

# Stress Measurements using the Picosecond Ultrasonic Method

Chris Korabik

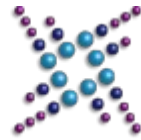
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Lu, Hong-Cin Liou

# Acknowledgements

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- This work utilized Northwestern University Micro/Nano Fabrication Facility (NUFAB)

Northwestern

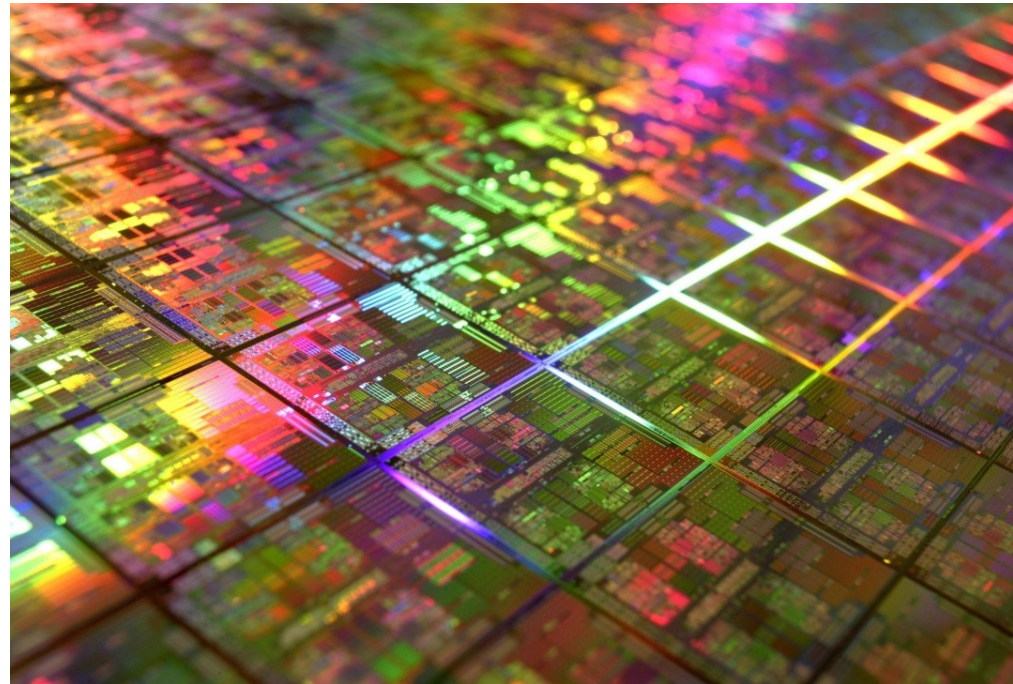
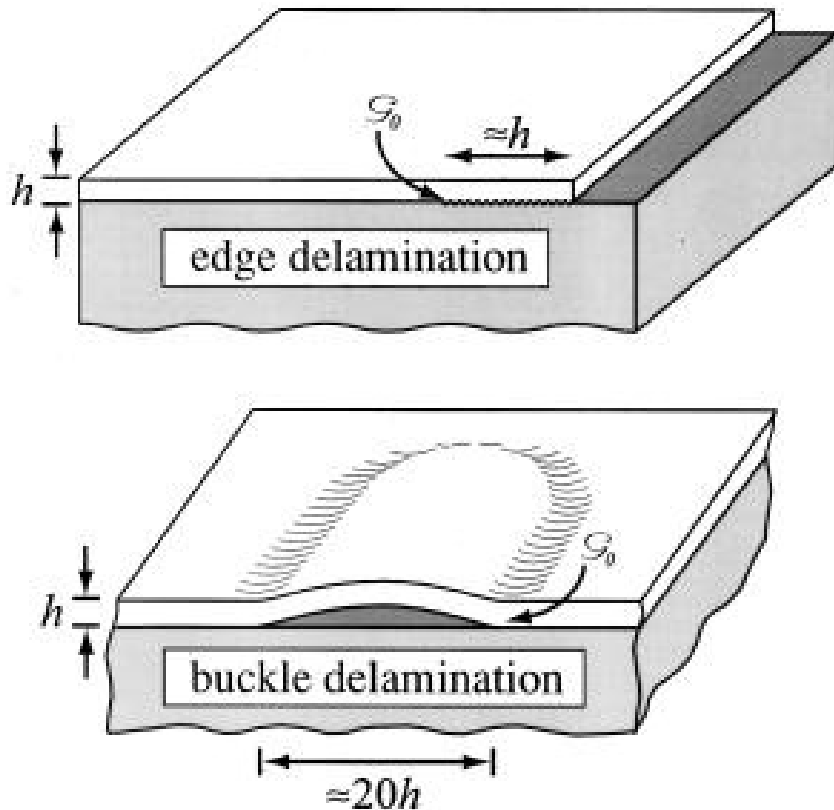


