



Lecture #7

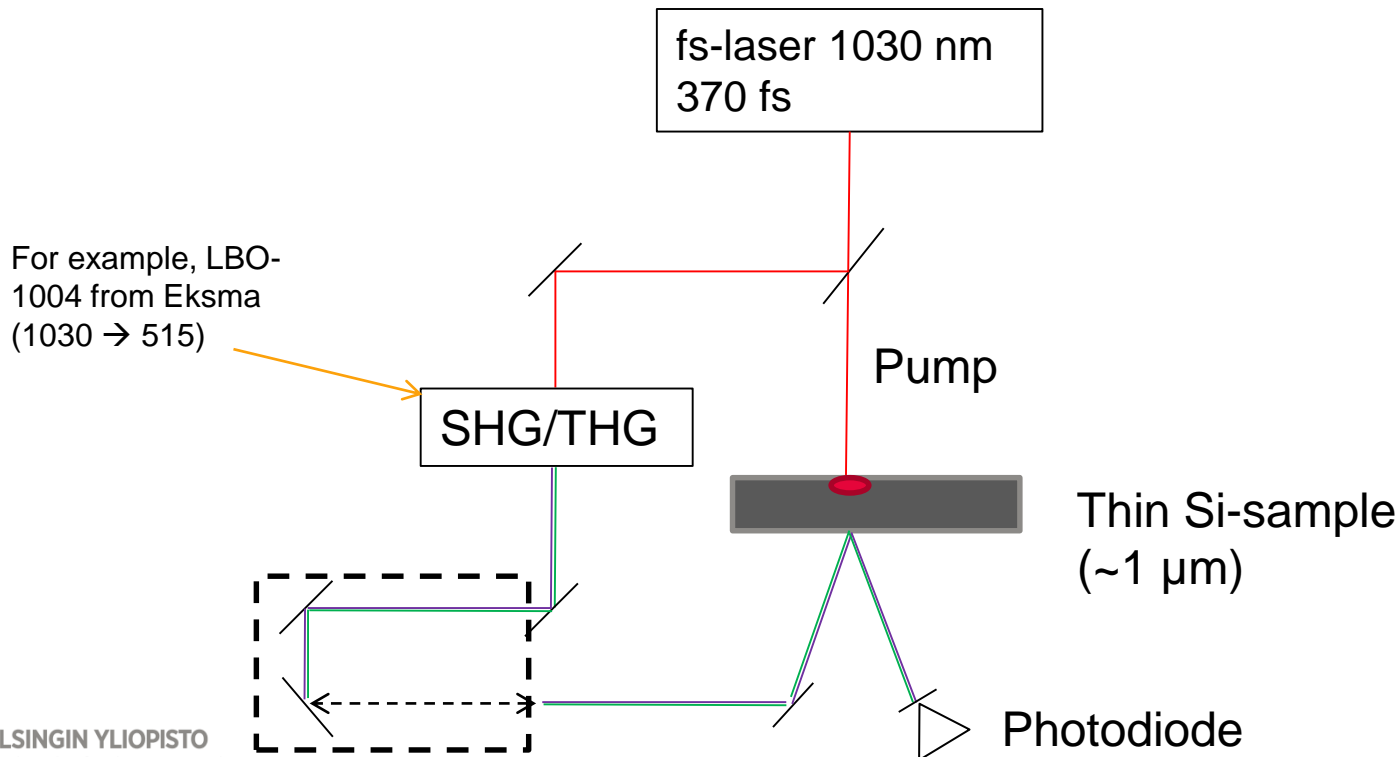
Pump probe in practice

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Pump-probe

- A method to measure coherent phonons





Components: Femtosecond laser

- Calmar laser FLCPA-05UUHF

Calmar Product Specification Name	FLCPA-05U-UHF-02	
Calmar Model Number	FLCPA-05UUHF	
Product Description	Cazadero 1030nm/515nm High Pulse Energy Femtosecond Fiber-Based Pulse Laser with AOM1	
Customer	Physics Department, University of Helsinki, Finland	
Optical Specifications		
Central Wavelength (nm)	1030	515
Minimum Pulse Width (ps)	<0.4 (0.37 typical)	<0.4 (0.37 typical)
Average Power (W)	>2.4	> 0.8
Maximum Pulse Energy (uJ)	>1.2@ 2MHz	>0.4@ 2MHz
Primary Repetition Rate with AOM 1 (MHz)	9 manually selectable repetition rates between 2MHz to 27MHz. Pulse energy reduces with higher repetition rates (89nJ @ 27MHz).	9 manually selectable repetition rates between 2MHz to 27MHz. Pulse energy reduces with higher repetition rates.
Polarization Extinction Ratio (dB)	>18	
Beam Quality (M^2)	< 1.2 (typ. 1.1)	< 1.2
Beam Diameter at Exit, $2\omega_0$ (mm)	~ 3	~ 2
Termination	Free space collimated beams; Switchable 2 wavelength outputs, manual control.	



Components: Shutter

- To give out pulse trains from the laser
