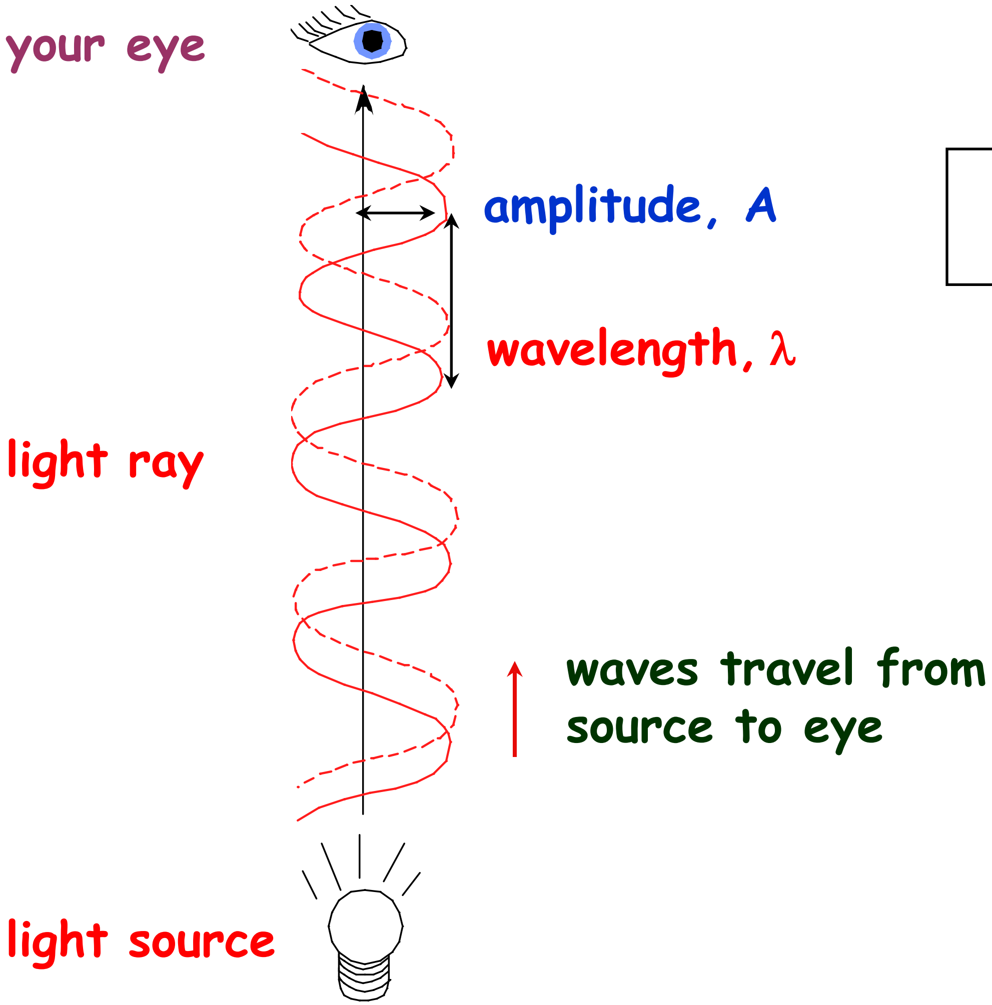
PH 301

ENGINEERING OPTICS

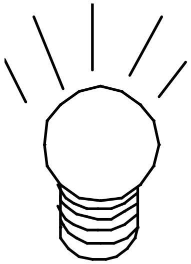
Lecture_Interferometers_16

What happens as light moves through scope?



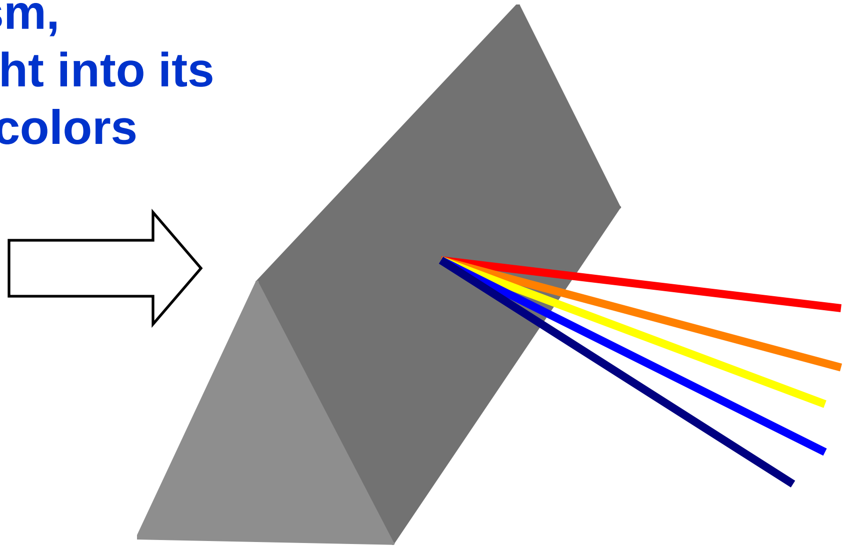
light travels as waves

What happens as light moves through the scope?



Microscope light is white light,
i.e. it’s made up of lots of different wavelengths;
Each wavelength of light corresponds to a different color

Can prove this with a prism,
which separates white light into its
constituent wavelengths/colors

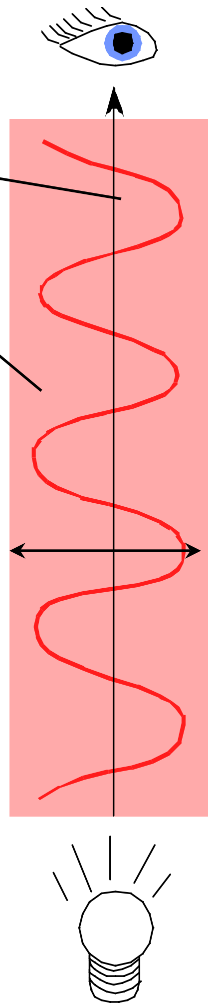


What happens as light moves through scope?