MRSEC

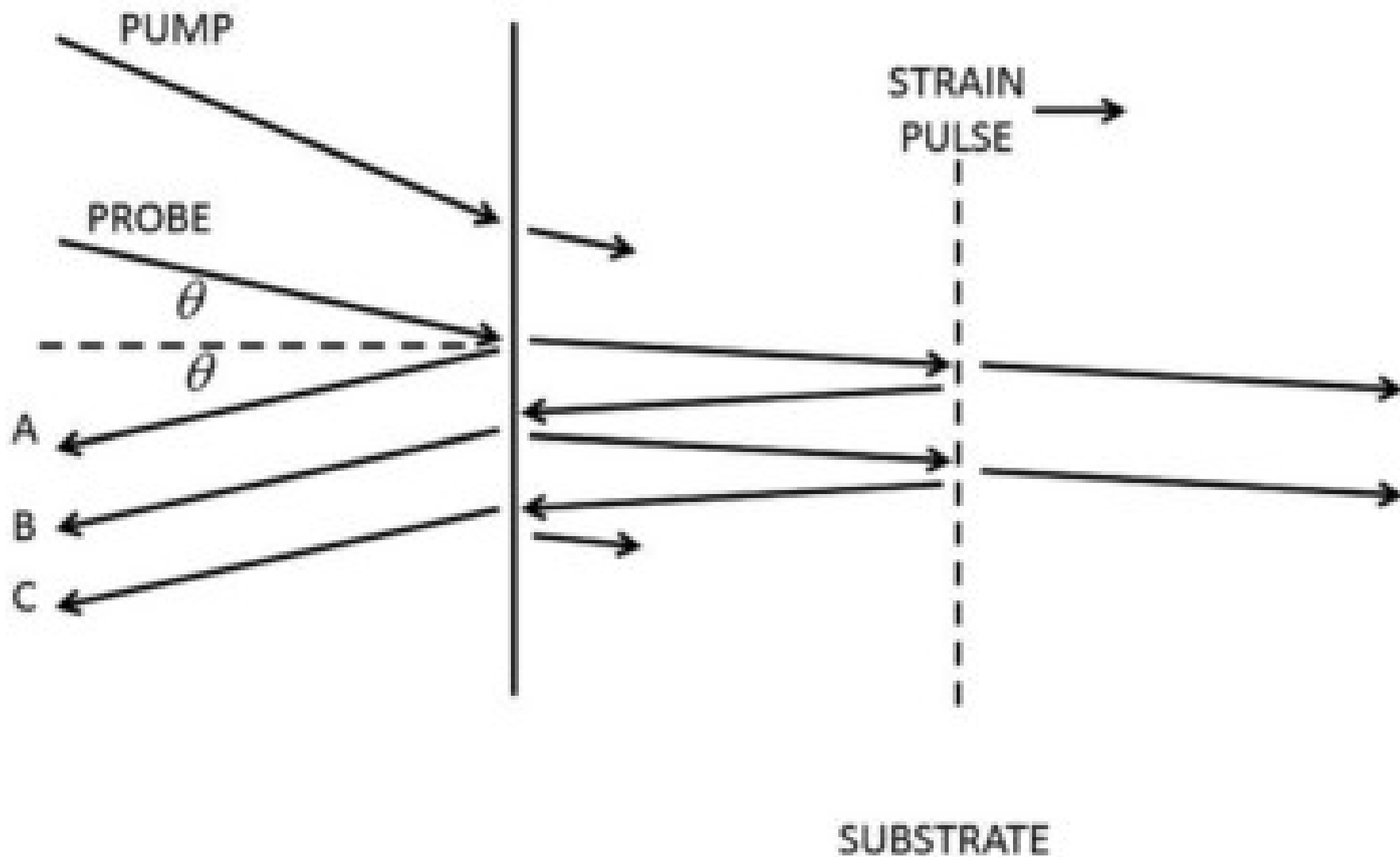
MATERIALS RESEARCH SCIENCE  
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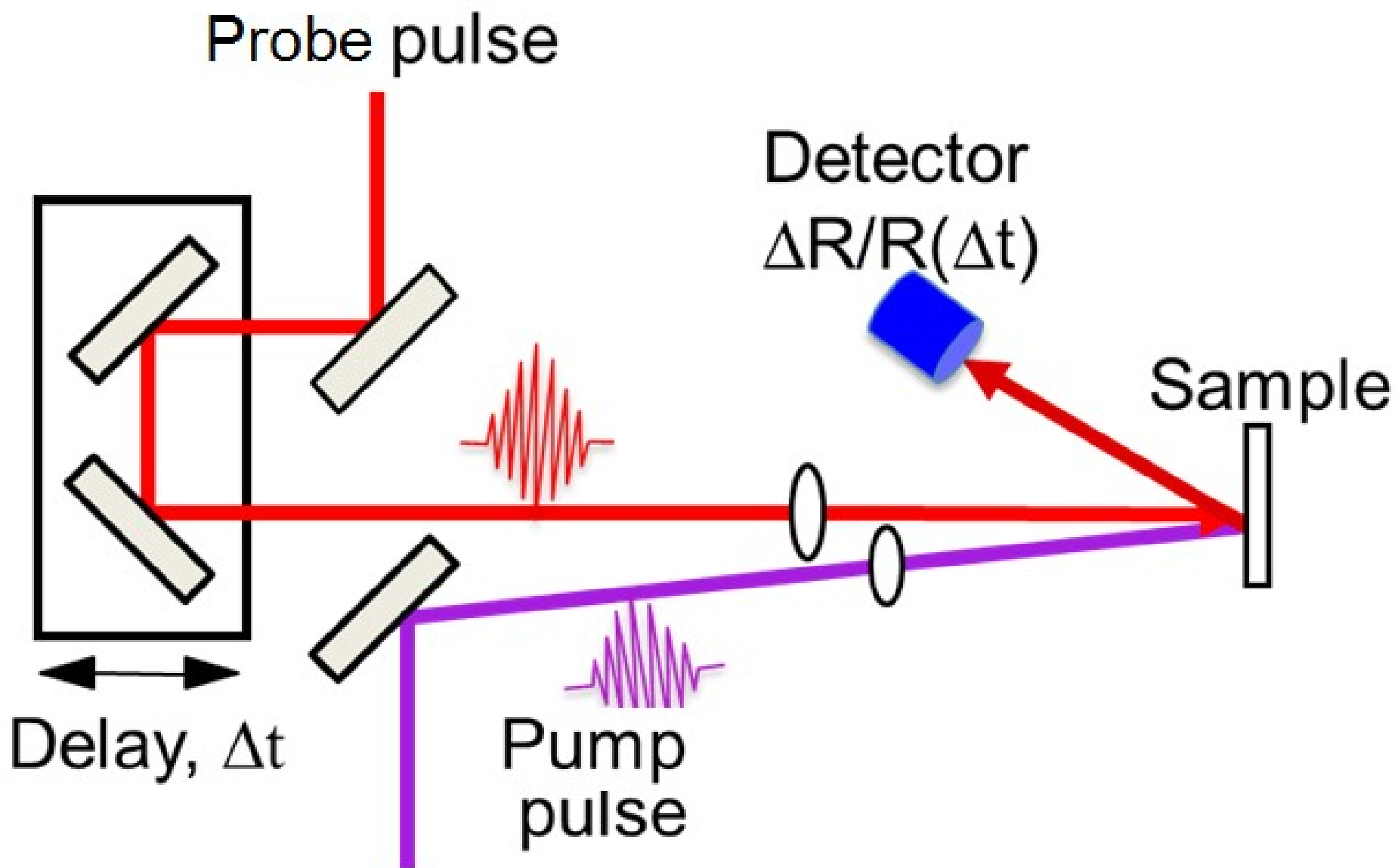
# Stresses in thin films

