



UNIVERSITY OF  
CAMBRIDGE  
Department of Engineering



UNIVERSITY OF GHANA



# Generation of Ultra Short Pulses

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Collaborators: Prof I. White and Prof R. Penty

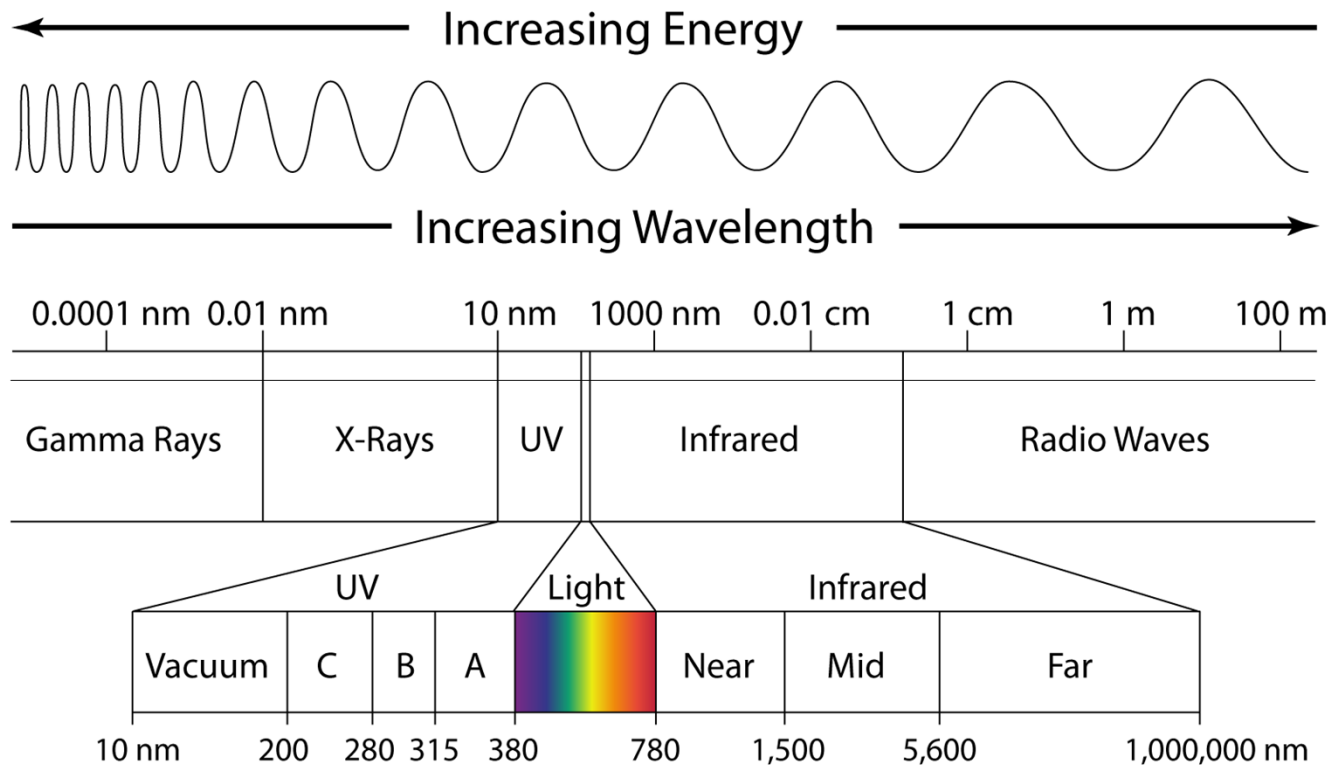
  
  
 The ALBORADA Trust   
  


# Outline

- What are Ultra Short Pulses?
- Applications of Ultra Short Pulses
- Techniques of Generating Ultra Short Pulses
- Challenges of Generating Ultra Short Pulses
- Our Approach and Initial Results
- Possible Collaborations
- Questions
- <https://www.youtube.com/watch?v=fBV-f1qXlps>
- <https://www.youtube.com/watch?v=J6hLOeXFpME>

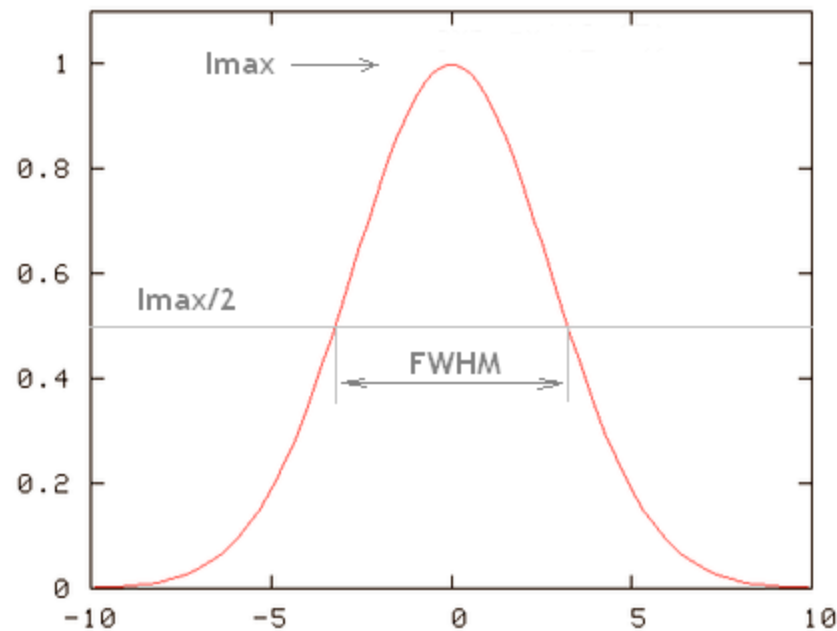
# What are Ultra Short Pulses?

- Electromagnetic Spectrum



# What are Ultra Short Pulses?

- Definition:
- An electromagnetic light whose duration is on the order of a few picoseconds or less

