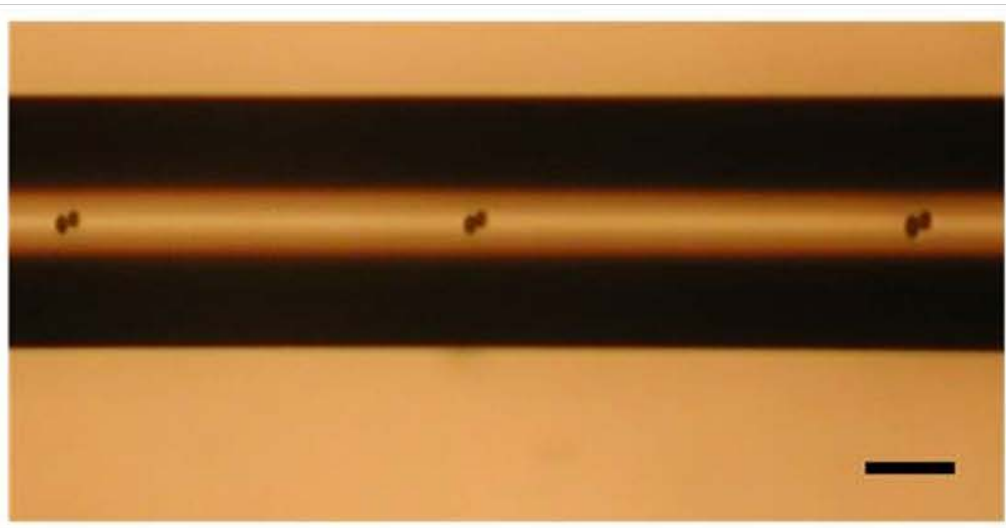
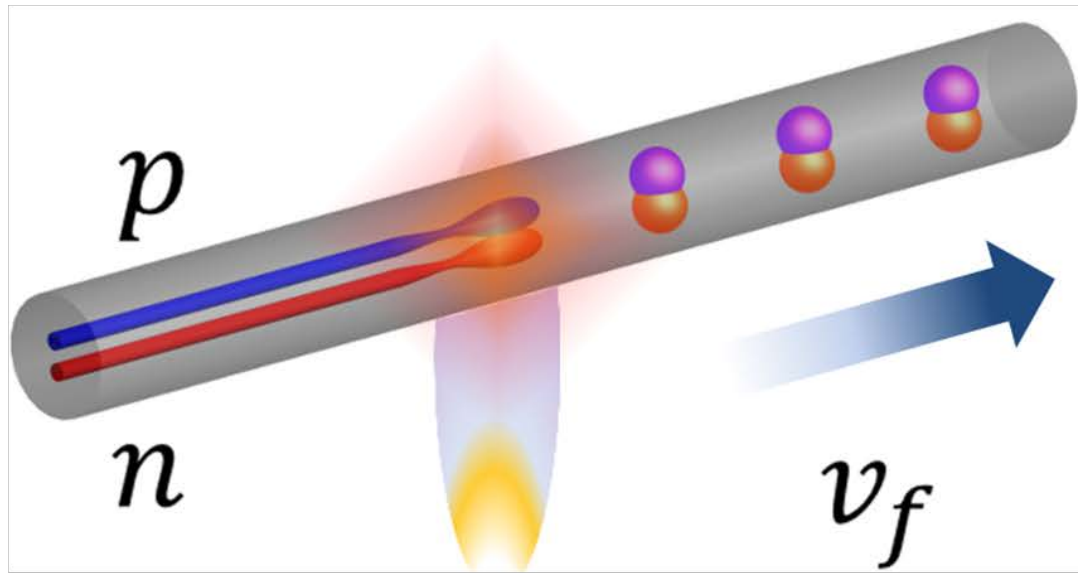
# Structured Spheres