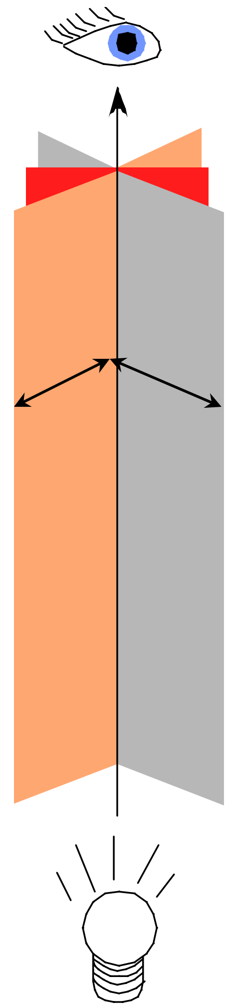
propagation direction

plane of vibration

vibration direction



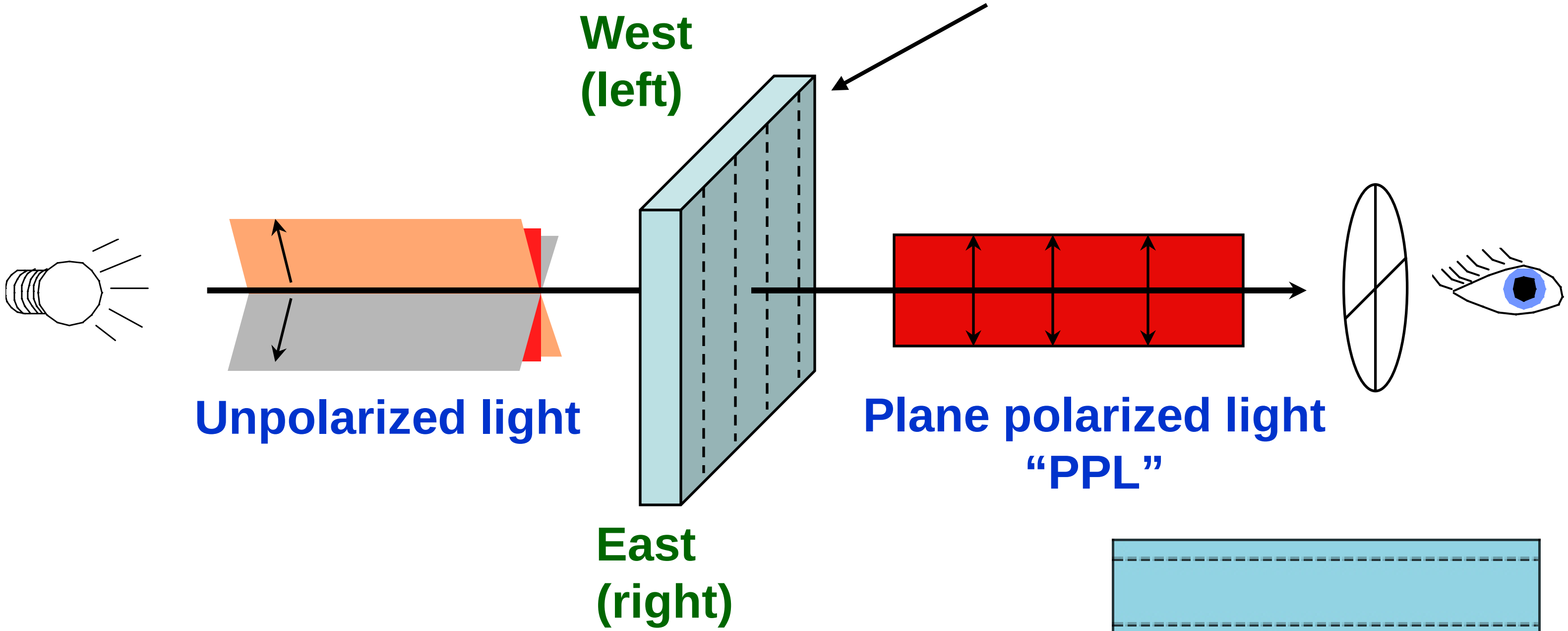
Polarized Light

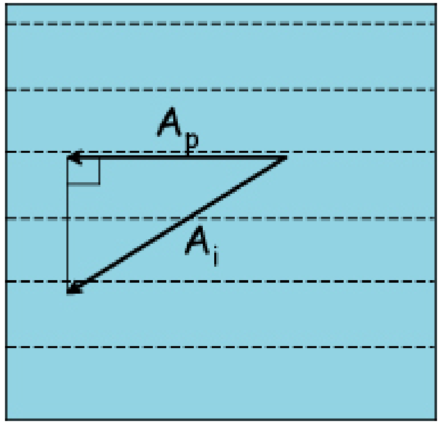


Unpolarized Light

light vibrates in all planes that contain the light ray (i.e., all planes perpendicular to the propagation direction)

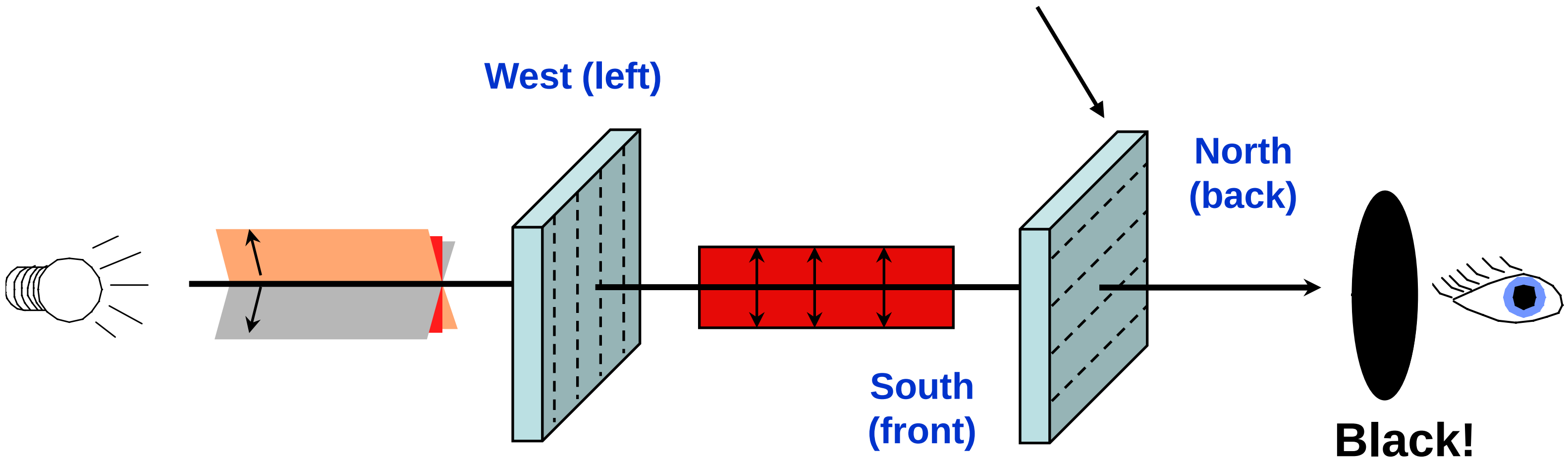
1) Light passes through the **lower polarizer**





Only the component of light vibrating in E-W direction can pass through lower polarizer – light intensity decreases

2) Insert the upper polarizer

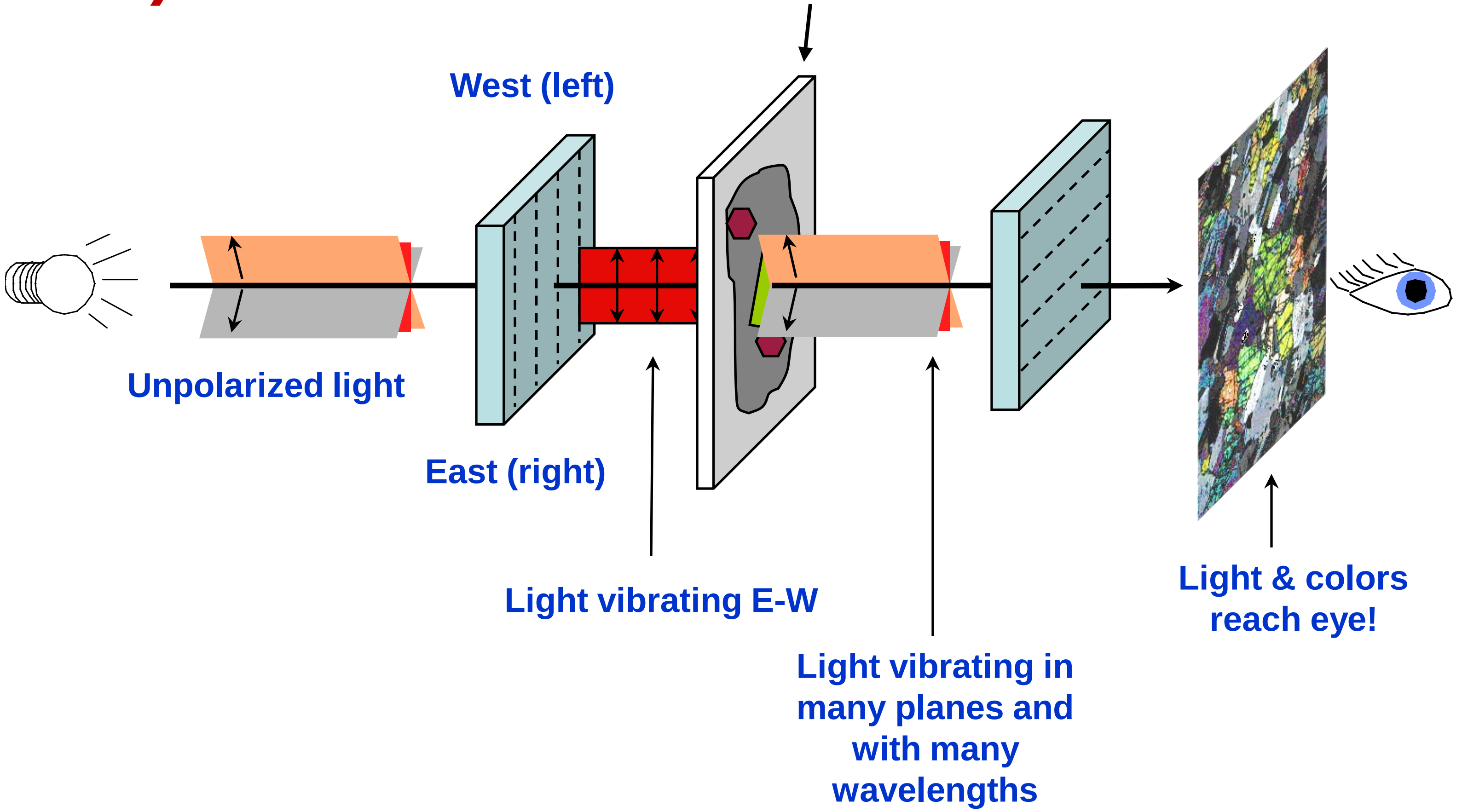


XPL
(crossed nicols or crossed polars)

Now what happens?
What reaches your eye?

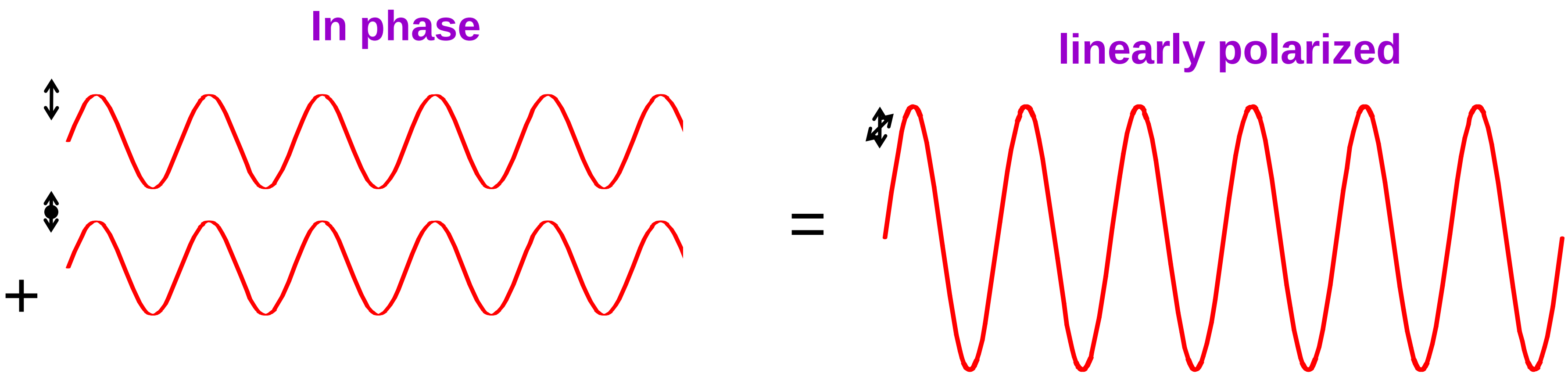
Why would anyone design a microscope that prevents light from reaching your eye?