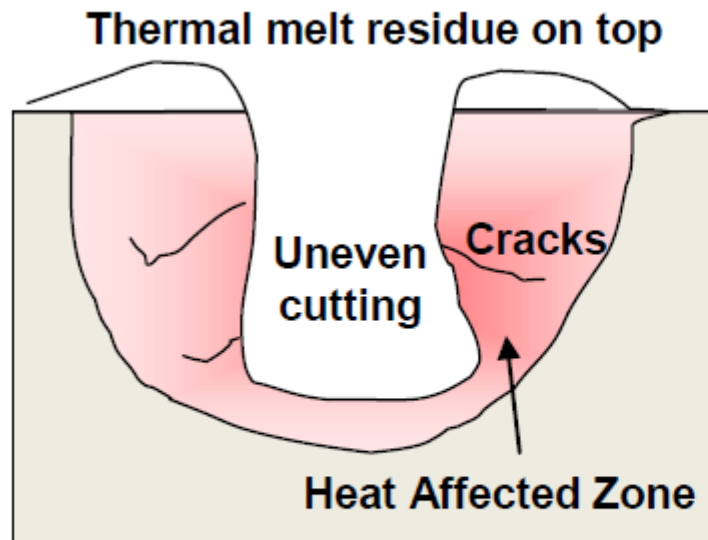


# Applications of Ultra Short Pulses

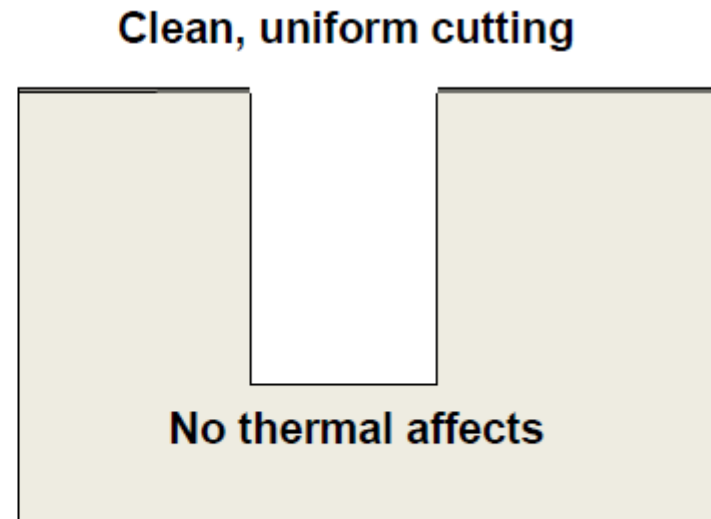
- Ultrashort Pulse duration
  - enables fast temporal resolution ‘freezes’ fast moving objects
- High Repetition Rate
- Broad Spectrum
  - A broad spectrum supports good spatial resolution for optical coherence tomography (OCT), a technique for non-invasive cross-sectional imaging in biological systems
- High Peak Intensity
  - The high peak intensity of the pulse can be used to alter materials by ‘cold’ ablation

# Applications of Ultra Short Pulses

- Micro-machining



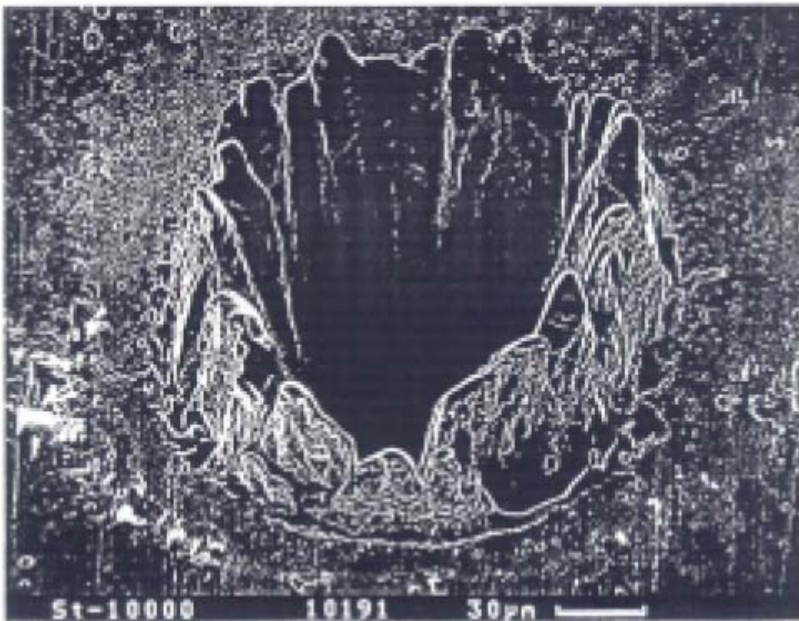
**Long Pulse Laser**  
Thermal Drilling / Cutting



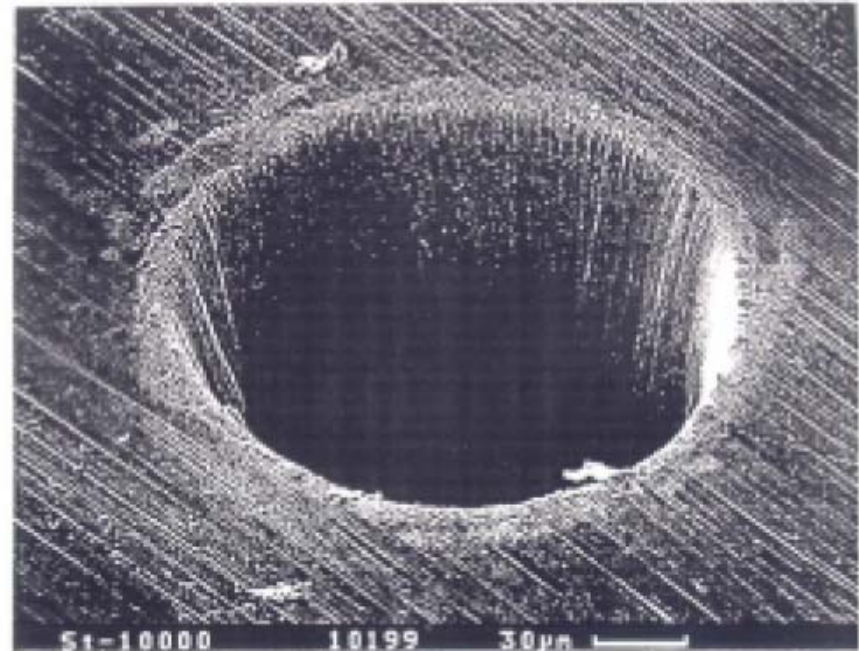
**Ultrafast Laser**  
Ablation Drilling / Cutting

# Applications of Ultra Short Pulses

- Micro-machining



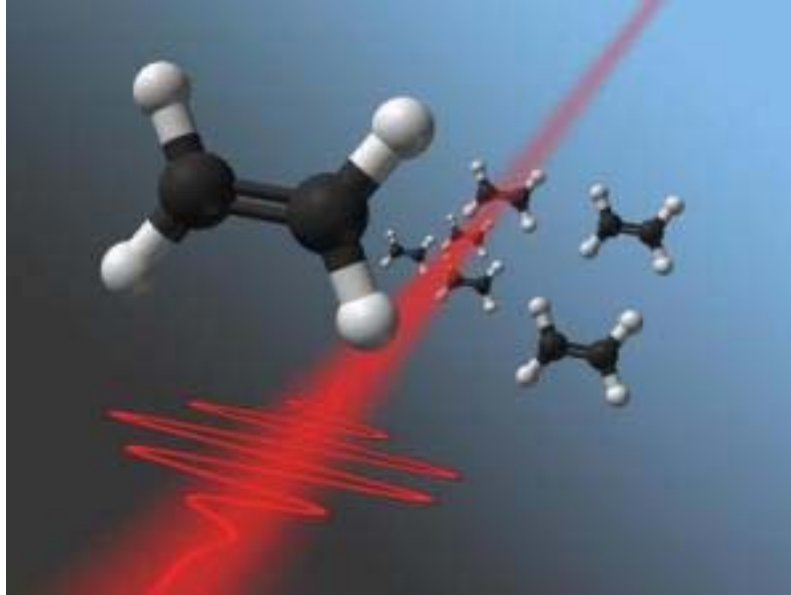
steel,  $\lambda = 780 \text{ nm}$ ,  $\tau = 3,3 \text{ ns}$ ,  $F = 4,2 \text{ J/cm}^2$



steel,  $\lambda = 780 \text{ nm}$ ,  $\tau = 200 \text{ fs}$ ,  $F = 0,5 \text{ J/cm}^2$