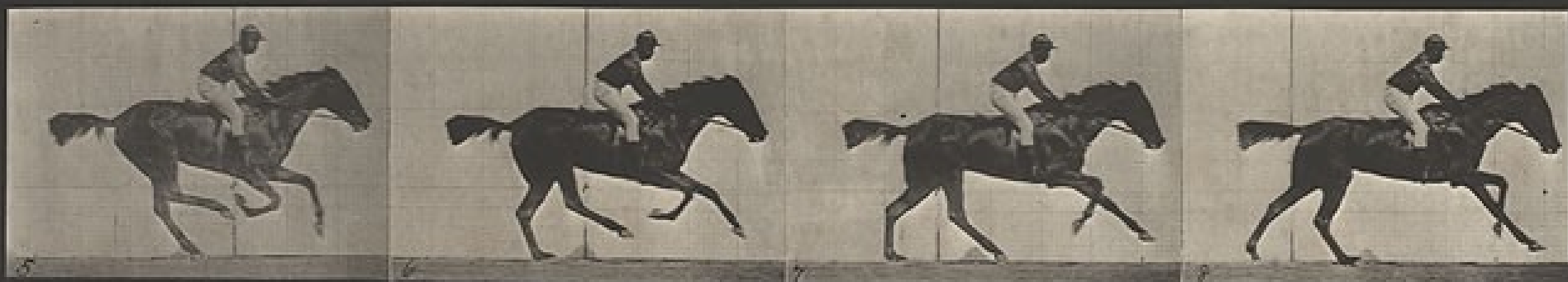
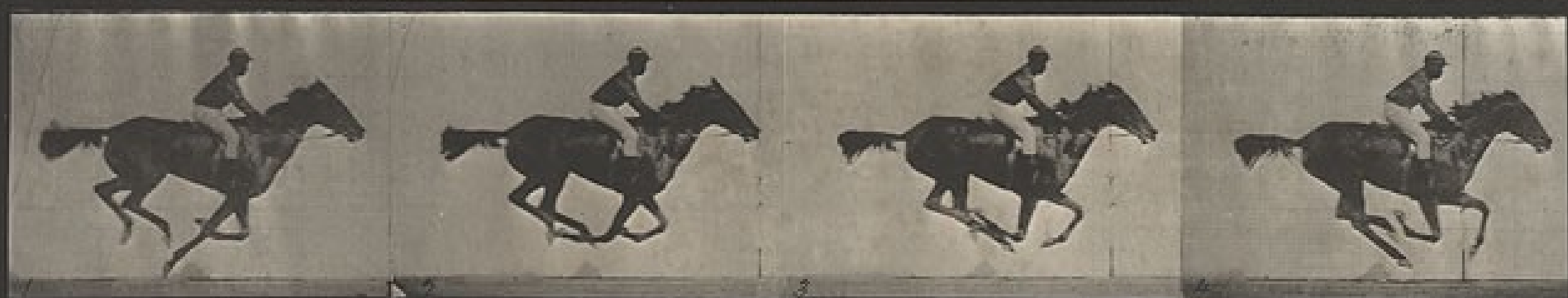


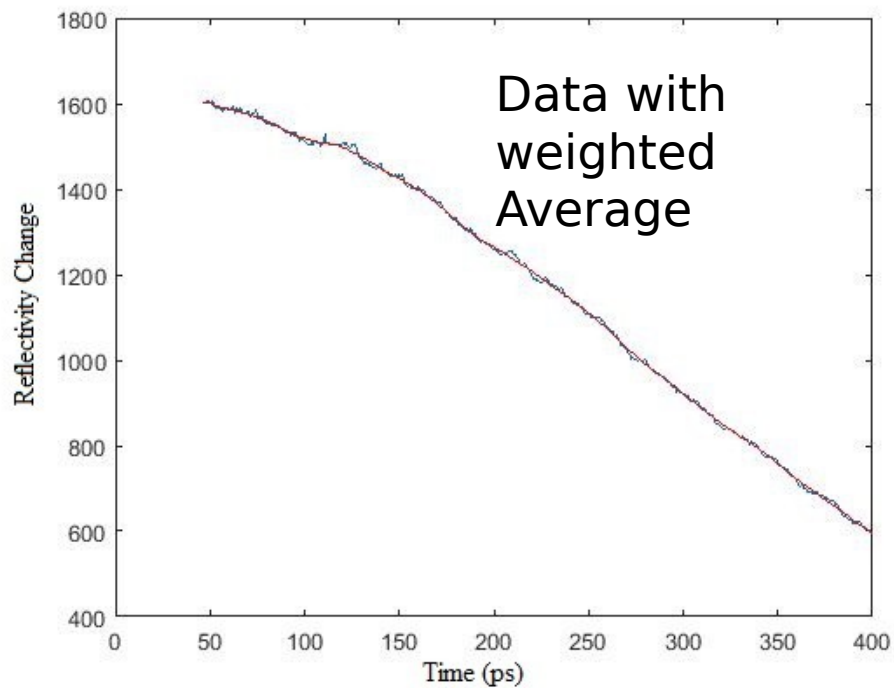
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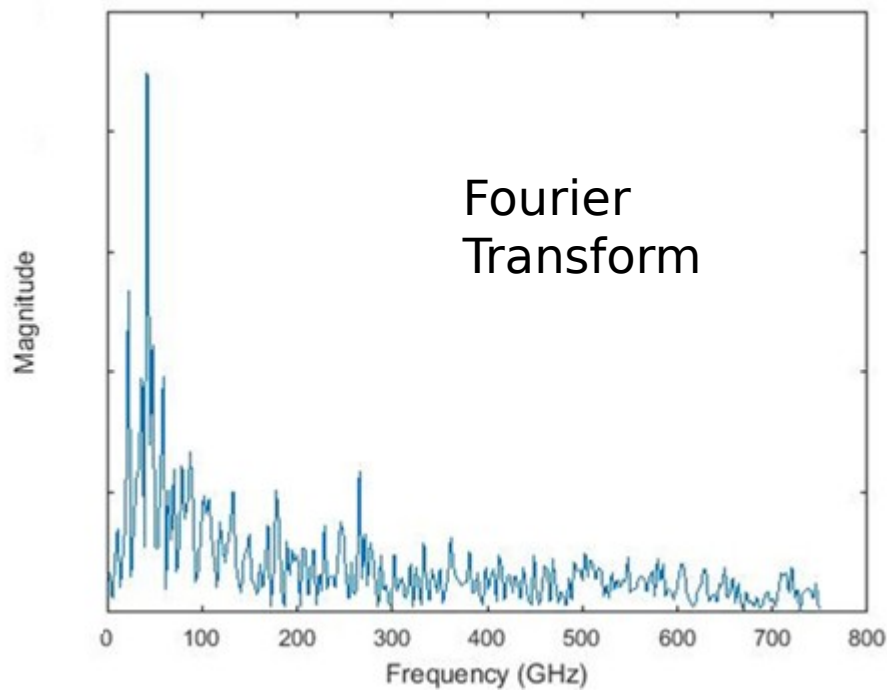
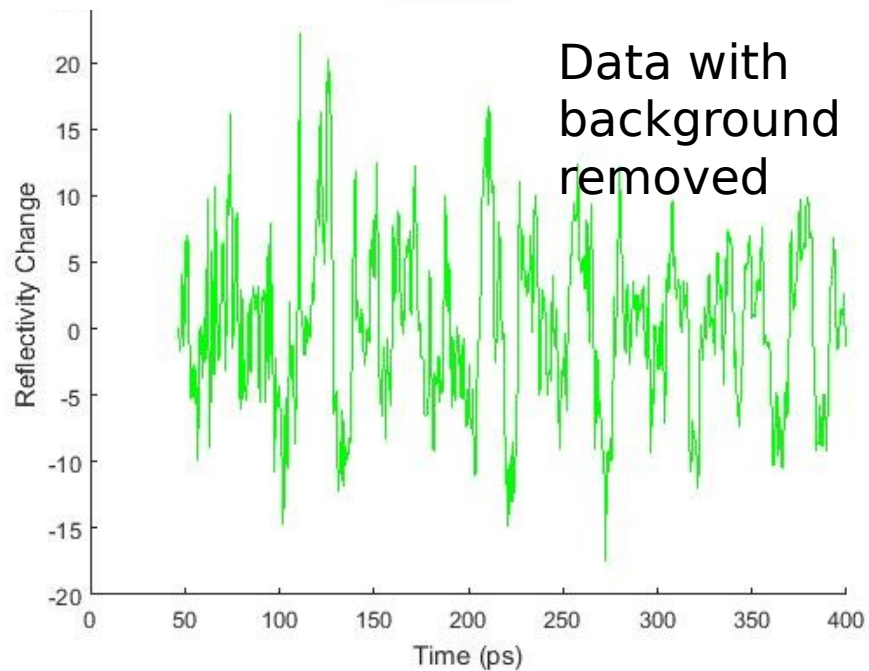