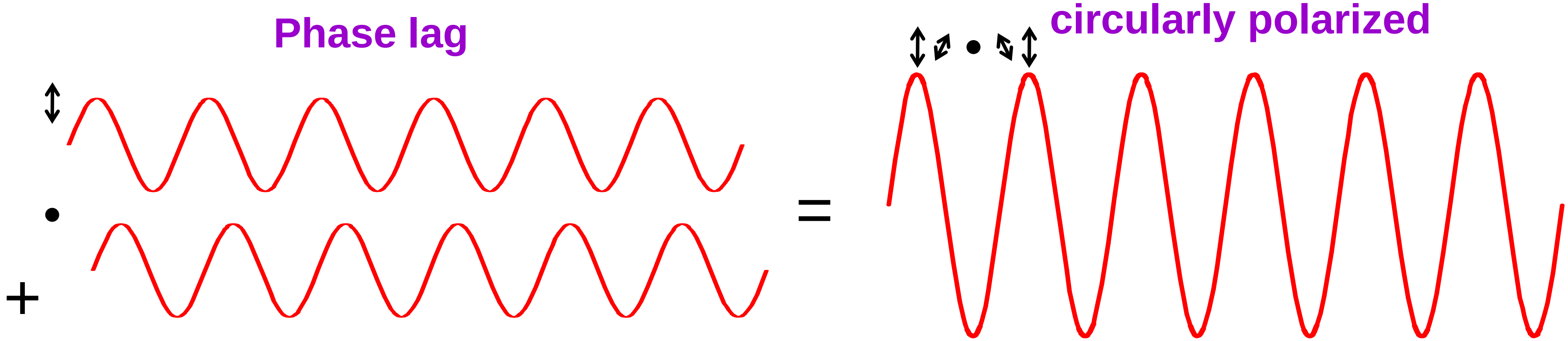
3) Now insert a thin section of a rock



How does this work?