# Applications of Ultra Short Pulses

- Femtochemistry
  - Observing the rate of chemical reactions
  - Controlling the chemical reaction



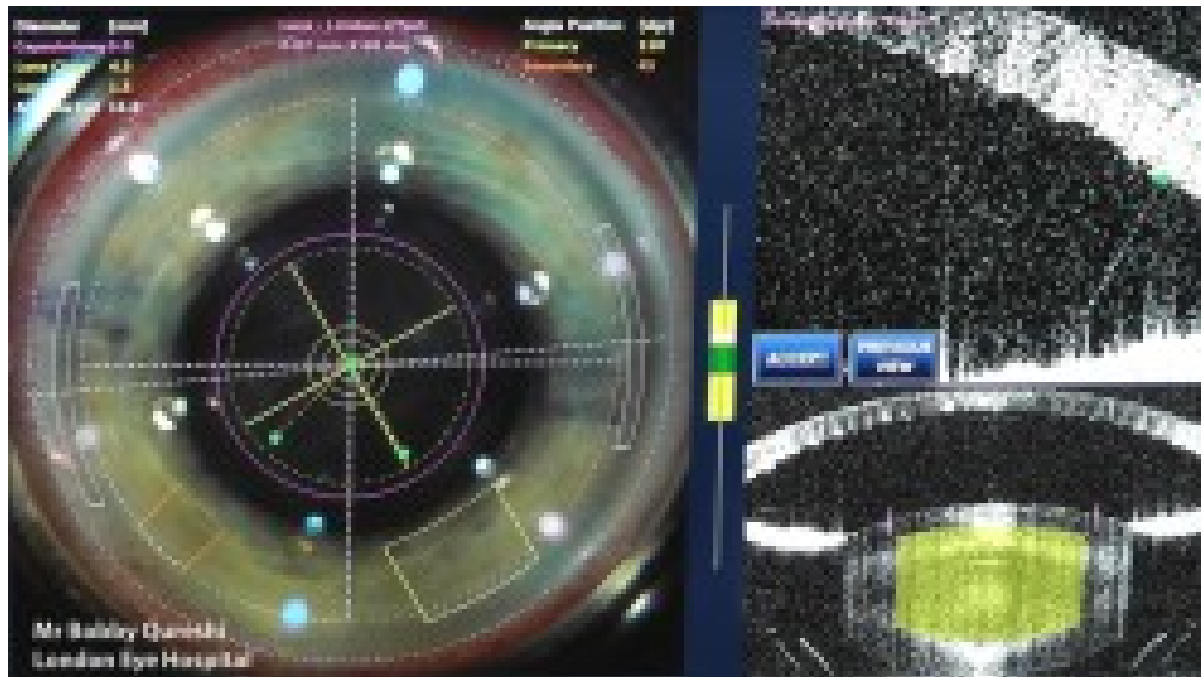


# Applications of Ultra Short Pulses

- Biomedical
  - Medical Imaging:
  - Tissue Modification and Micro Surgery:
  - Medical Device Manufacturing
  - BioResearch ‘spark of life’

# Applications of Ultra Short Pulses

- Imagine a device which can create a 3-dimensional micron level scan of your eye and then dissolve your cataract in 10 seconds without making a cut into the surface of the eye. No-needles, no-blades just perfect precision surgery. This is Femtosecond Laser Lens Extraction Surgery-

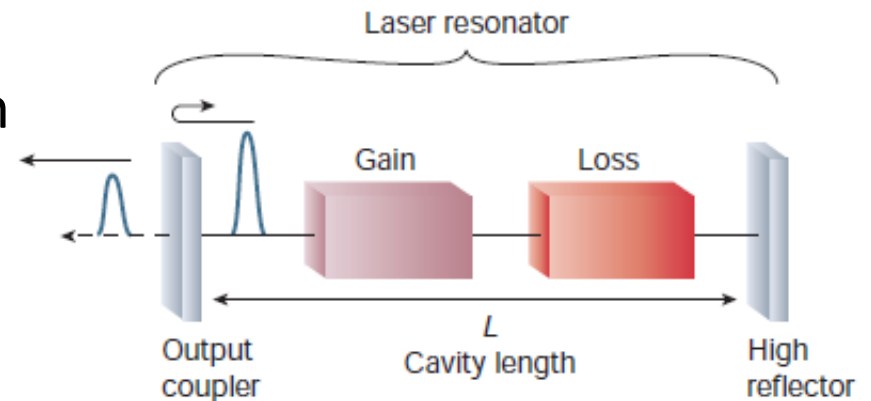
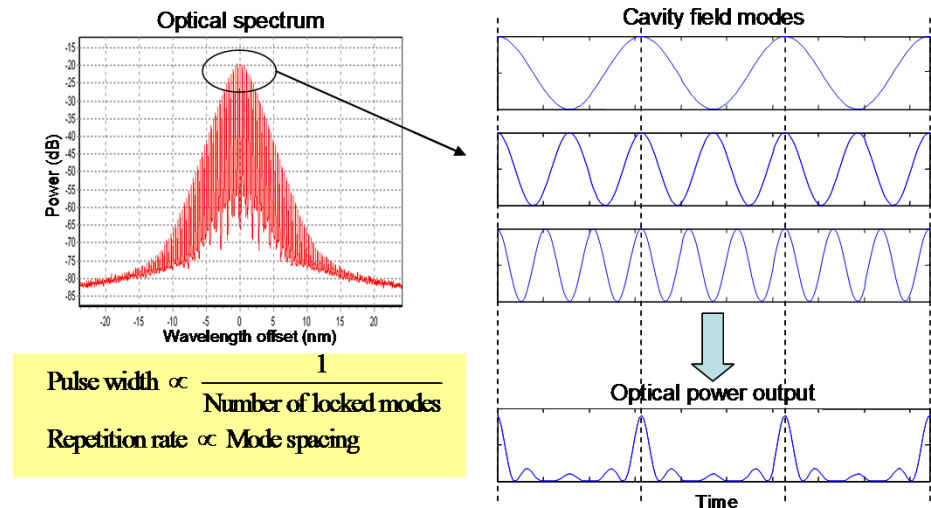


# Applications of Ultra Short Pulses

- Optical Communications
  - high-capacity telecommunication systems
  - photonic switching devices
  - optical interconnections
  - clock distribution