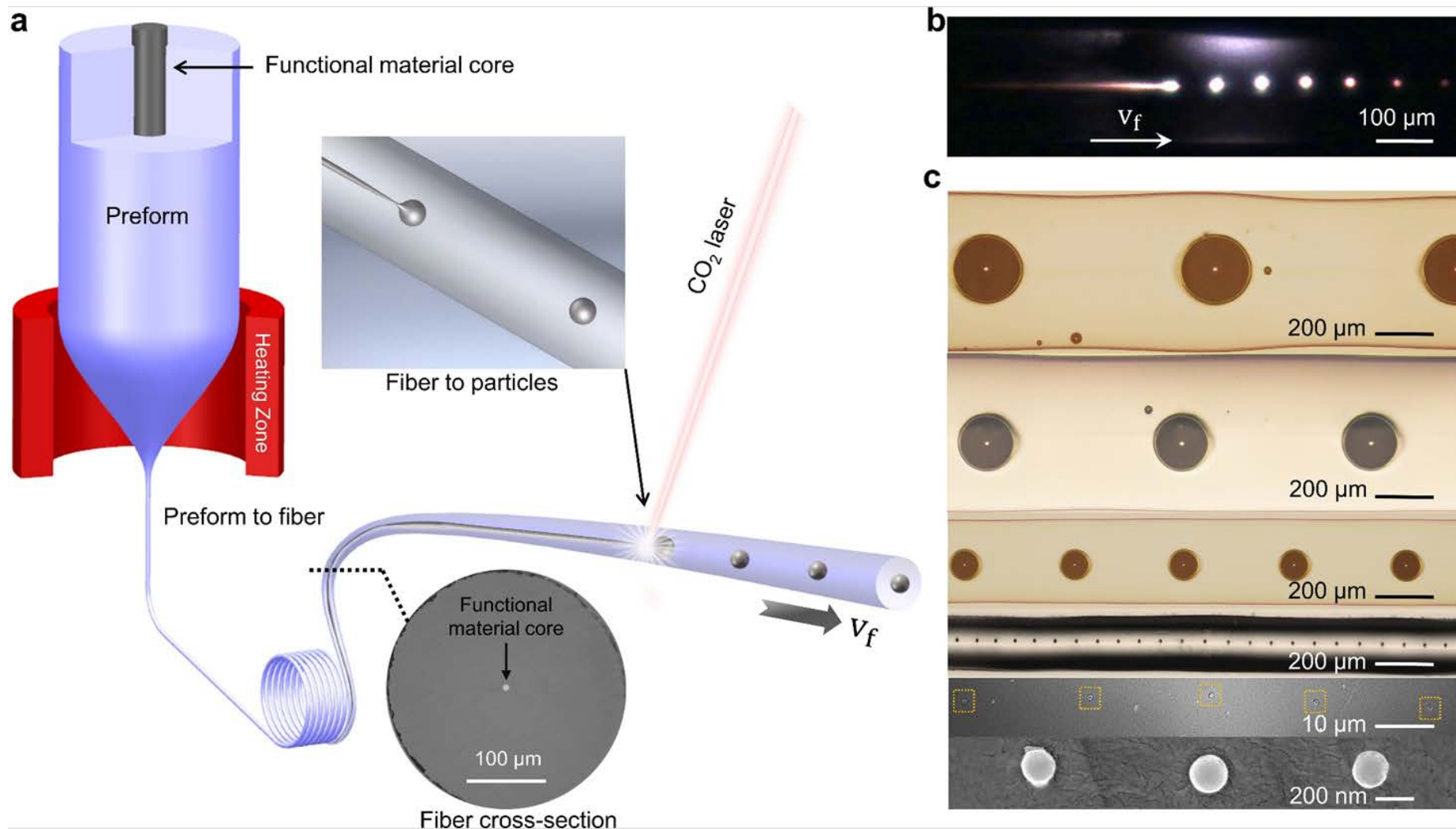
# In-Fiber Fluid Instability (High T)