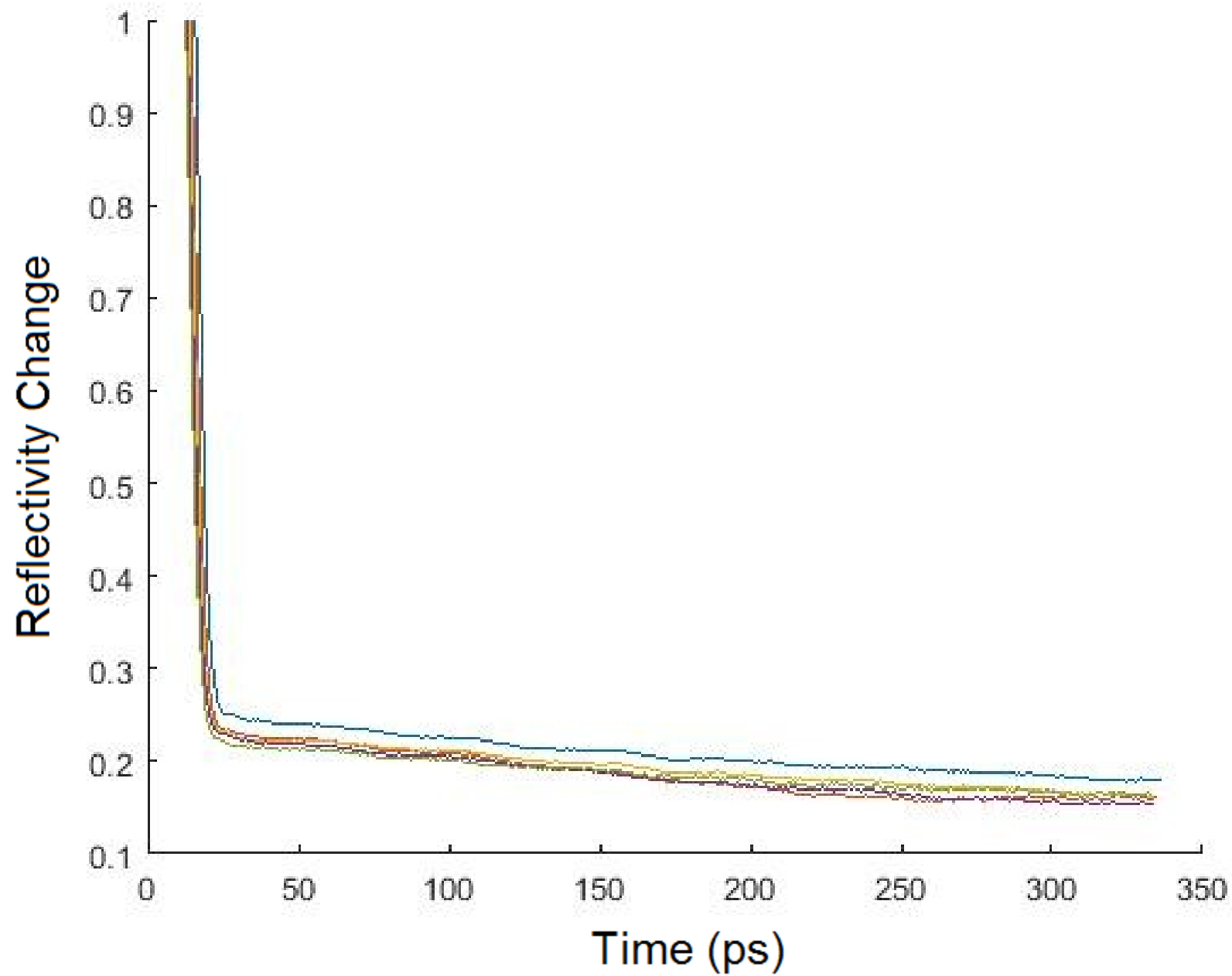


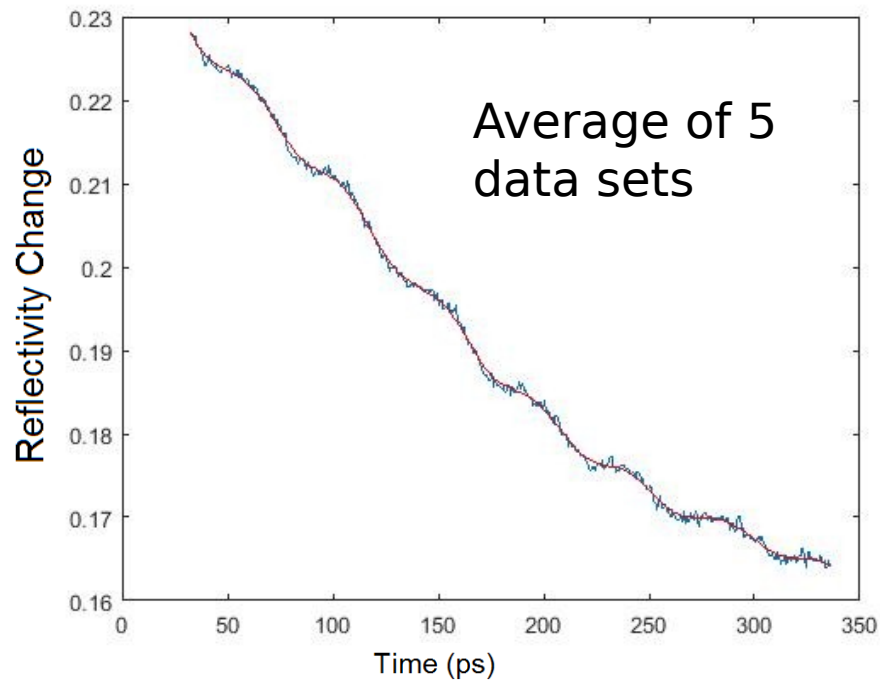


10 nm of gold on glass

