Building a Carbon Nanotube Mode-Locked Fiber Laser and Exploring the Deposition Process in Photonic Bandgap Fibers

KSU PHYSICS

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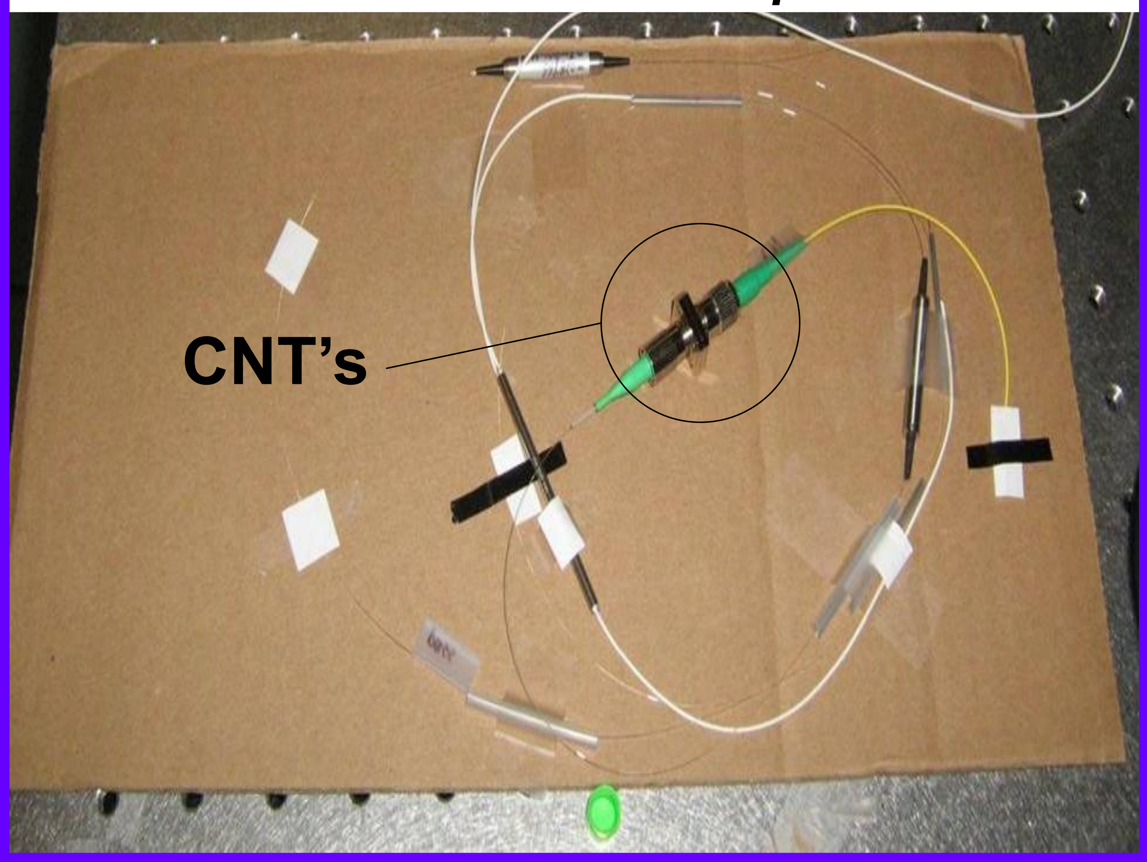
Abstract: Carbon nanotubes (CNT's) have proven to be robust saturable absorbers in mode-locked fiber lasers. The ability of CNT's to be deposited onto single mode fiber (SMF) allows for the creation of frequency combs that can be used in metrology. In addition to building a carbon nanotube fiber laser (CNFL), I also explore the deposition process, particularly by depositing CNT's on photonic bandgap fiber (PBGF), trying new ways to measure deposition, and determining deposition on an angled cleave. Successful deposition on PBGF has the potential to greatly refine and improve CNFL design.