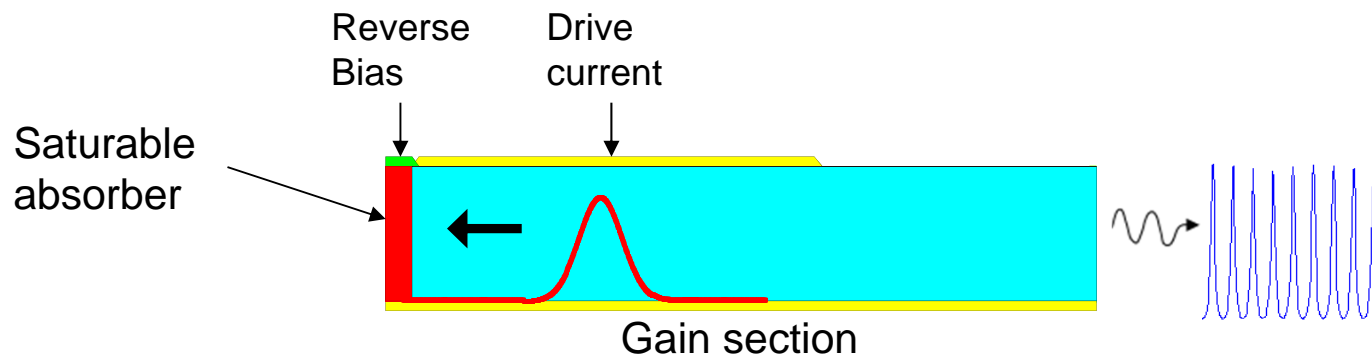
# Techniques of Generating Ultra Short Pulses

- Mode Locking
  - Active mode locking
  - Passive mode locking
- Pulse Compression
  - Soliton effect
  - Adiabatic pulse compression



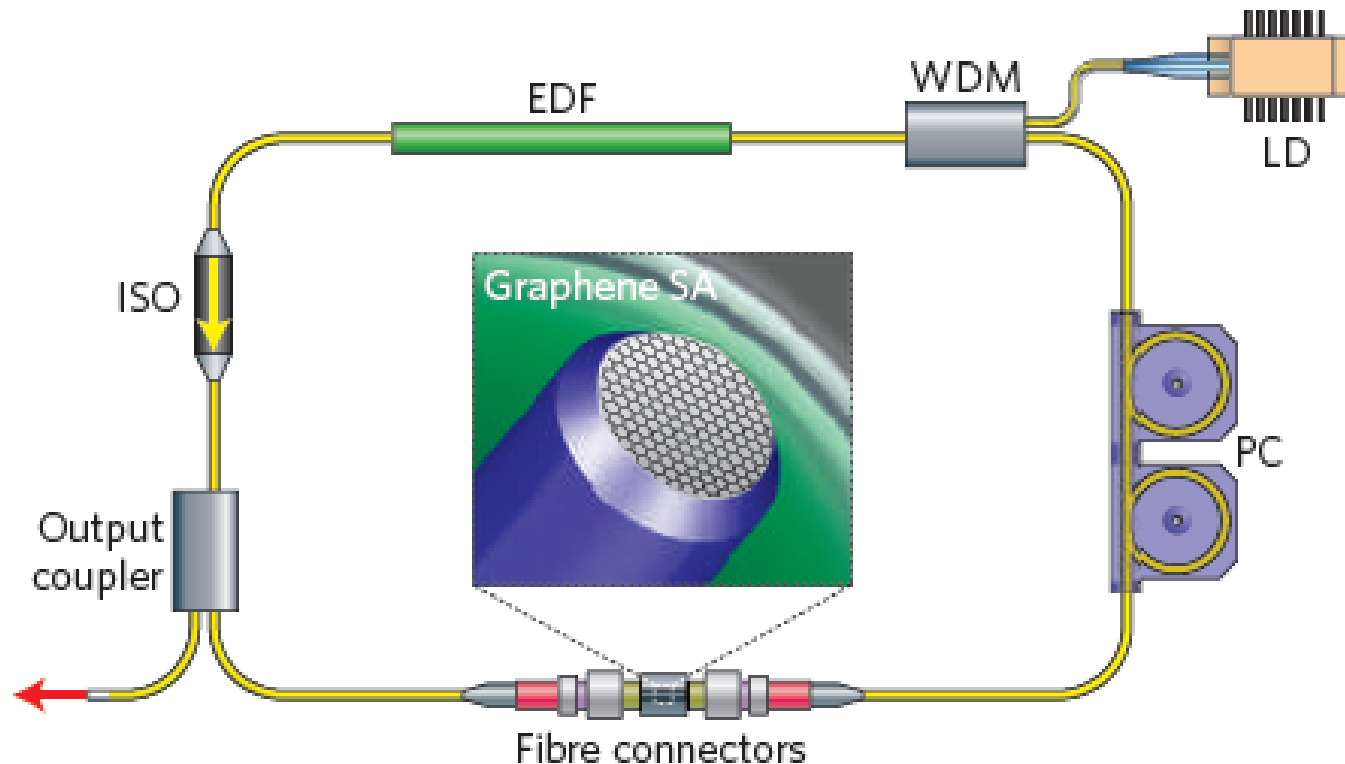
# Techniques of Generating Ultra Short Pulses

- A saturable absorber is a vital element for passive mode-locking, acting as a gate only allowing high intensity pulses to pass



# Techniques of Generating Ultra Short Pulses

- Graphene mode locked ultra fast laser



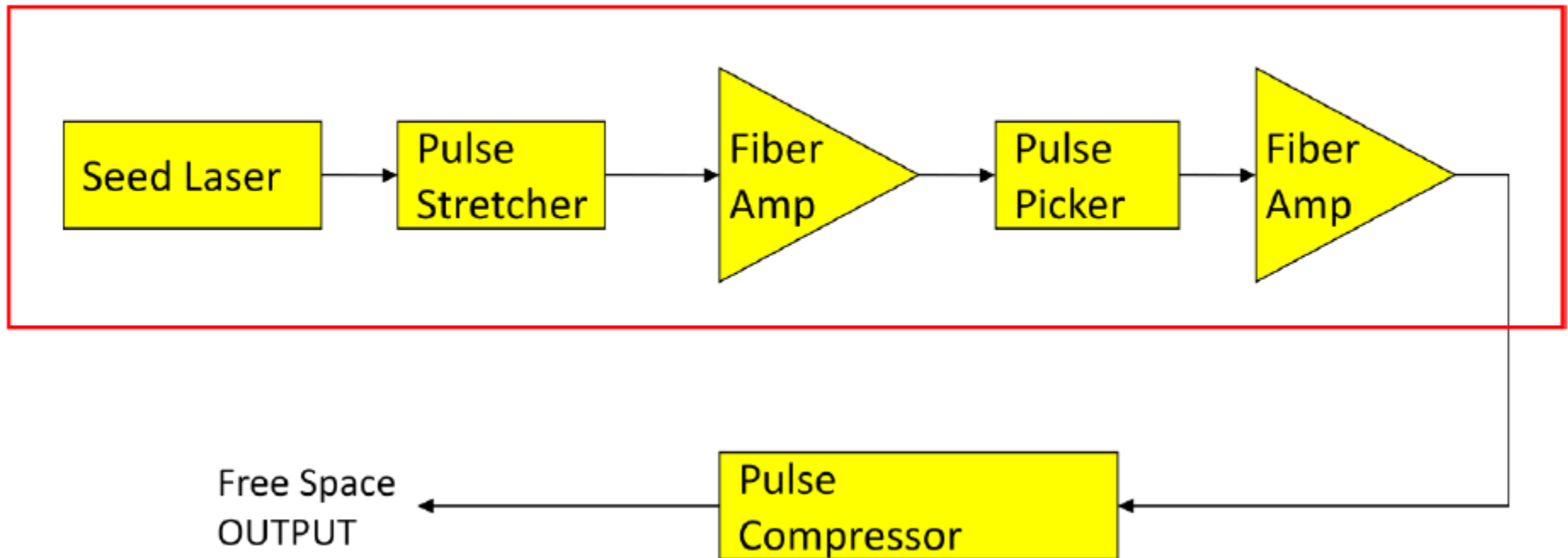
Cavity length must correspond to the repetition rate. complex feedback control to maintain the operating stability, It is difficult to obtain femtosecond pulses with a high repetition rate exceeding 1GHz.