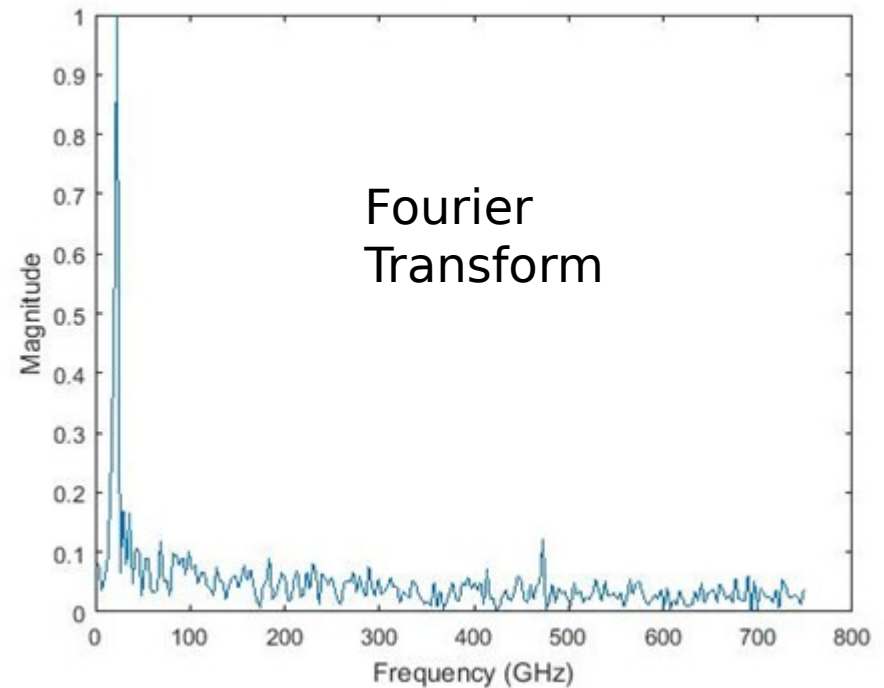
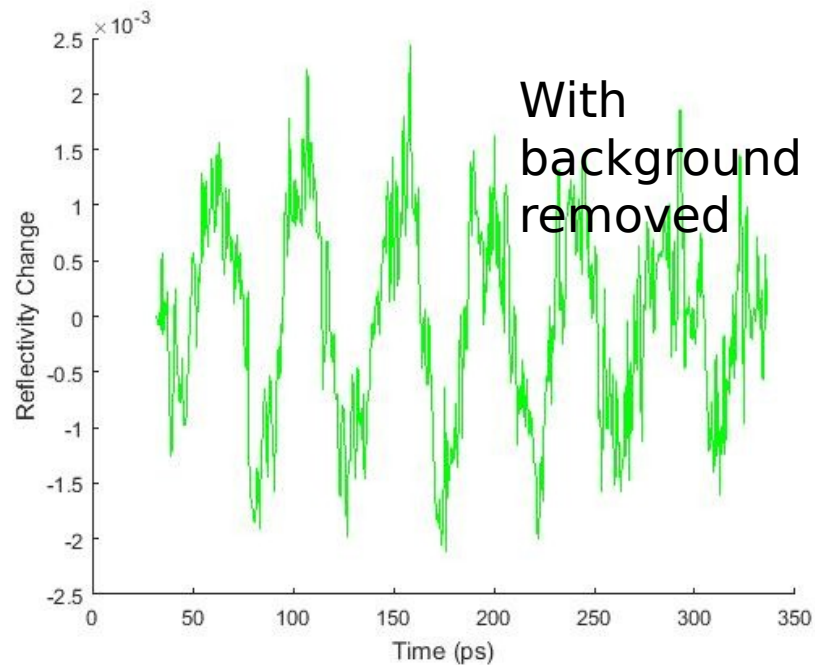
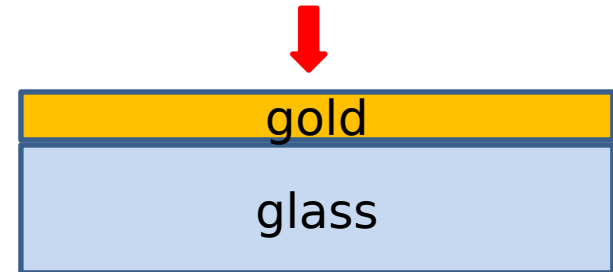