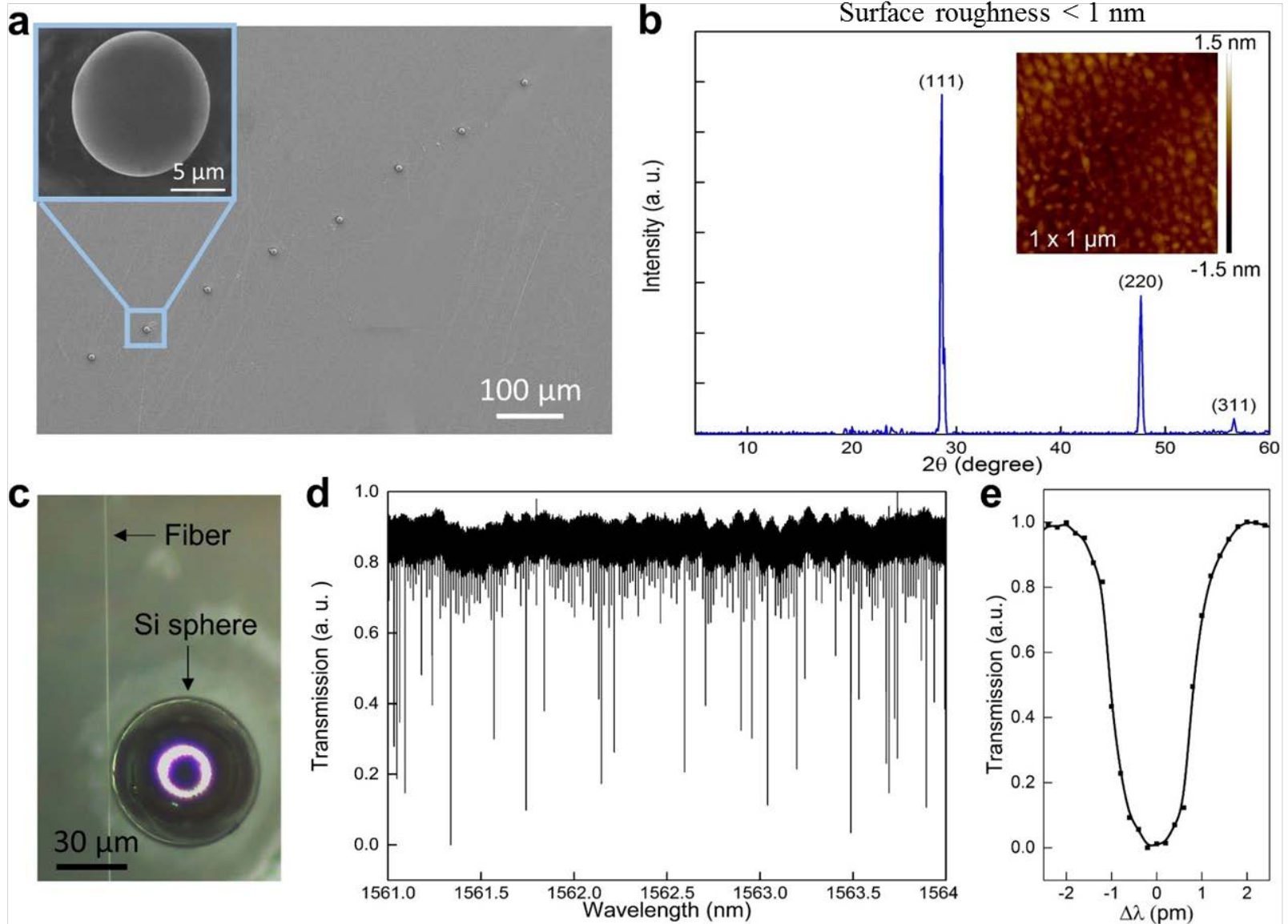
# In-Fiber pn Junction



# Laser Induced In-Fiber Fluid Dynamical