# Challenges of Generating Ultra Short Pulses

- Large size
- Stability
- Pulse Quality
- Large Pedestal

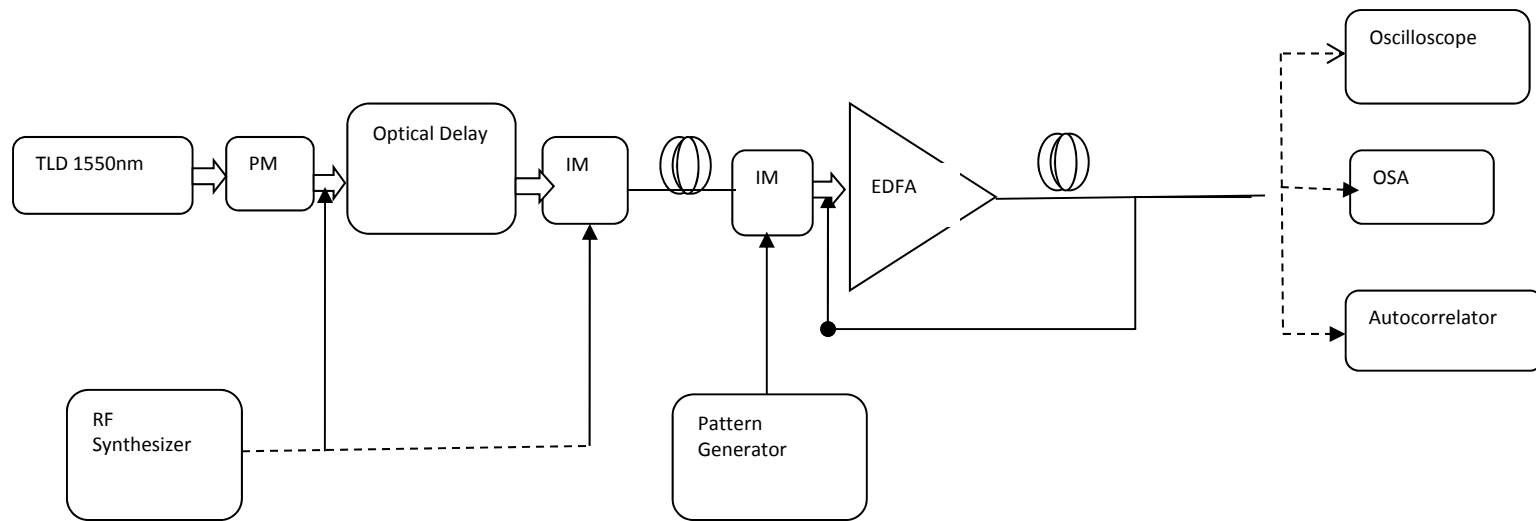
# Techniques of Generating Ultra Short Pulses

- Pulse Compression

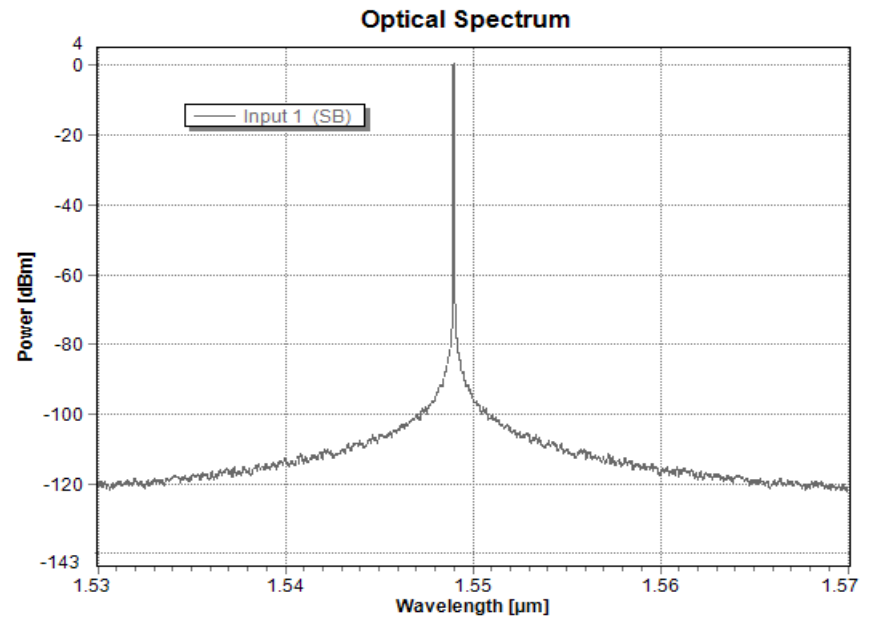
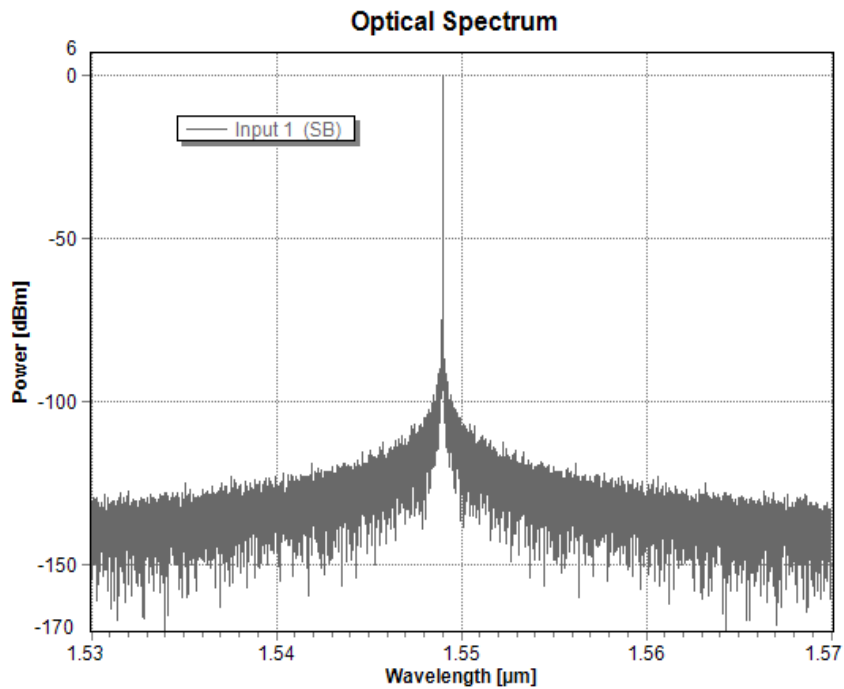