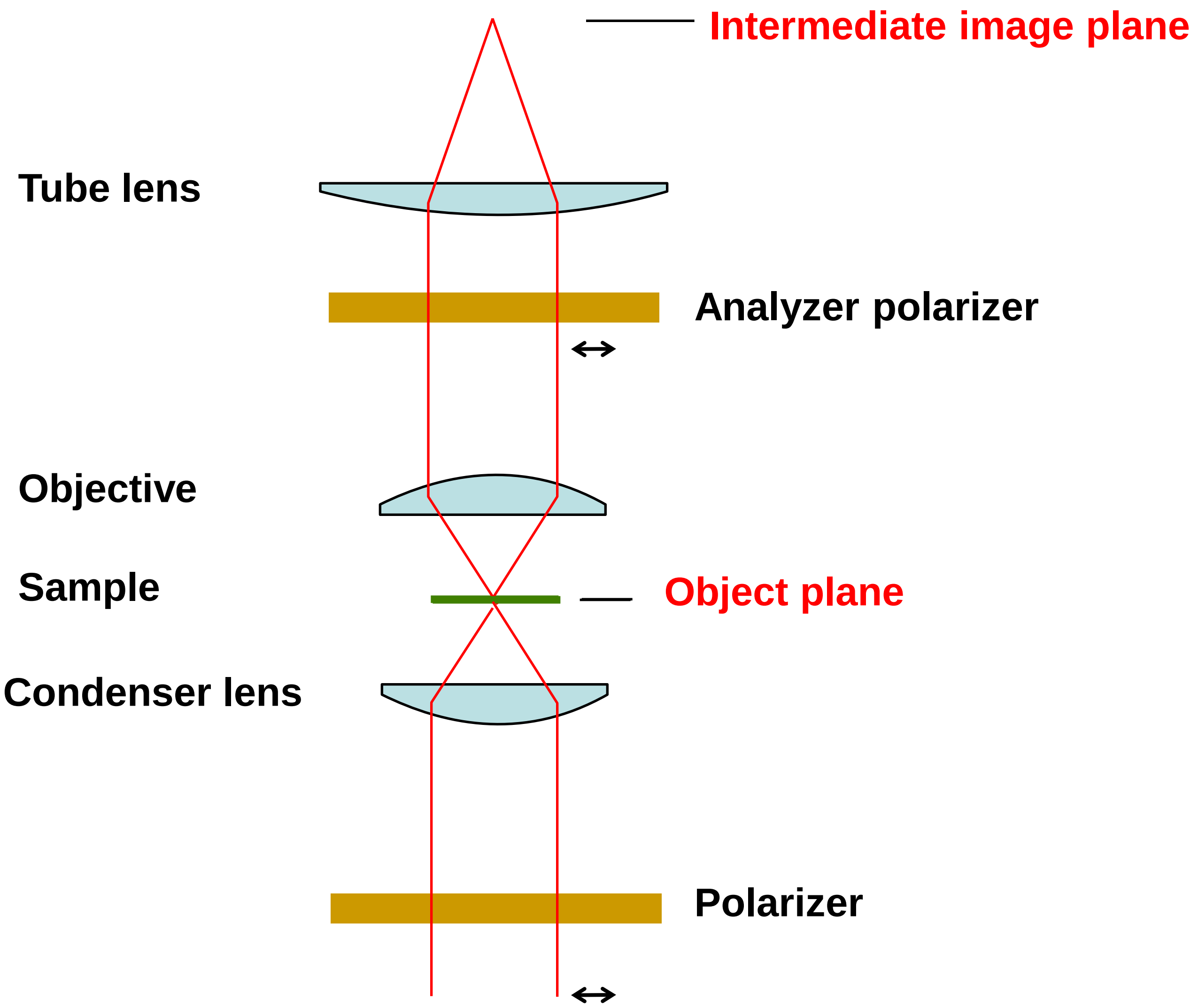
Interference & Polarization





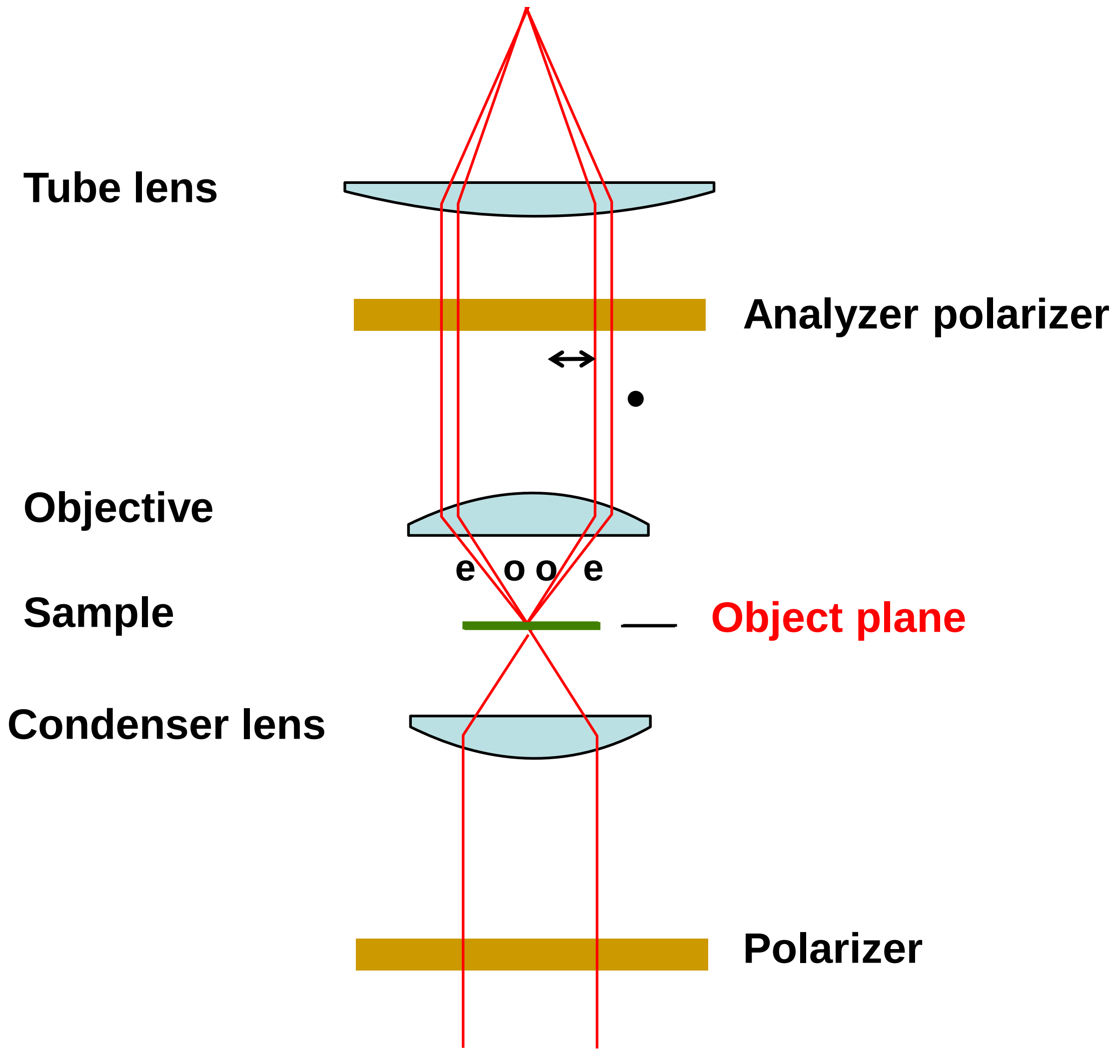
Polarized Light Microscope

Imaging a normal sample



Polarized Light Microscope

Imaging a birefringent sample

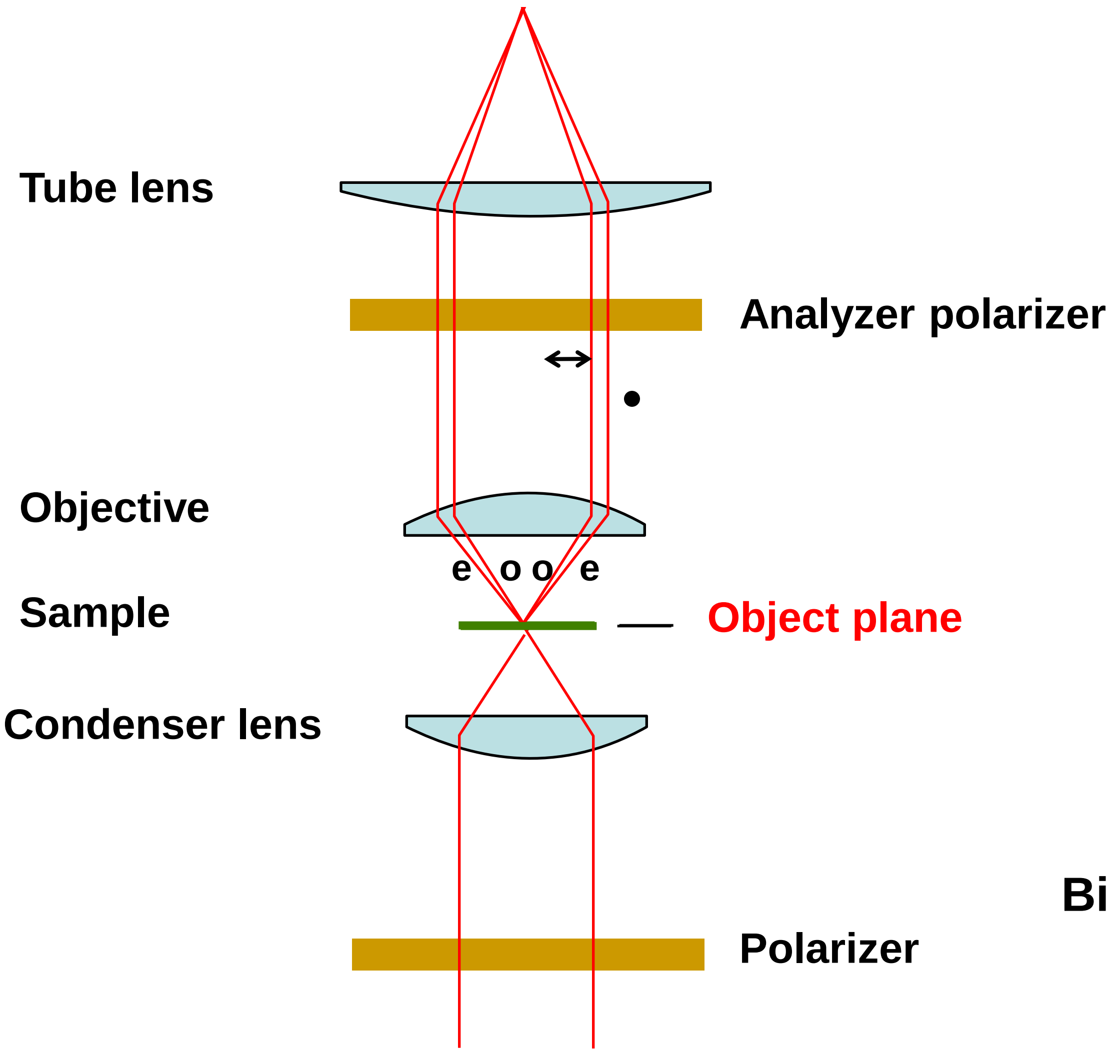


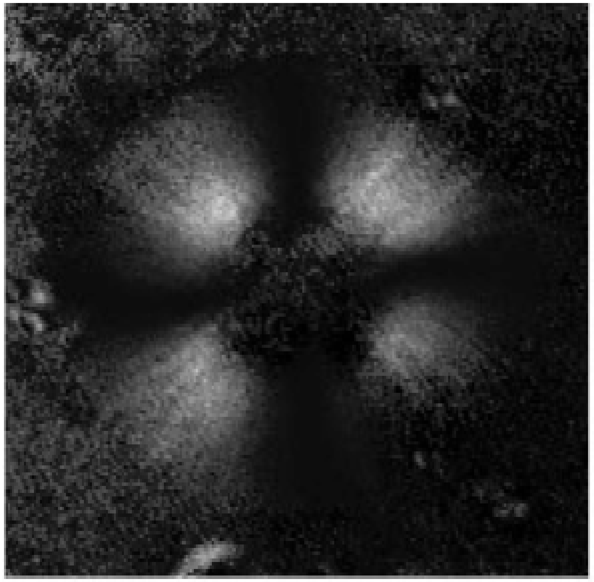
- Bifringent sample splits light into *e*- & *o*- rays, which see different refractive indices

- Phase retardation of one ray with respect to other gives rise to elliptically polarized light, which is transmitted by the polarizer