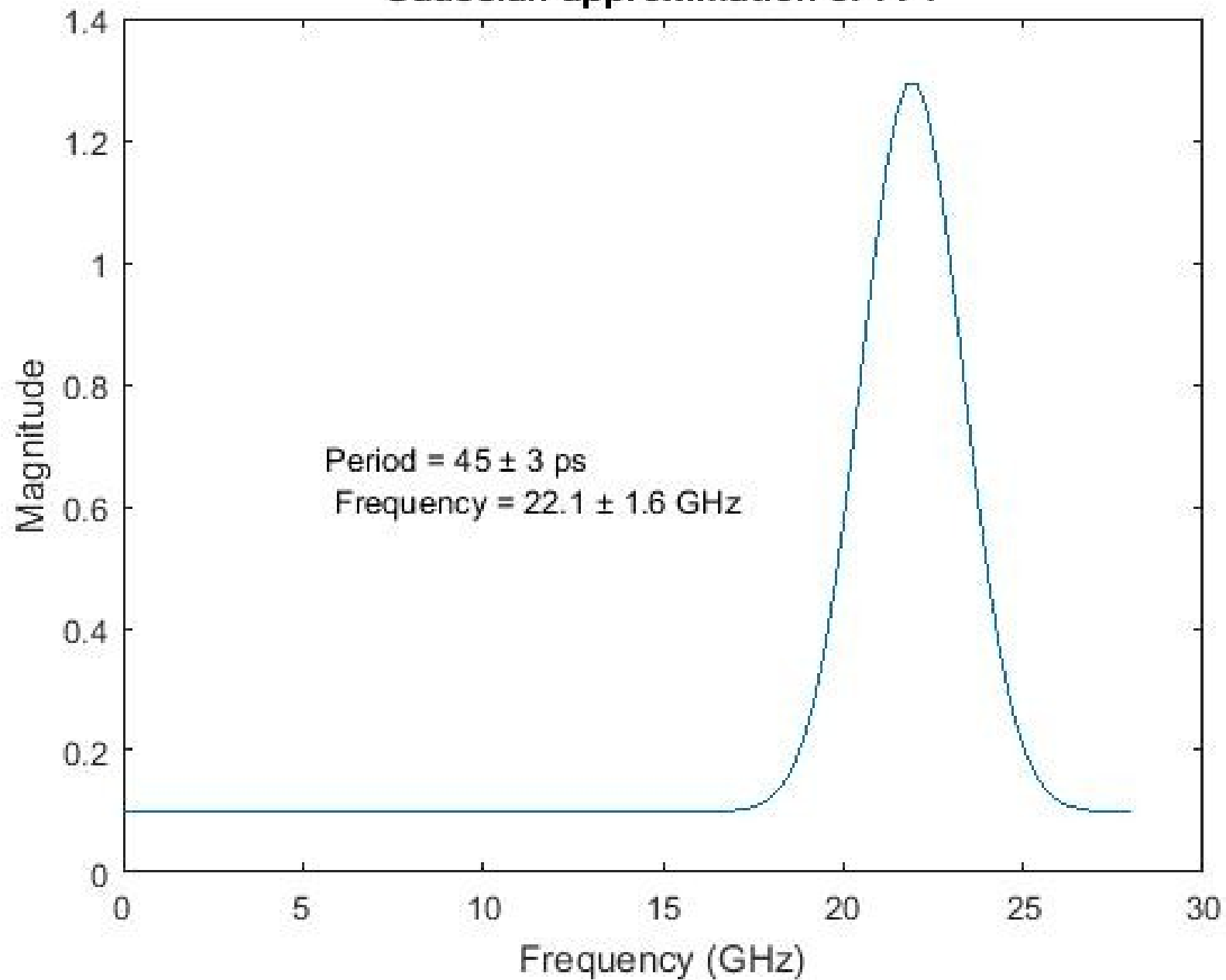




10 nm gold on glass with reduced noise



## Gaussian approximation of FFT

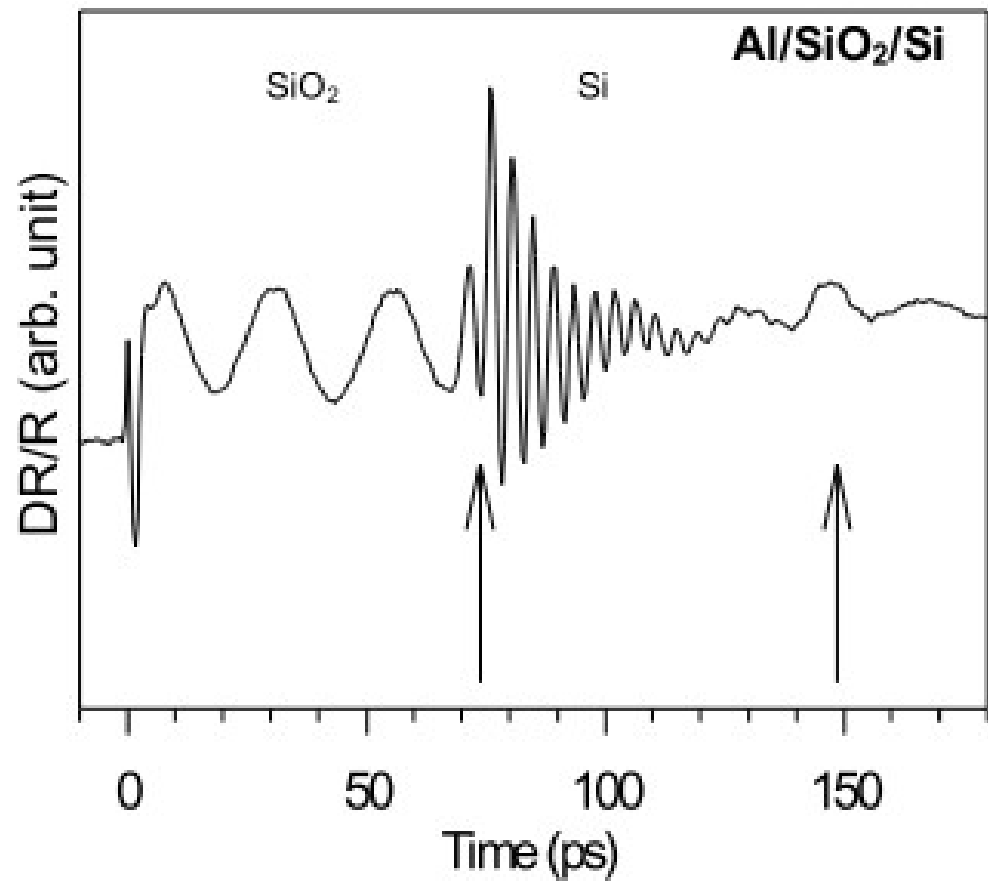