Creation of the mode-locked carbon nanotube fiber laser

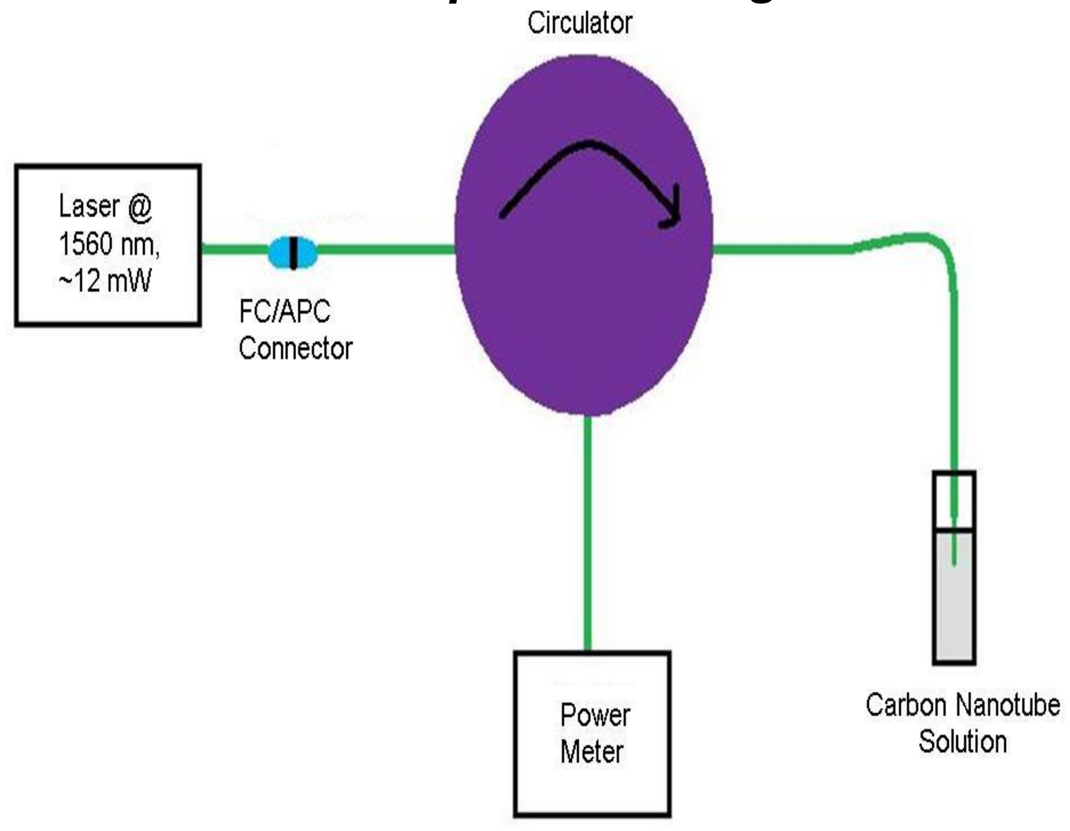
CNT Deposition Process

- Method for CNT deposition on SMF fiber and FC/APC had to be repeated [1].
- SMF fiber with a flat cleave is attached to a circulator and dipped in a solution of single-walled carbon nanotubes and ethanol with laser light being put through the fiber
- As CNT's attach, more light is reflected since the nanotubes have a higher index of reflection than the solution
- Deposition occurs at λ= 1560 nm and 12 mW of power, over an average duration of 15 minutes
- Laser repetition rate was **100.5 MHz** with a bandwidth ranging between **5-8 nm**. The total cavity length was **2 m** with a net cavity dispersion of **-0.025 ps²**
- Damage observed when step index fiber was used at higher powers