Polarized Light Microscope

Imaging a birefringent sample

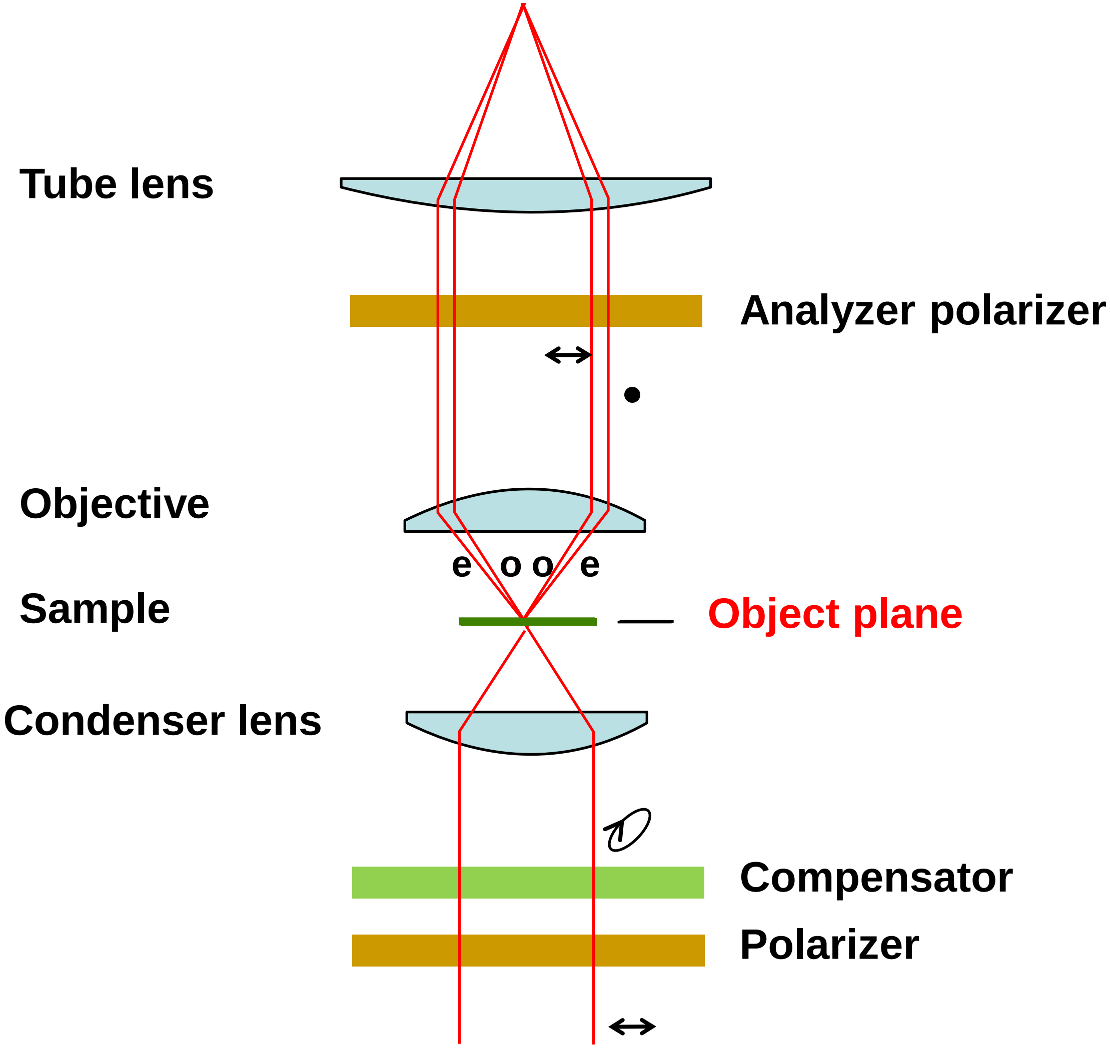


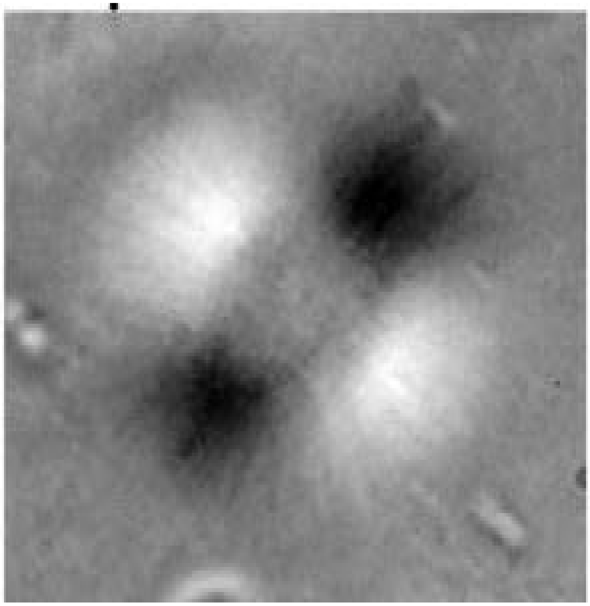


Birefringent sample is bright on dark background

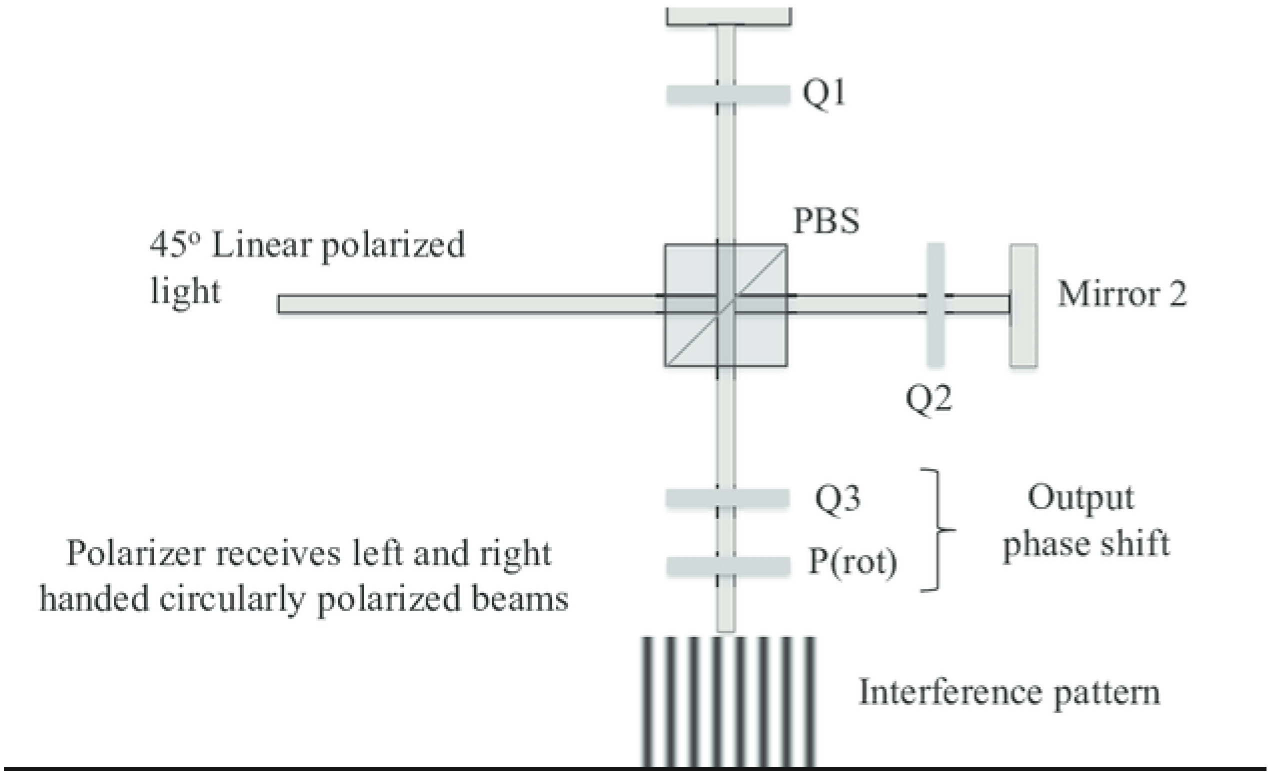
Polarized Light Microscope

Add a compensator (wave plate) for better contrast

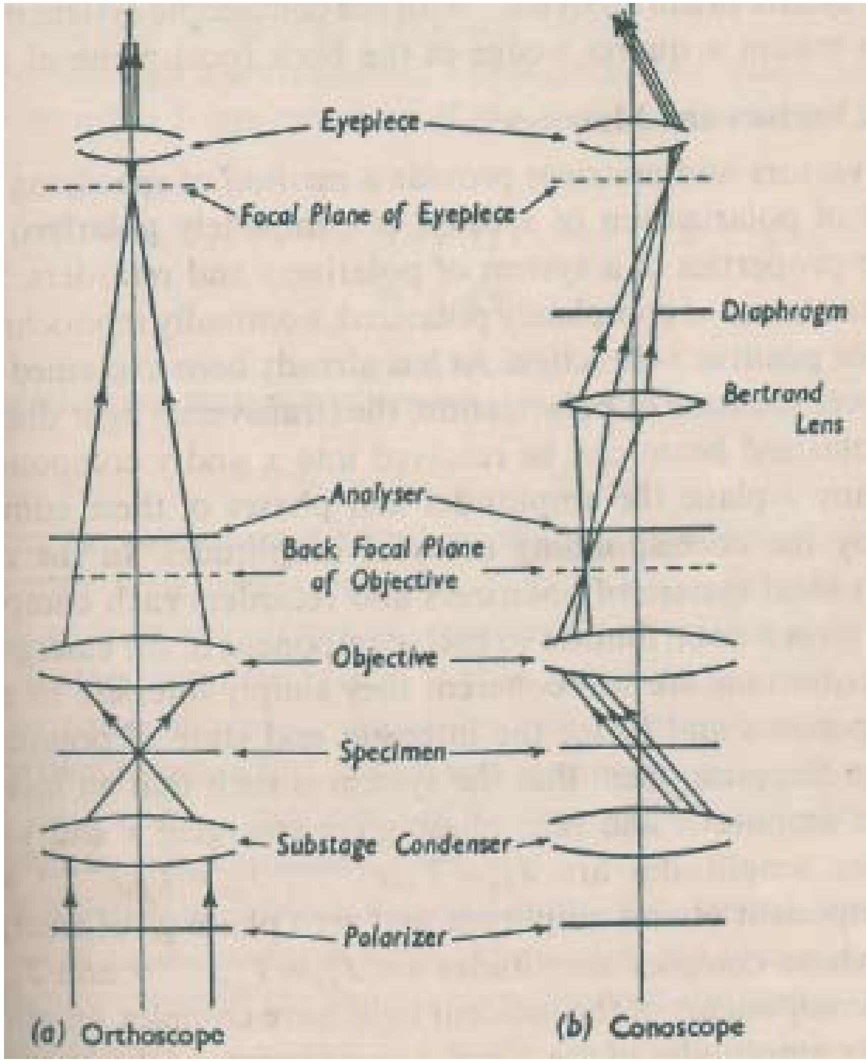




Polarization Interferometer



Polarizing Microscope



Orthoscope: An instrument used to examine the eye that eliminates corneal refraction by means of a layer of water.

Conoscope: A polarizing microscope for giving interference fringes & for determining principal axis of a crystal.

Dual-Polarizing Interferometer

Dual-polarization interferometry (DPI) probes molecular layers adsorbed to the surface of a waveguide using evanescent wave of a laser beam.

It is used to measure conformational change in proteins, or other biomolecules, as they function.

DPI focuses laser light into two waveguides. One of these functions as "sensing" waveguide having an exposed surface while second one functions to maintain a reference beam.

DPI technique rotates polarization of laser, to alternately excite two polarization modes of waveguides. Measurement of interferogram for both polarizations allows both r.i. & thickness of adsorbed layer to be calculated.

Polarization can be switched rapidly, allowing real-time measurements of chemical reactions taking place on a chip surface in a flow-through system.