Instabilities

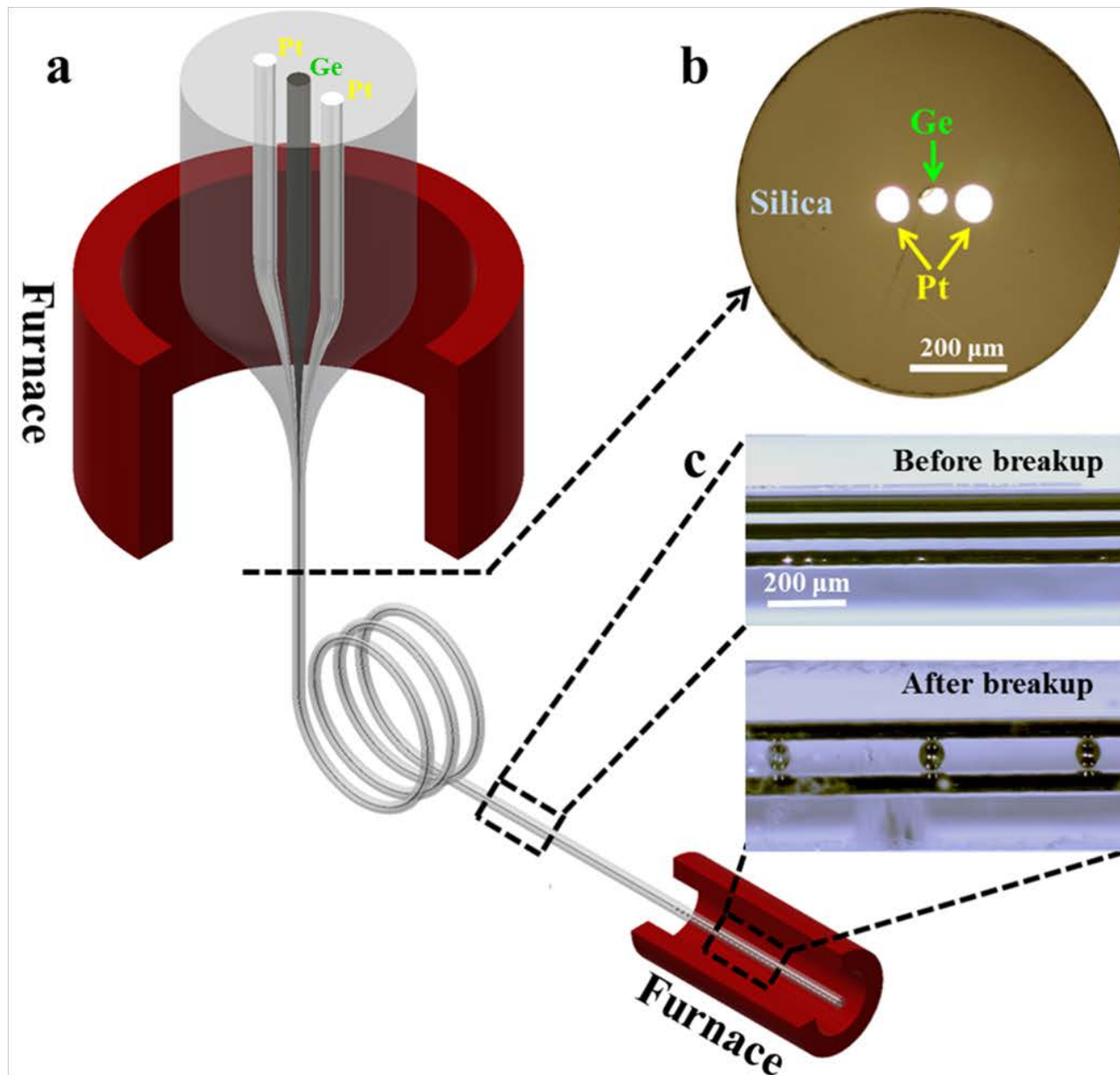


# High-Quality Whispering-Gallery Mode Resonators