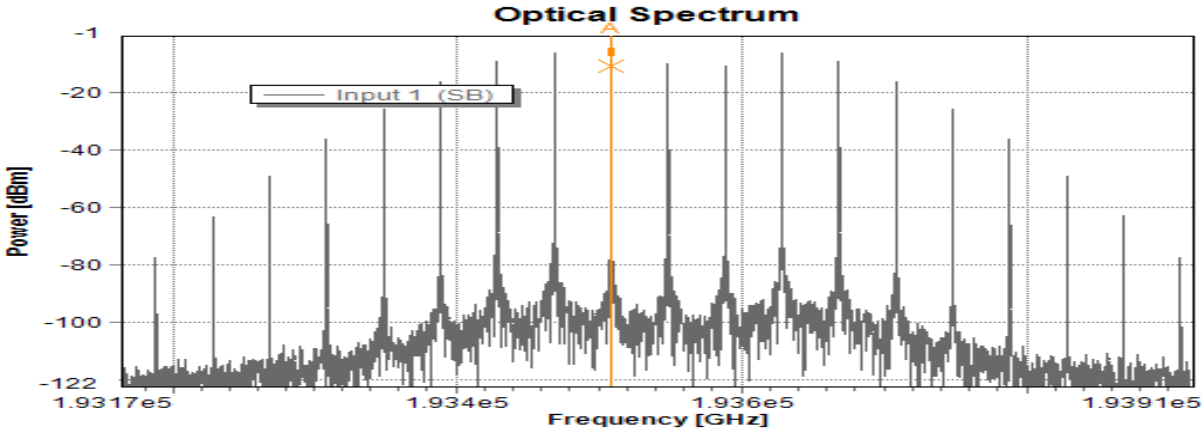
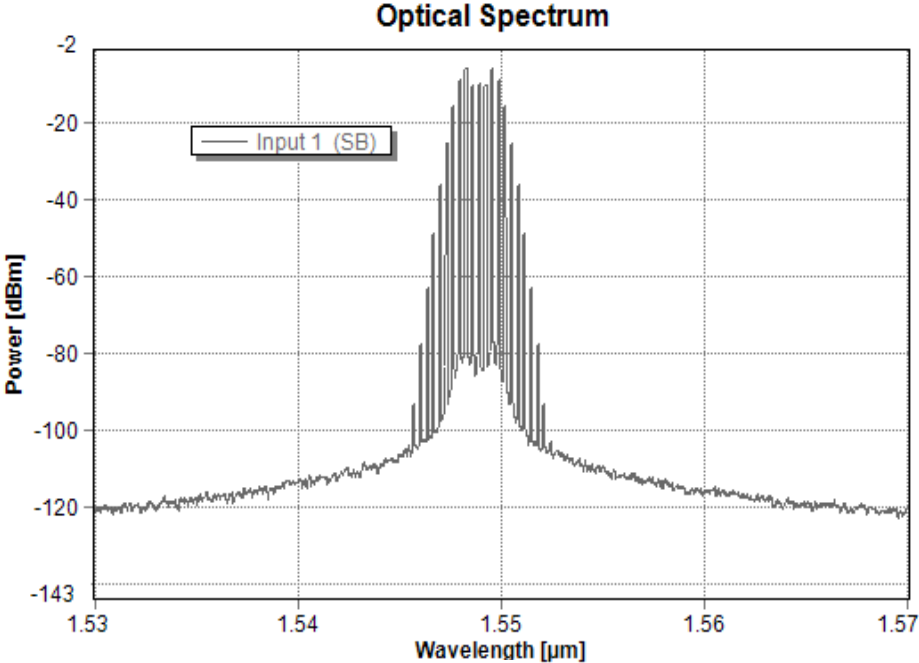
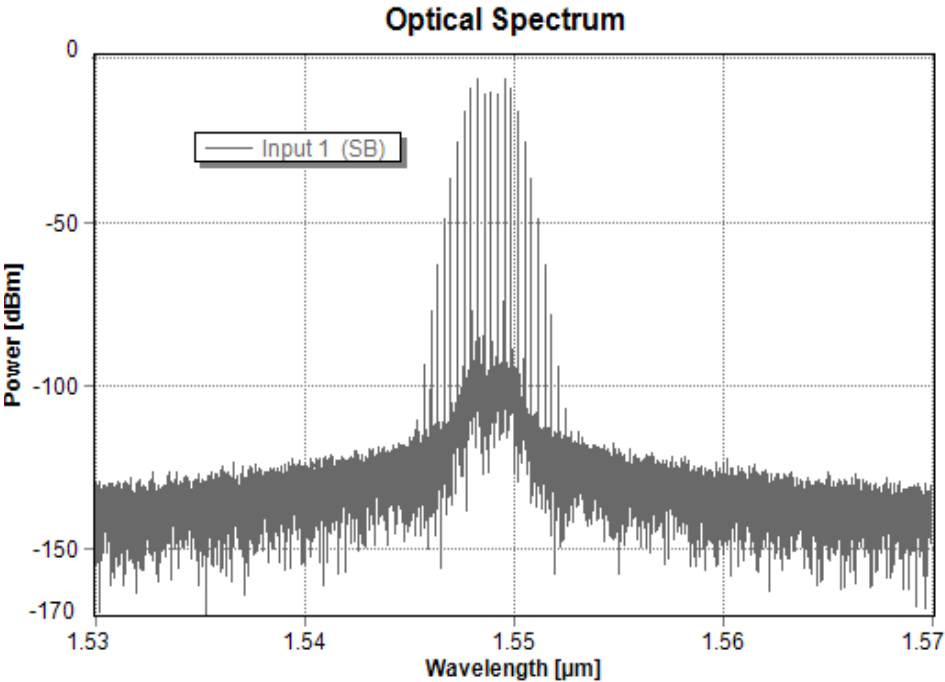
# Schematic of Proposed System