Al

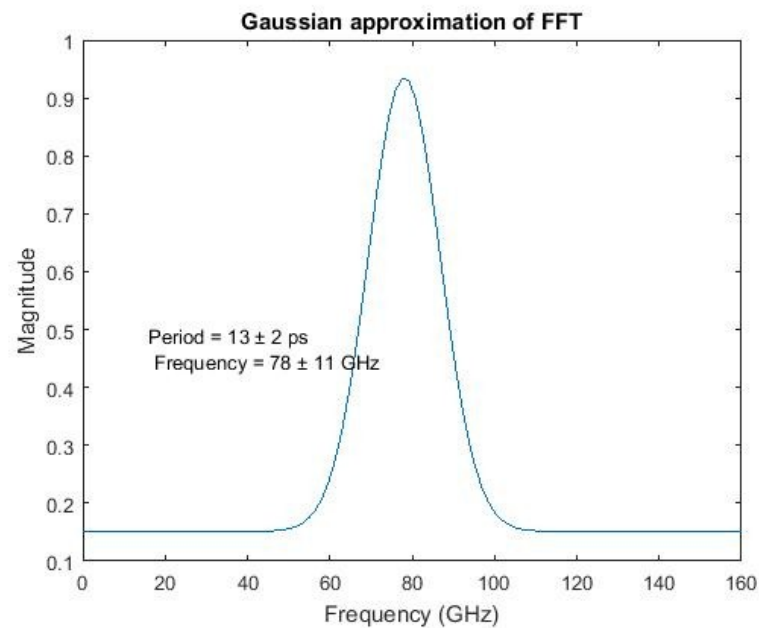
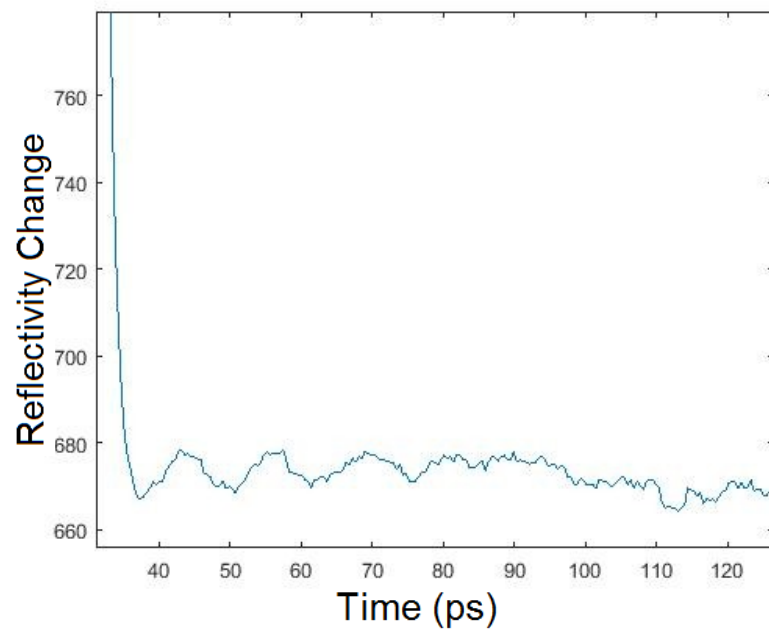
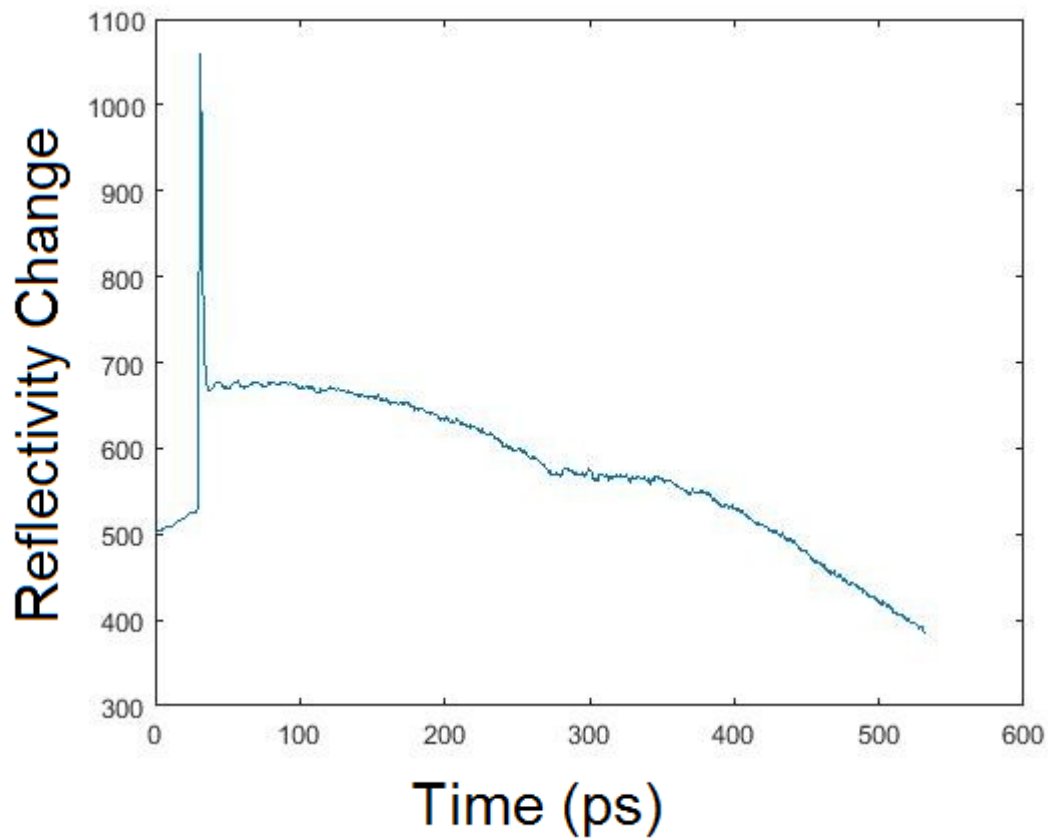
SiO<sub>2</sub>