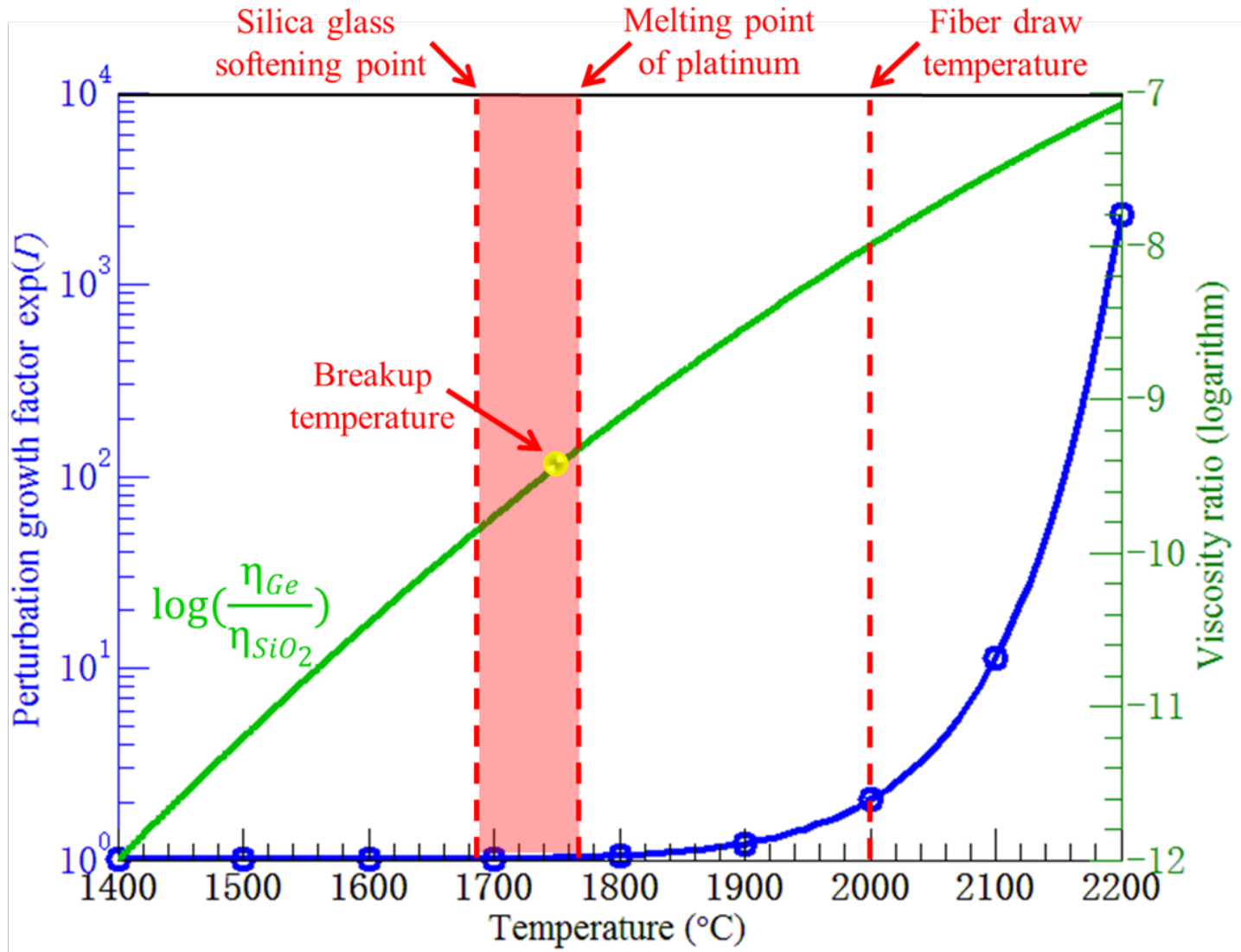


Q factor as high as  $7.1 \times 10^5$  is achieved

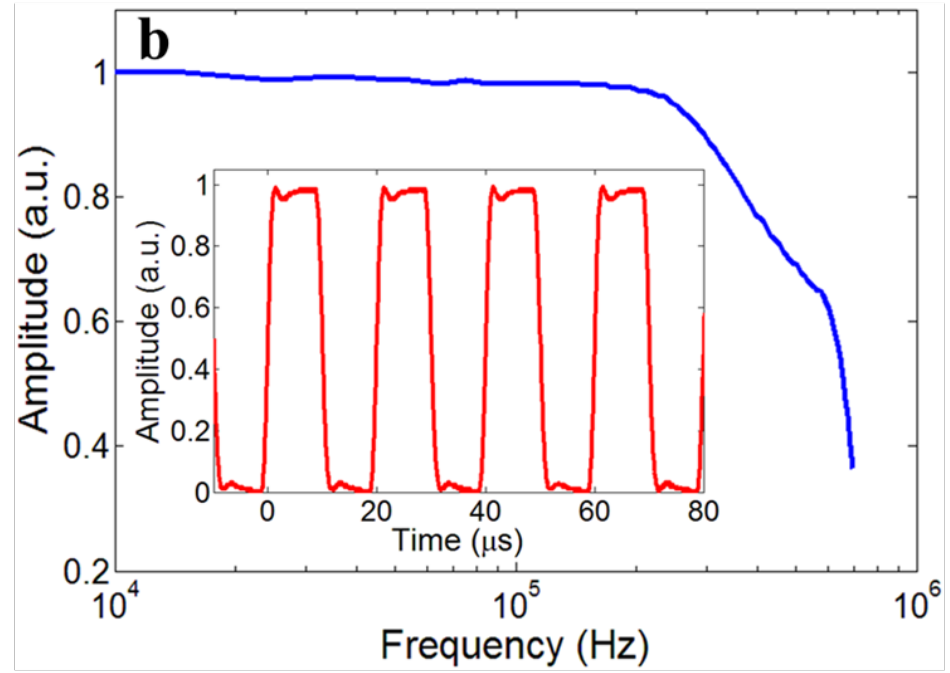