# Output from cw laser

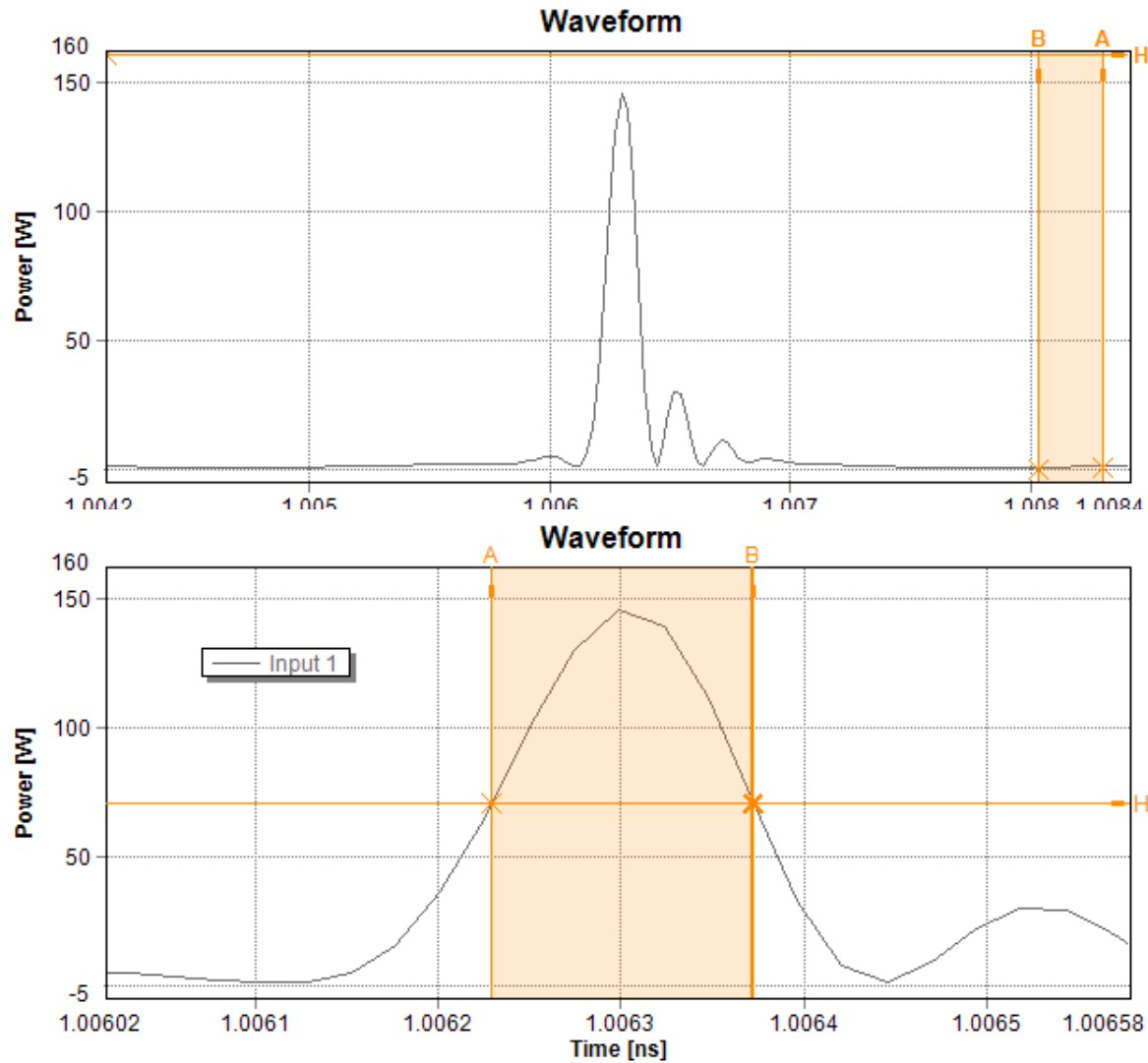


# Output from PM



Peak to peak was verified to be 40GHz

# Final output



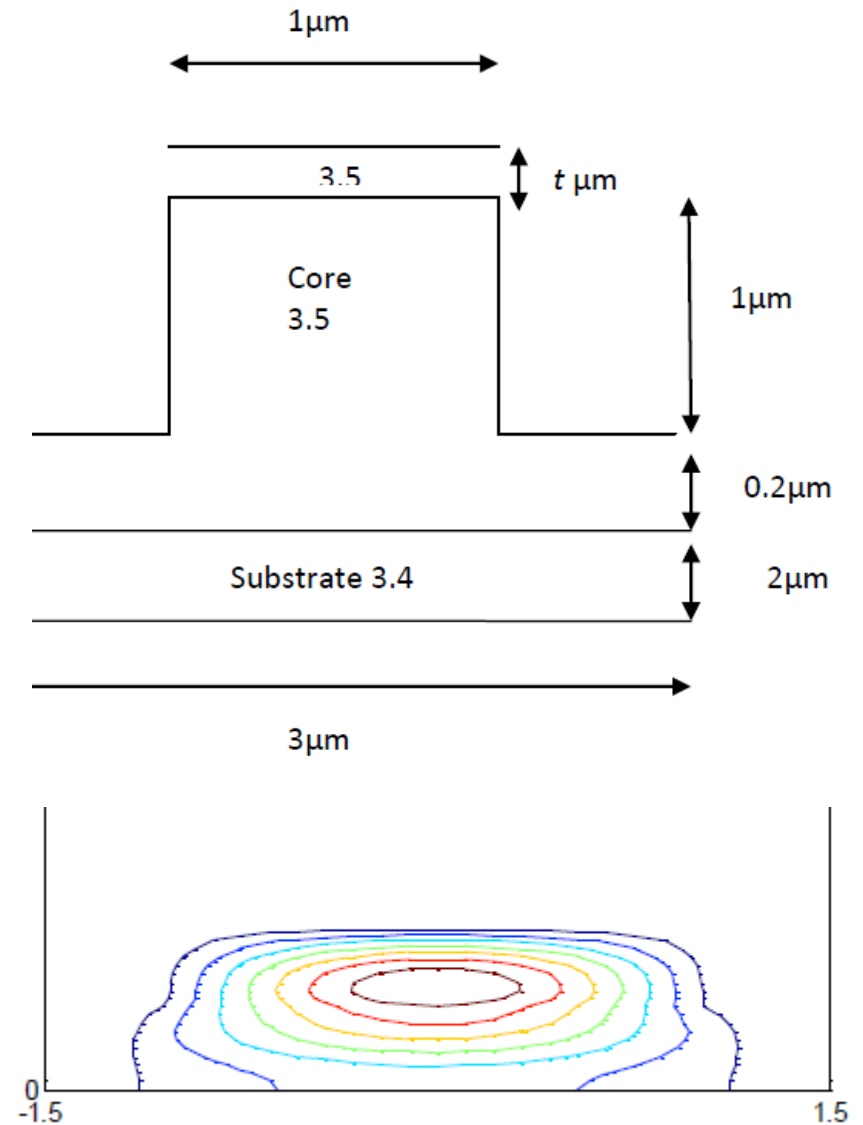
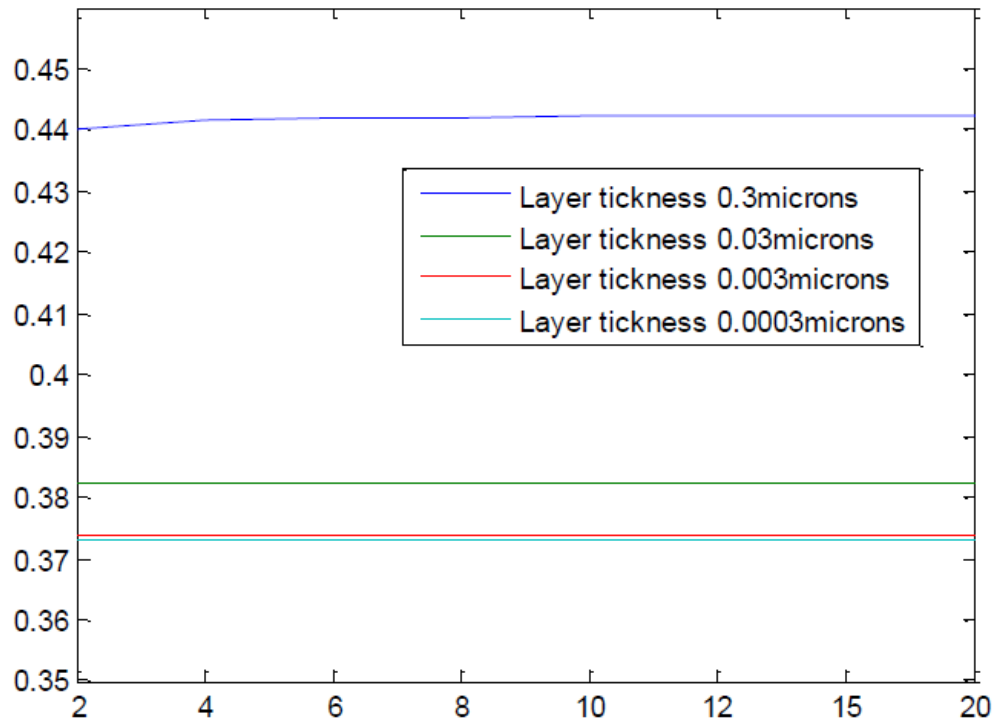
There is a noticeable side pulse, pulse width is 140fs peak power 146W