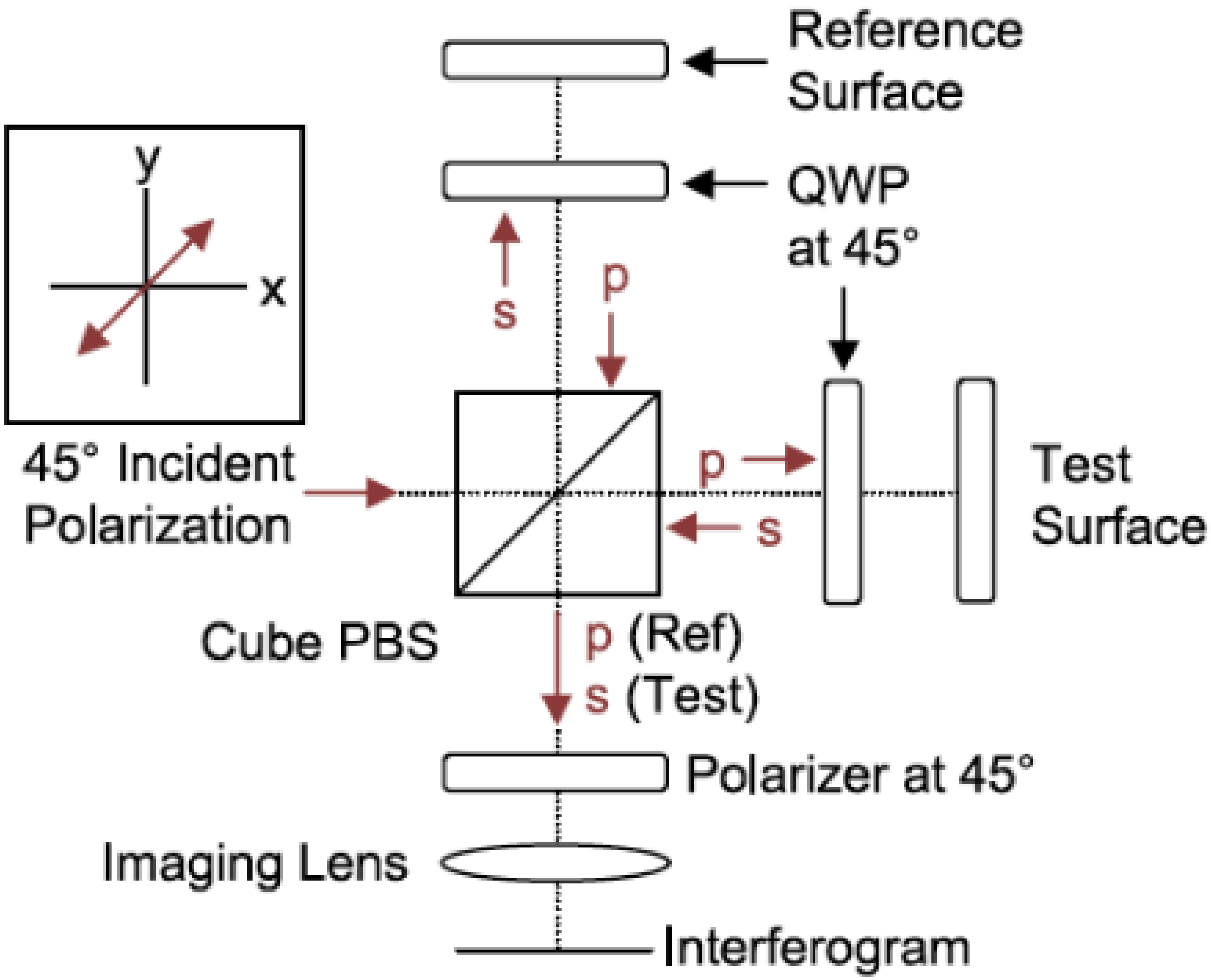
It is quantitative & real-time (10 Hz) with a dimensional resolution of 0.01 nm.

Polarized Light Microscopy

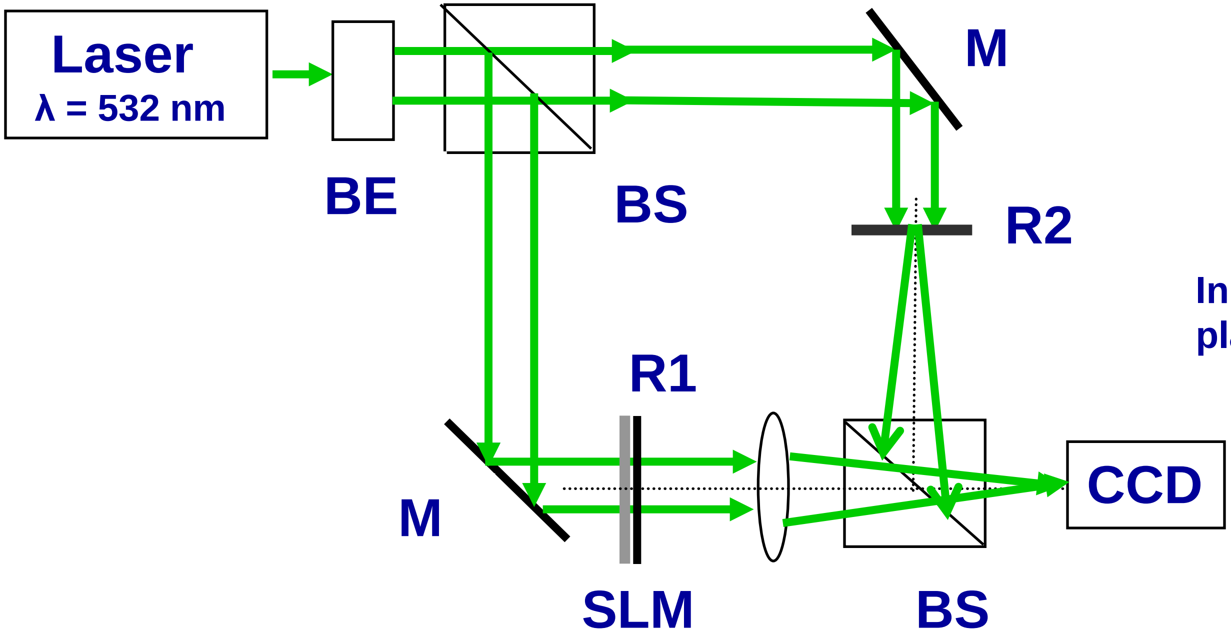
- Good for
  - Seeing ordered structures in the cell:
  - Spindles
  - Other cytoskeletal structures
  - Membranes
  - Collagen

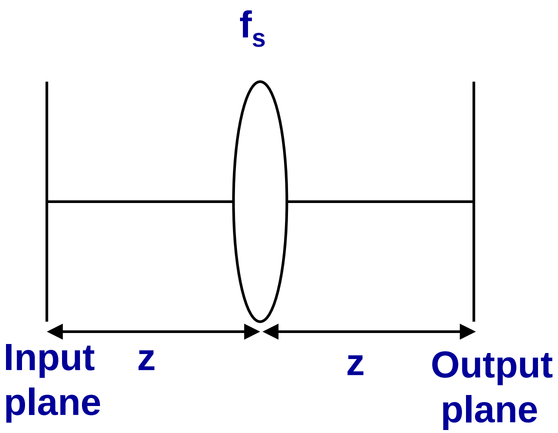
- No staining required!

PBS-TGI


Reference
Surface
QWP
at 45°
y
x
s
p
45° Incident
Polarization
p
s
Test
Surface
Cube PBS
p (Ref)
s (Test)
Polarizer at 45°
Imaging Lens
Interferogram

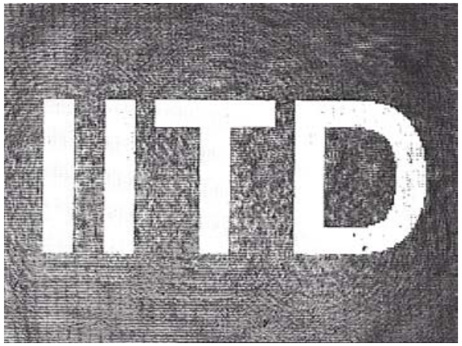
Encryption using FRT & digital holography



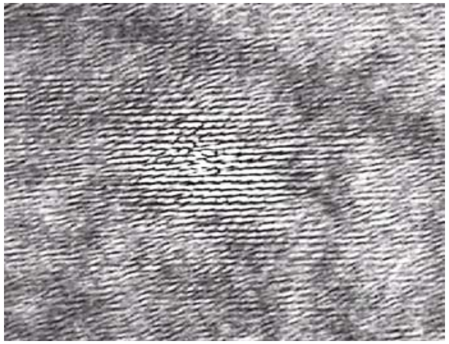


BE: beam expander, BSs: beam splitters, SLM: spatial light modulator, RPM: random phase mask, CCD: charge-coupled device, L: lens