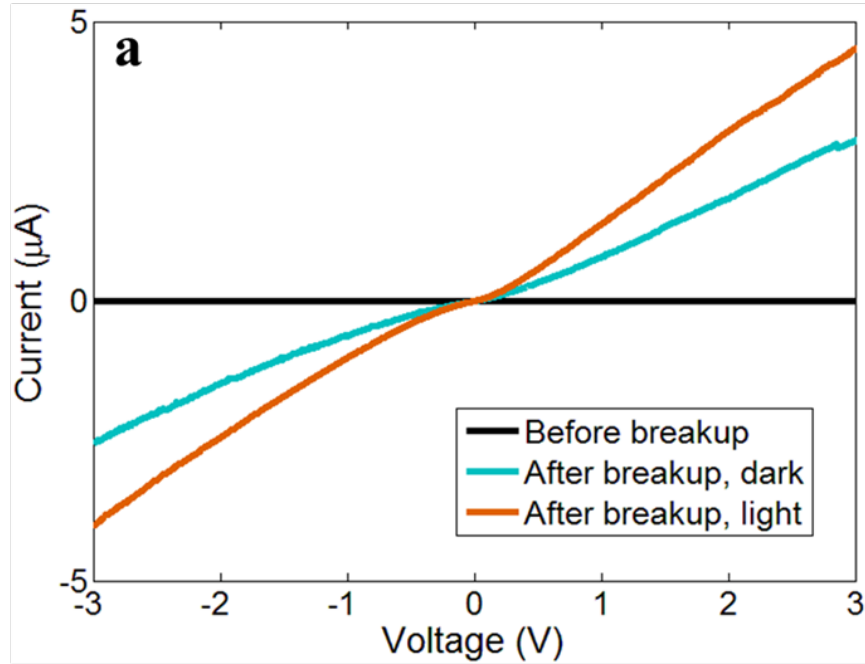
# Selective Amplification of In-fiber Capillary Instabilities