## Next Stages

- The proposal is to replace the last stage fibre with a nonlinear element as discussed below.
- A challenge in using graphene as the nonlinear element in our proposed compressing scheme is the short interaction length. A number of promising solutions can be proposed.
- Use of a loop: In this configuration the graphene is deposited at the end of a fibre and this is formed into a connector. This connector can then simply be incorporated into the compression scheme and looped in order to increase the interaction length.
- Use of carbon nanotubes as the interaction medium for pulse compression.

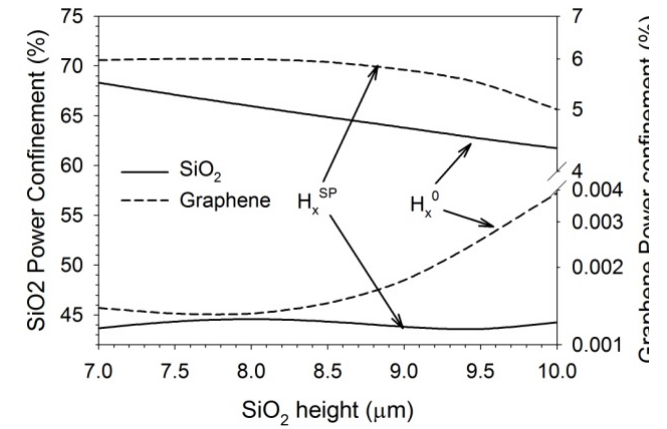
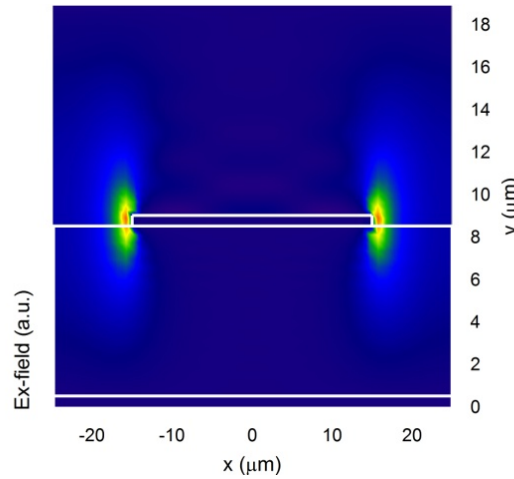
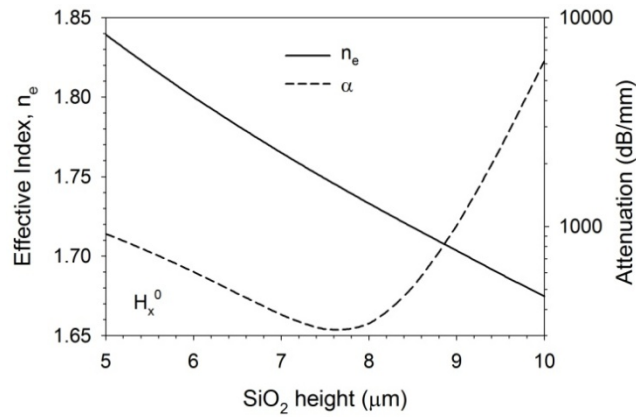
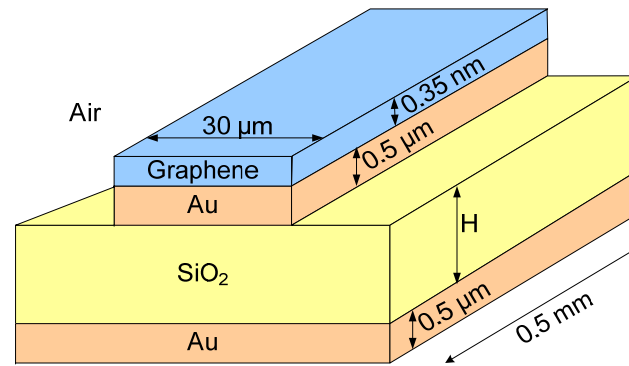
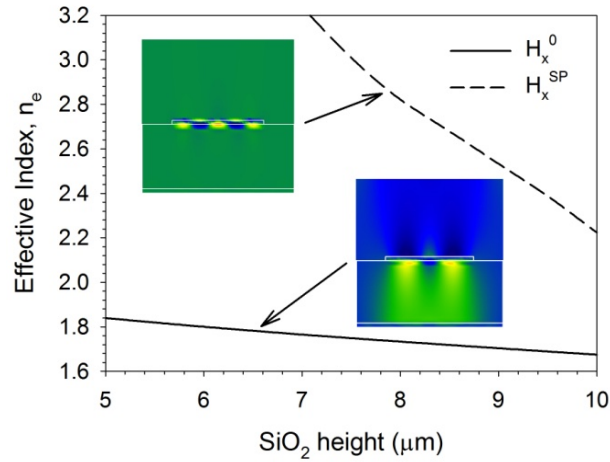
# Next Stages

- Testing Accuracy of the numerical method

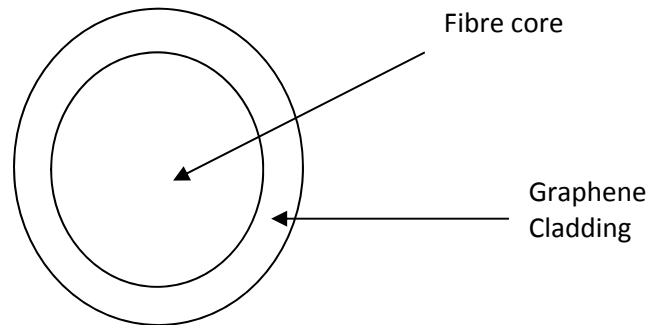


# Next Stages

- Comparison with previous work



# Graphene Cladded Fibre



- Still working on generating an accurate mesh



# Collaborations

- City University?
  - Integrating the sensor work at City with the work of the laser group supported by modelling at UG

Thank You!

Any Questions?