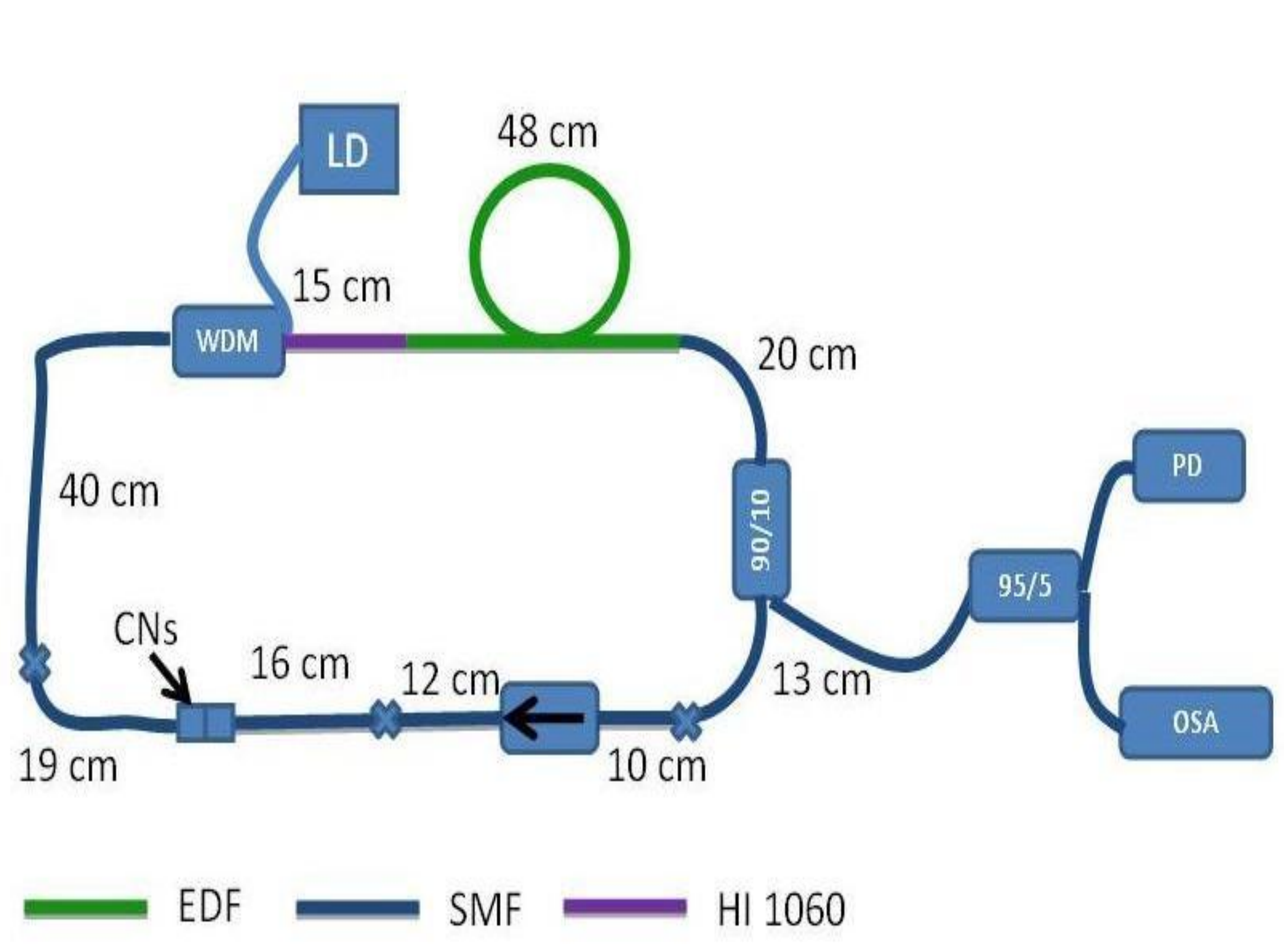
CNFL Setup



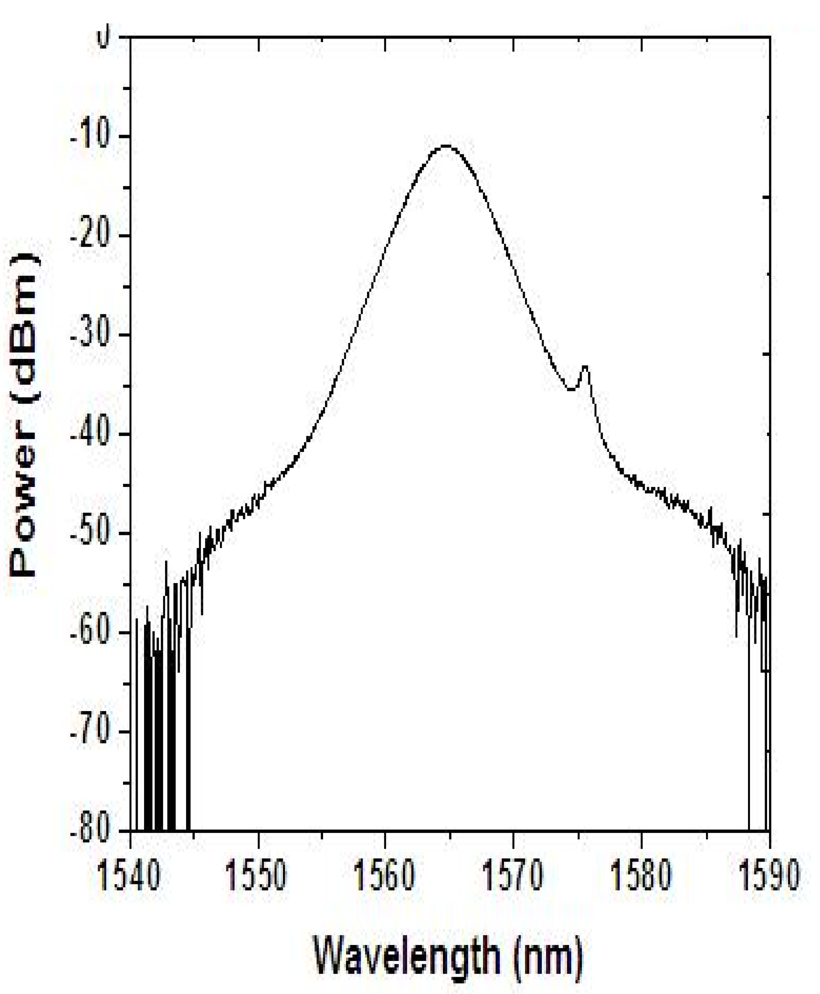
Deposition Diagram



CNFL Diagram



CNFL Spectrum



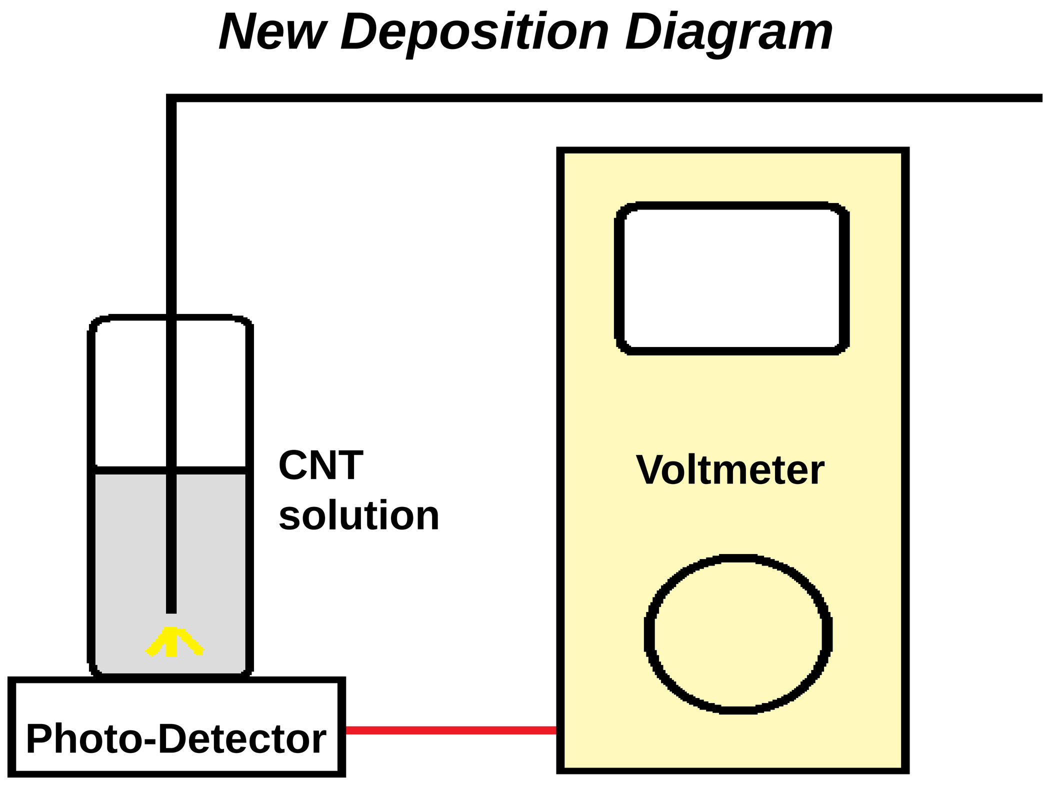
Photonic Bandgap Fibers for CNT Deposition

- PBGF has a honeycomb of holes surrounding a hollow core that guides light thought interference [2]
- Holes can be filled with various substances that change the properties of the fiber
- Evanescent coupling to the CNT's in the cladding would increase the damage threshold
- Since PBGF has a higher β_2 than SMF, a shorter length is needed to minimize dispersion in a CNFL