# Processing Temperature



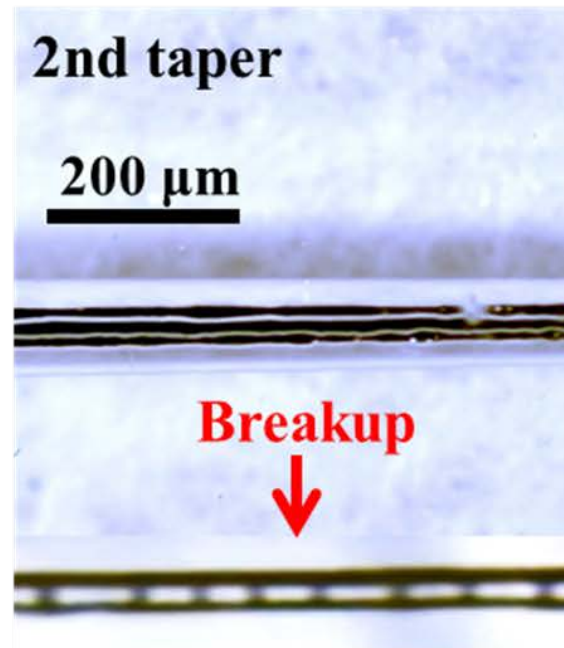
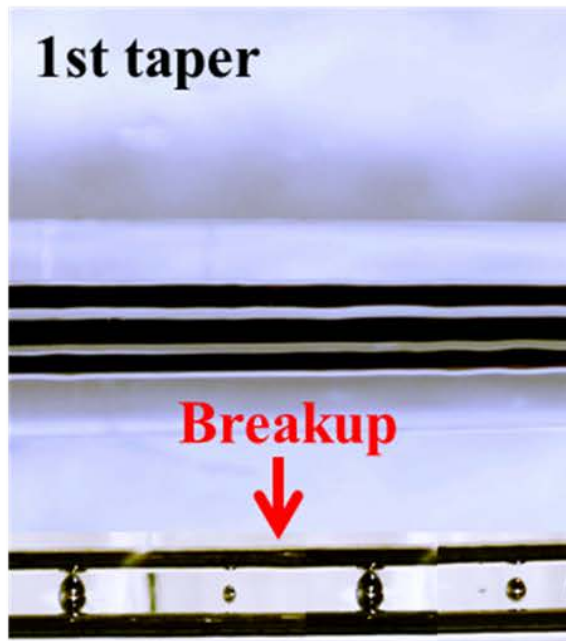
# Selective Amplification of In-fiber Capillary Instabilities



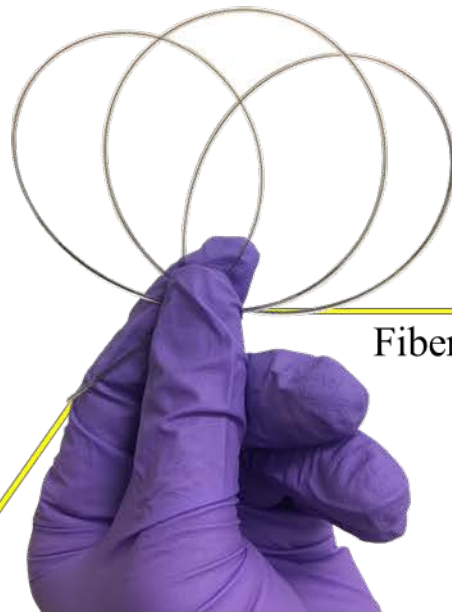
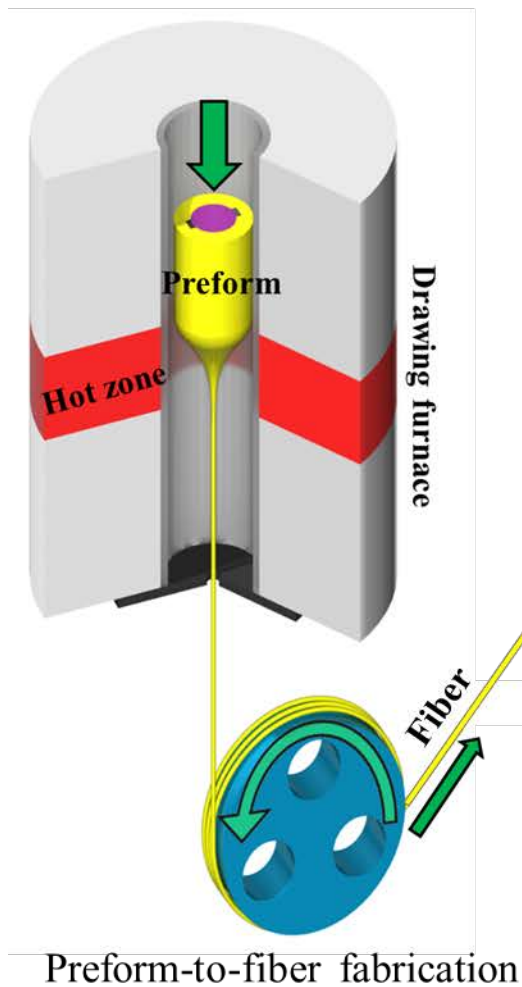
Optical bandwidth: 470 kHz