- Thorlabs SH05 (10 ms minimum exposure time = 20000 pulses)



SH05
10' Cable Included



Components: Beamsplitter

- Specialized femtosecond components required
- Eksma optics 032-7520A
 - 80% transmission, 20% reflection to 90 degree angle
 - Anti-reflection coated for 1030 nm

SUBSTRATE

Material	UV FS
S1 Surface Flatness	$\lambda/10$ at 633 nm
S1 Surface Quality	20-10 scratch & dig (MIL-PRF-13830B)
S2 Surface Flatness	$\lambda/10$ at 633 nm
S2 Surface Quality	20-10 scratch & dig (MIL-PRF-13830B)
Diameter Tolerance	+0.00 mm-0.12 mm
Thickness Tolerance	± 0.25
Parallelism	30 arcsec
Chamfer	0.3 mm at 45° typical

COATING

Technology	Electron beam multilayer dielectric
Adhesion and Durability	Per MIL-C-675A. Insoluble in lab solvents
Clear Aperture	Exceeds central 85% of diameter
Angle of Incidence	45 \pm 3°
Back side antireflection coated	R<0.5%



Components: Mirrors

- Pump arm is 1030 nm, probe arm 515 nm
- Femtoline mirrors from Eksma Optics

SUBSTRATE

Material	UV grade Fused Silica or BK7 glass
S1 Surface Flatness	$\lambda/10$ at 633 nm
S1 Surface Quality	20–10 scratch & dig (MIL-PRF-13830B)
S2 Surface Quality	Commercial polish
Diameter Tolerance	+0.00 mm -0.12 mm
Thickness Tolerance	± 0.25 mm
Wedge	< 3 min
Chamfer	0.3 mm at 45° typical