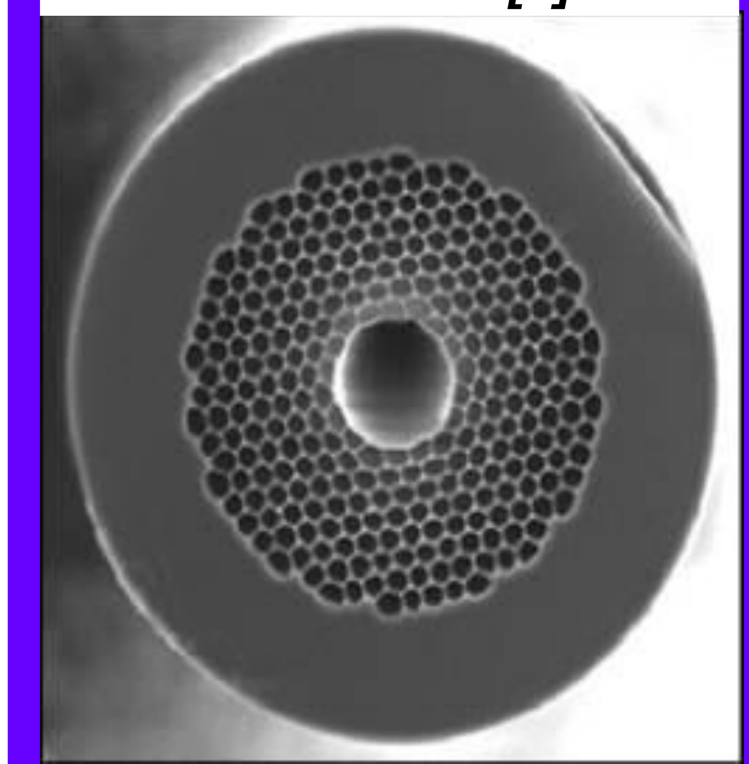
Problems Encountered

- Reflected light from SMF-PBGF splice overshadowed any data from change in reflected light
- Photo-detector and voltmeter placed directly underneath the solution to measure transmitted light rather than reflected light
- Settling of CNT's during deposition is a significant source of error

New Deposition Diagram



PBGF Fiber [3]



Future Work

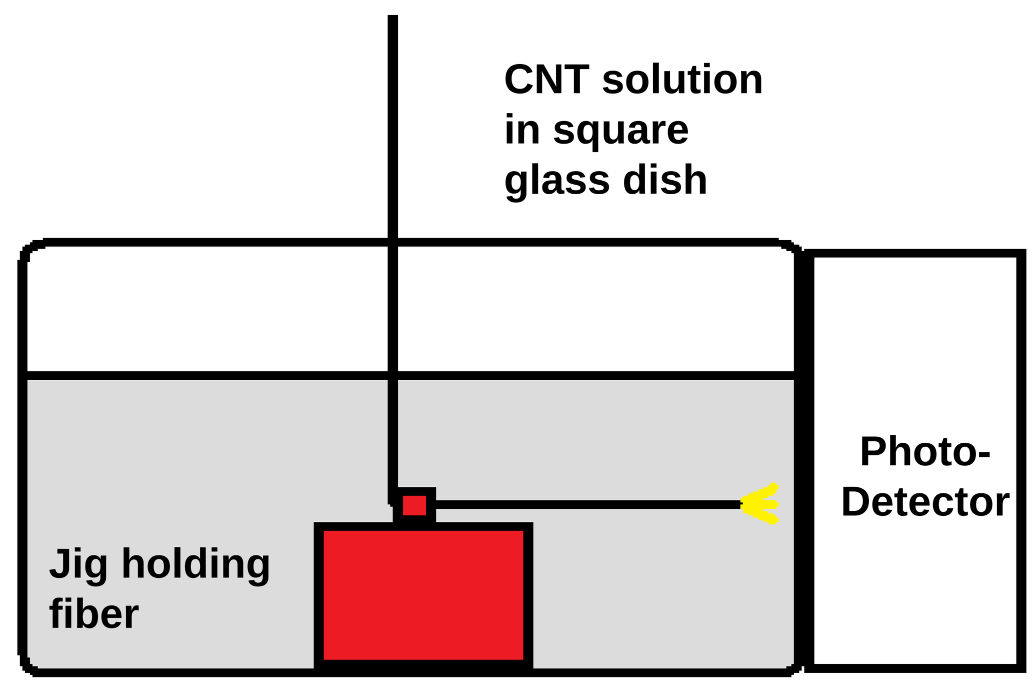
Depositing on PBGF instead of SMF

- Hope to see if the CNT's are drawn up into the fiber, and deposited inside the honeycomb
- Find out whether deposition in fiber can act as a saturable absorber
- Try to just deposit in cladding to reduce damage threshold
- Additional support from CNT's may allow PBGF to be made into a connector in a laser cavity
- Other placements and containers are being considered to avoid error due to CNT's settling on vial's bottom during deposition

Using an angled cleave

- Due to the new data collection method utilizing transmission rather than reflection, data concerning deposition on an angled cleave can be collected.

Proposed setup eliminating problem of settling CNT's >



References: [1] "Optically driven deposition of single-walled carbon-nanotube saturable absorbers on optical fiber end-faces" by Nicholson et al. [2] Photonic bandgap guidance in optical fibers" by Broeng et al. [3] www.rdmag.com/images/0407/RD47FE_PH1.jpg

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