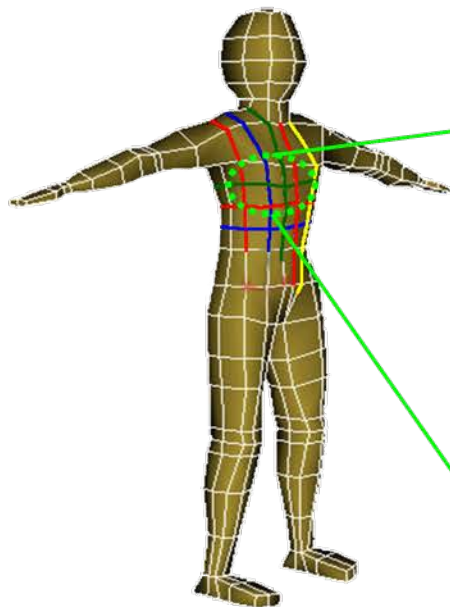
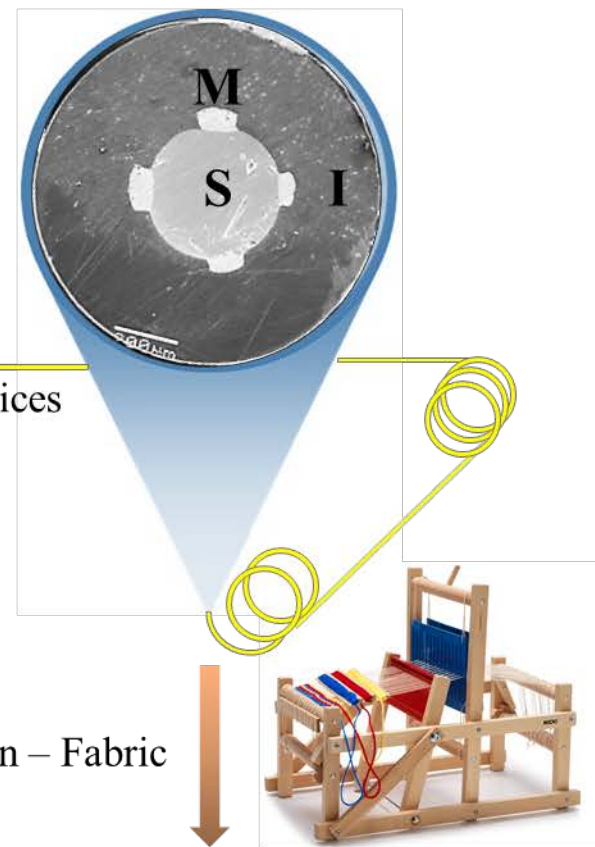
# Further size reduction



# Future Development



Fibers are devices



Wearable multi-functional fabrics



Thank you!