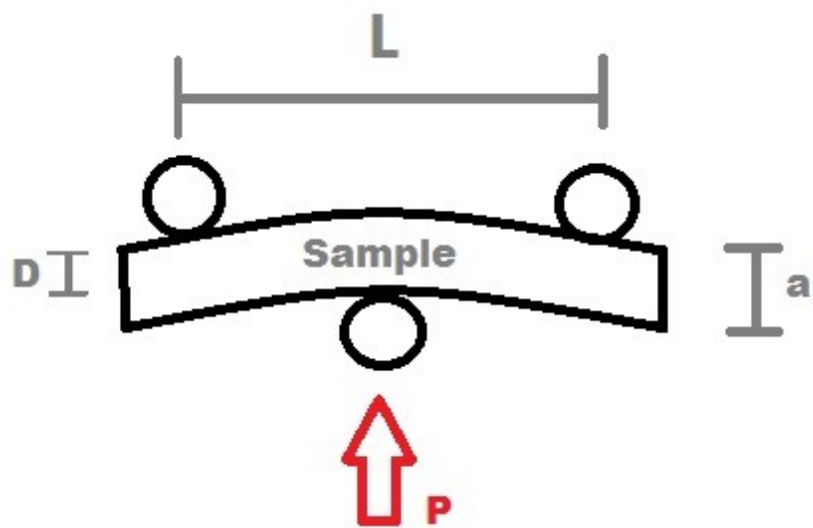
Si

$$\tau = \frac{\lambda_0}{2 n v \cos \theta'}$$



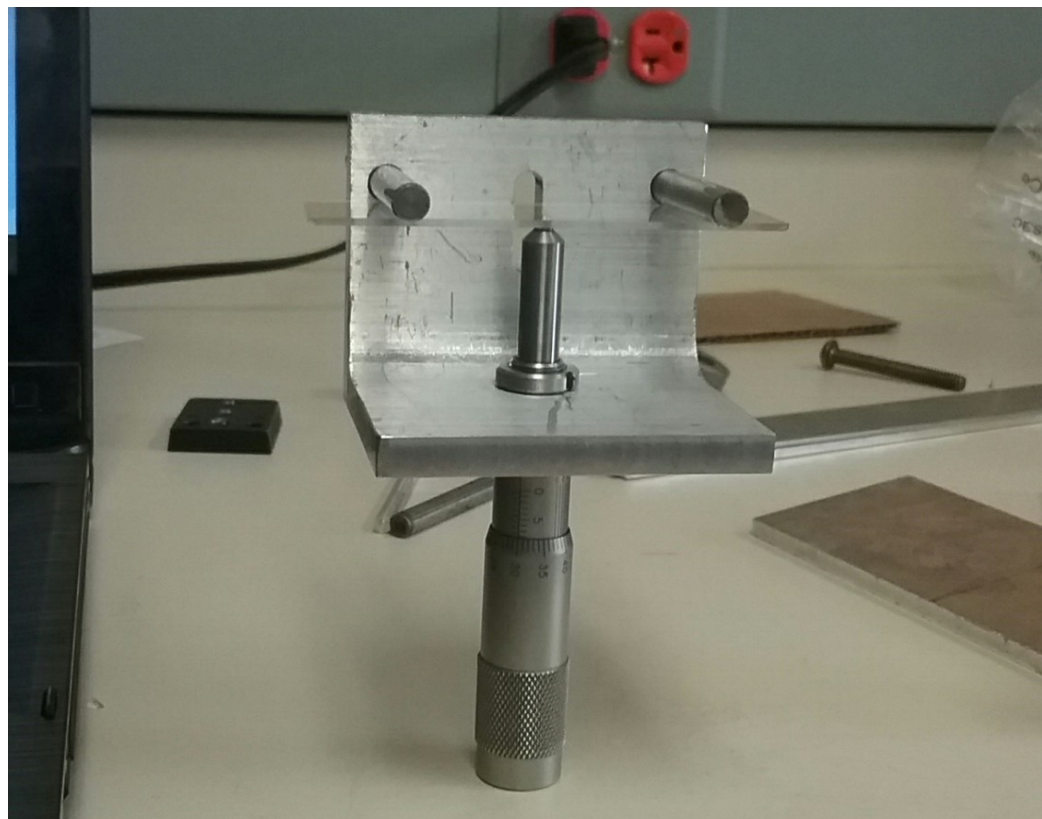
20 nm gold on glass sample





$$\epsilon = \frac{6Da}{L^2}$$

$$\sigma = E\epsilon$$



# Conclusions

- High signal-to- noise ratio is essential
- 3 point bend setup created
- Specific stress measurements can be made
- This can help optimize performance of electronic devices

# References

- Dai J, Mukundhan P, Kim C, Maris HJ. Analysis of a picosecond ultrasonic method for measurement of stress in a substrate. *J Appl Phys*. 2016;119(10). doi:10.1063/1.4943541.
- Tauc J, Maris HJ. Picosecond Ultrasonics. *IEEE J Quantum Electron*. 1989;25(12):2562-2569. doi:10.1109/3.40643.
- Devos, Arnaud, Renaud Cote, and Arnaud Le Louarn. 2003. "Giant Oscillations in the Picosecond Ultrasonic Response of Crystalline Silicon: Connection with the Electronic Structure." *WCU*, 1197-1200.
- Yu, Kuai, Tuphan Devkota, Gary Beane, Guo Ping Wang, and Gregory V Hartland. 2017. "Brillouin Oscillations from Single Au Nanoplate." doi:10.1021/acsnano.7b02703.