Fourier domain encoding

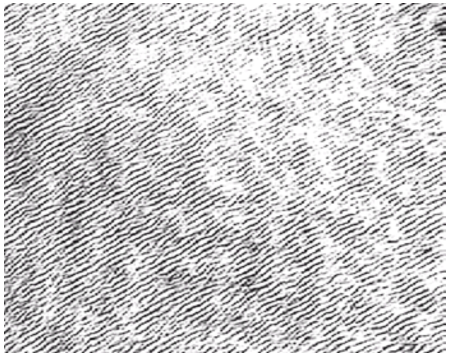


Original image



Encrypted hologram

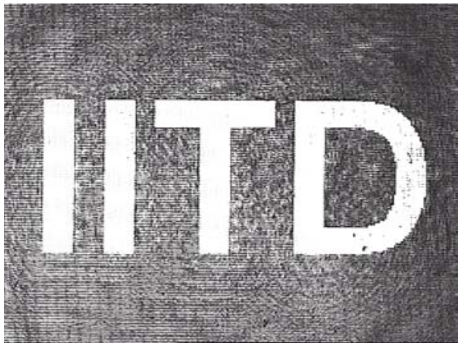
Encrypted image



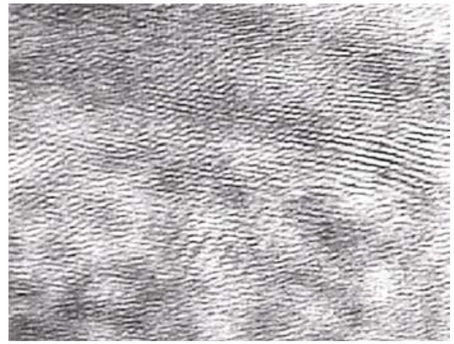
Key hologram

Retrieval with correct keys

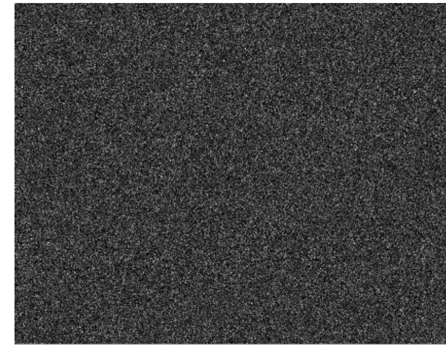
Fractional Fourier domain encoding



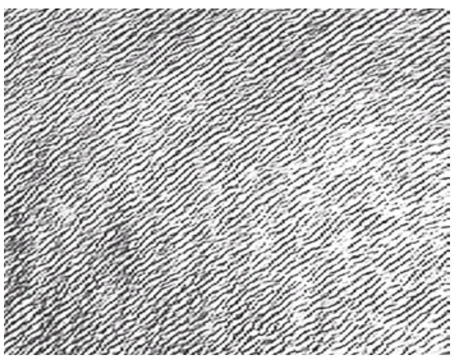
Original image



Encrypted hologram

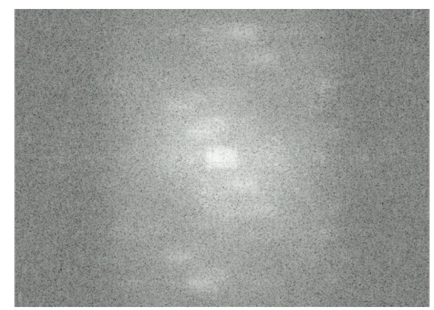


Encrypted image



Key hologram

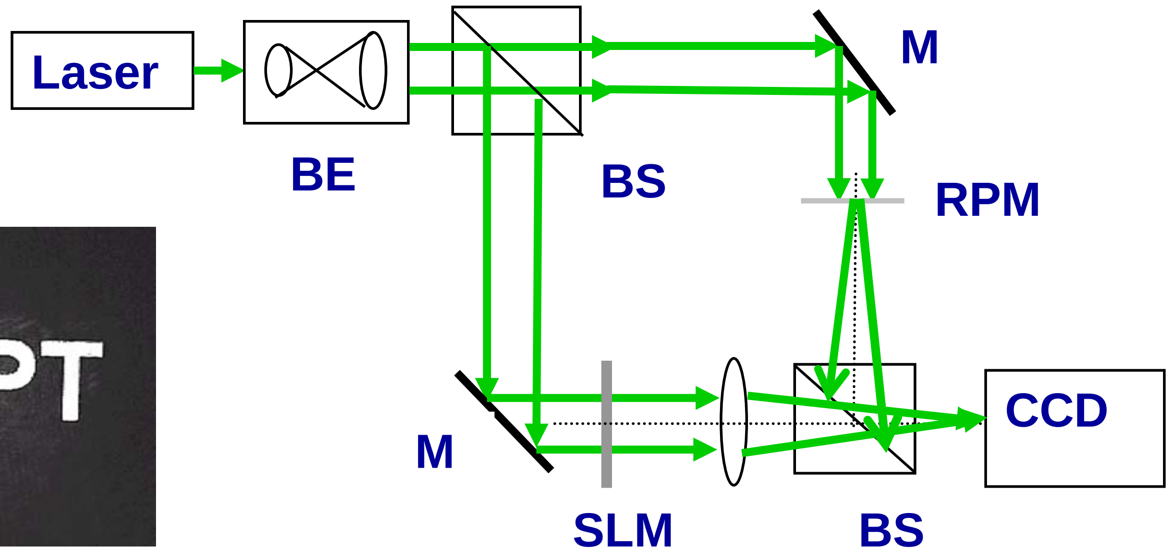
Retrieval with correct keys



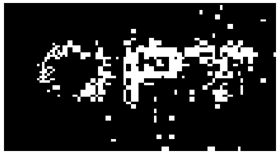
Retrieval with wrong fractional order

Fully phase encryption

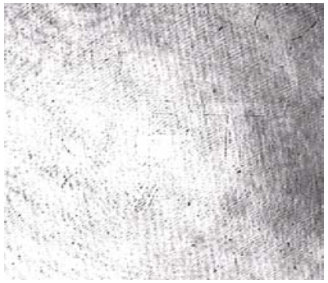
Fourier domain encoding



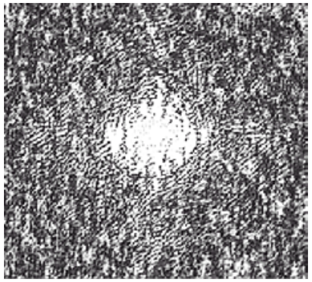
Input image



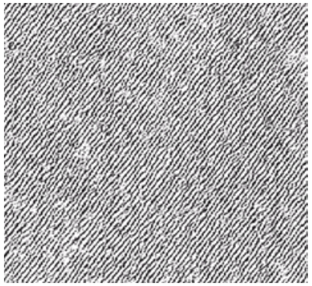
Decrypted image