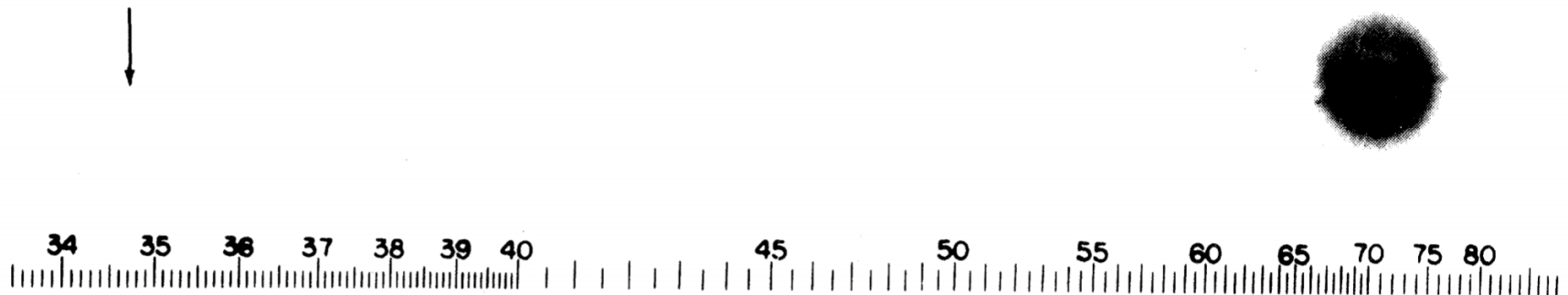
COATING

Technology	Electron beam multilayer dielectric or Ion beam sputtering
Adhesion and Durability	Per MIL-C-675A. Insoluble in lab solvents
Clear Aperture	Exceeds central 85% of diameter
Coating	Hard dielectric High Reflection $R > 99.5\%$
Angle of Incidence	0 or $45 \pm 3^\circ$
Designed for average polarization	$R = (R_s + R_p)/2$
Laser Damage Threshold	> 100 mJ/cm ² , 50 fsec pulse, 800 nm typical
Coated Surface Flatness	$\lambda/10$ at 633 nm over clear aperture



Frequency doubling

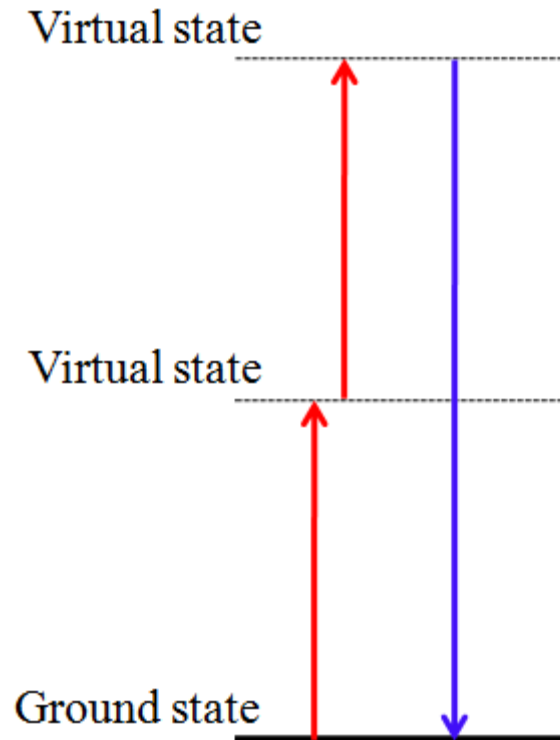
- Non-linear optics to change the wavelength of a laser
- First reported in Franken *et al.*, PRL 1961





Frequency doubling

- Non-linear excitation through virtual states





Components: Frequency doubling

- BBO crystal from Eksma Optics (BBO-654H)

SHG@1030 nm	BBO crystal thickness	LBO crystal thickness
50 fs	0.5 mm	0.9 mm
100 fs	1 mm	1.9 mm
150 fs	1.5 mm	2.8 mm
200 fs	2 mm	3.7 mm



Components: Optical delay line

- Thorlabs 220 mm ODL kit

220 mm Optical Delay Line Kit

- ▶ Repeatable 0.67 fs Delay Steps over a 1466 ps Range
- ▶ Computer Controlled via Included APT Software
- ▶ High-Speed Delay Stage Capable of 300 mm/s
- ▶ Kit Includes Controller and All Parts Pictured Below (Except for Optical Table)



BBD201
One-Channel
Controller Included





Components: Detector

- Thorlabs PDA36A

Item #	PDA100A ^{a,b}	PDA36A ^a
Click Image to Enlarge		
Wavelength Range	320 - 1100 nm	350 - 1100 nm
Bandwidth Range ^c	DC - 2.4 MHz	DC - 10 MHz
Gain ^c	1.51 kV/A - 4.75 MV/A (Hi-Z Load) 0.75 kVA - 2.38 MV/A (50 Ω Load)	1.51 kV/A - 4.75 MV/A (Hi-Z Load) 0.75 kVA - 2.38 MV/A (50 Ω Load)
Noise-Equivalent Power (NEP)	0.973 - 27 pW/Hz ^{1/2}	0.593 - 29.1 pW/Hz ^{1/2}
Responsivity Curve		
Active Area (Click Blue Text for Image)	100 mm ² (10 mm x 10 mm) Image of Detector Element	13 mm ² (3.6 mm x 3.6 mm) Image of Detector Element
Operating Temperature Range	10 to 40 °C	0 to 40 °C





Components: Sample to be measured

- How does one make a very thin free-standing film?