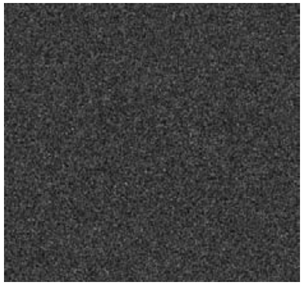
Phase-encoded image



Encrypted hologram

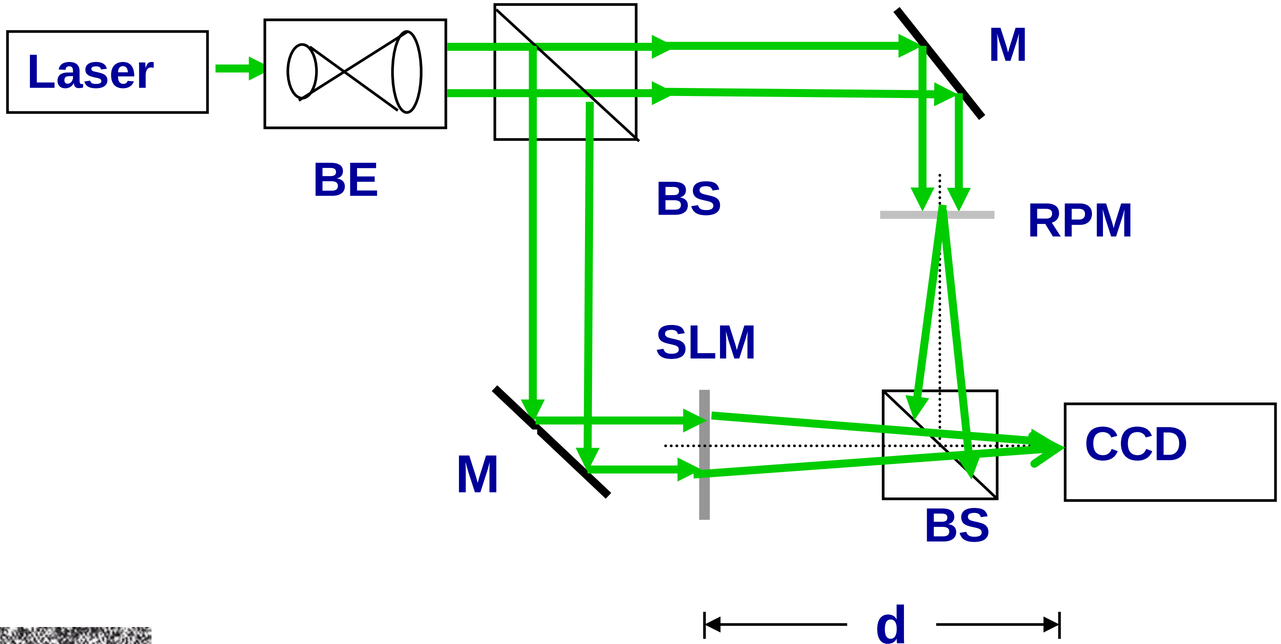


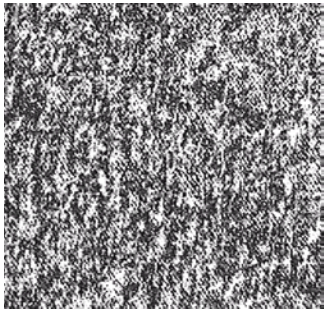
Key hologram

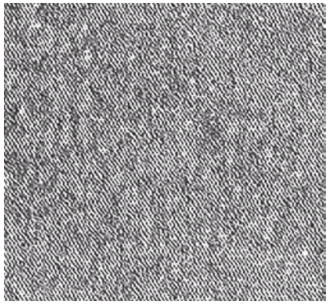


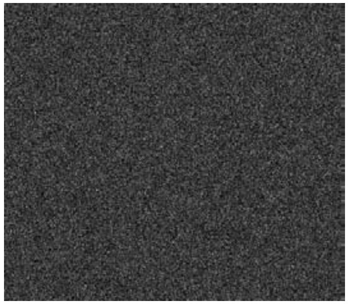
Encrypted image

Fresnel domain encoding



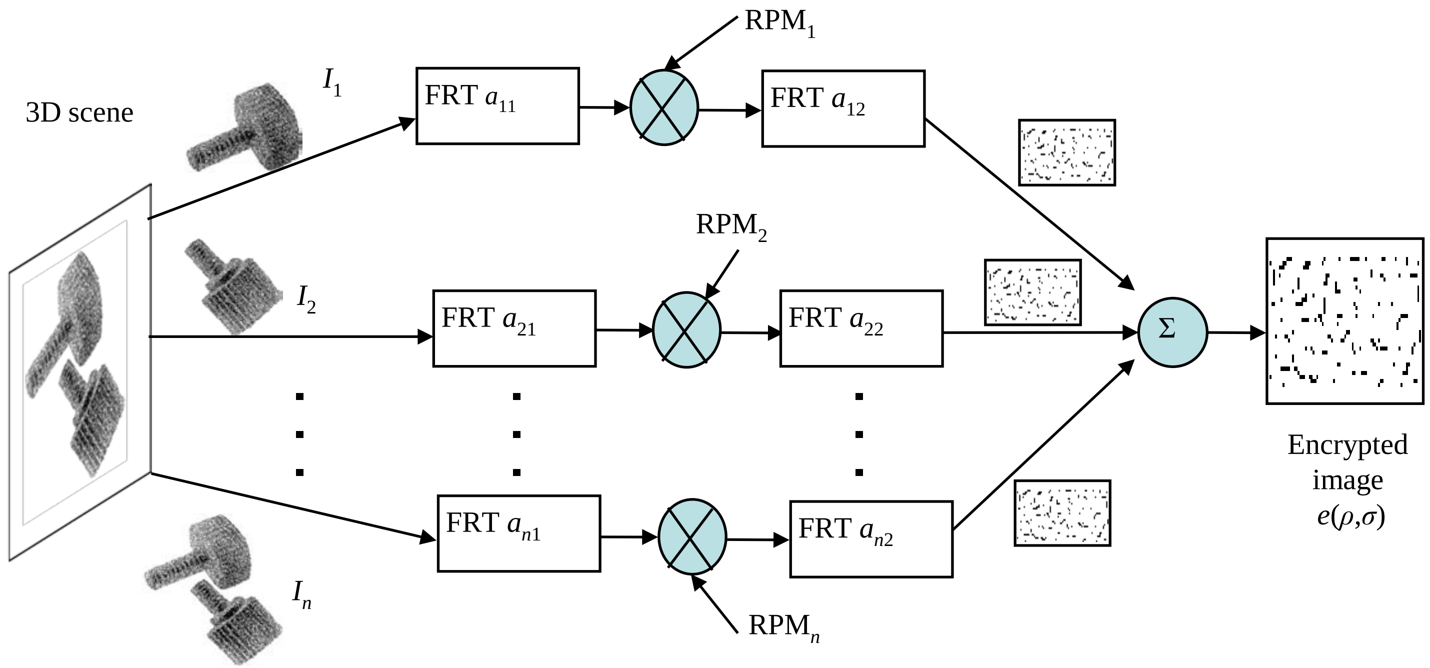

Encrypted hologram


Key hologram

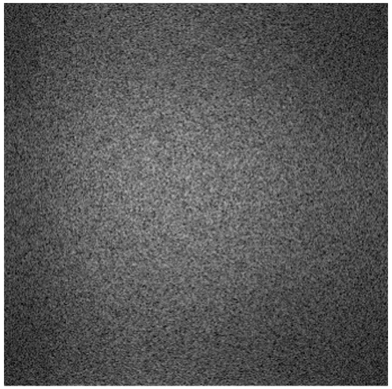

Encrypted image


Decrypted image

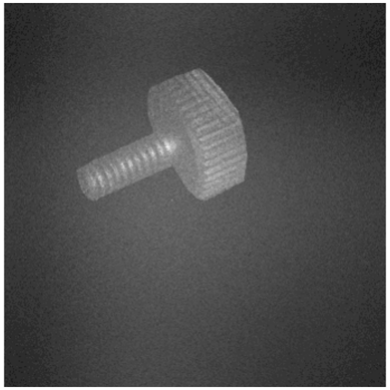
Flexible optical encryption with multiple users & multiple security levels



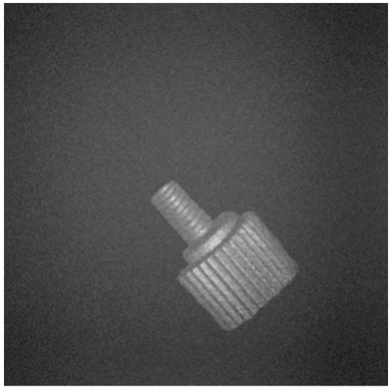
Contd…



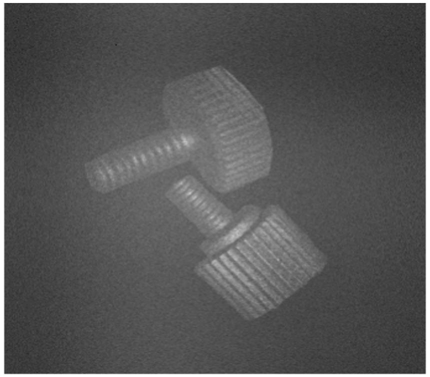
Multiplexed encrypted image



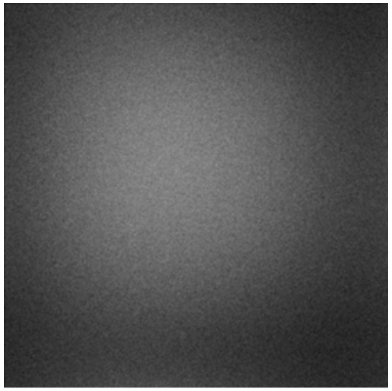
Decrypted image - User 1



Decrypted image - User 2

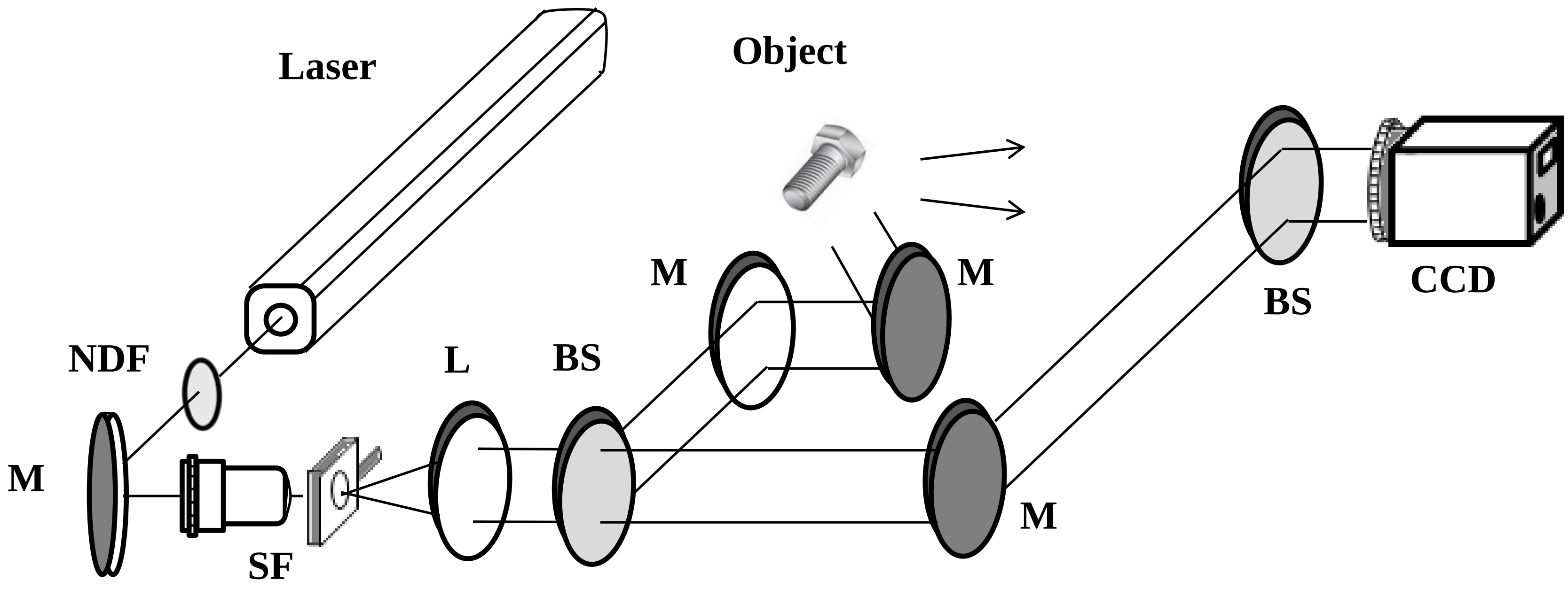


Decrypted image - User n

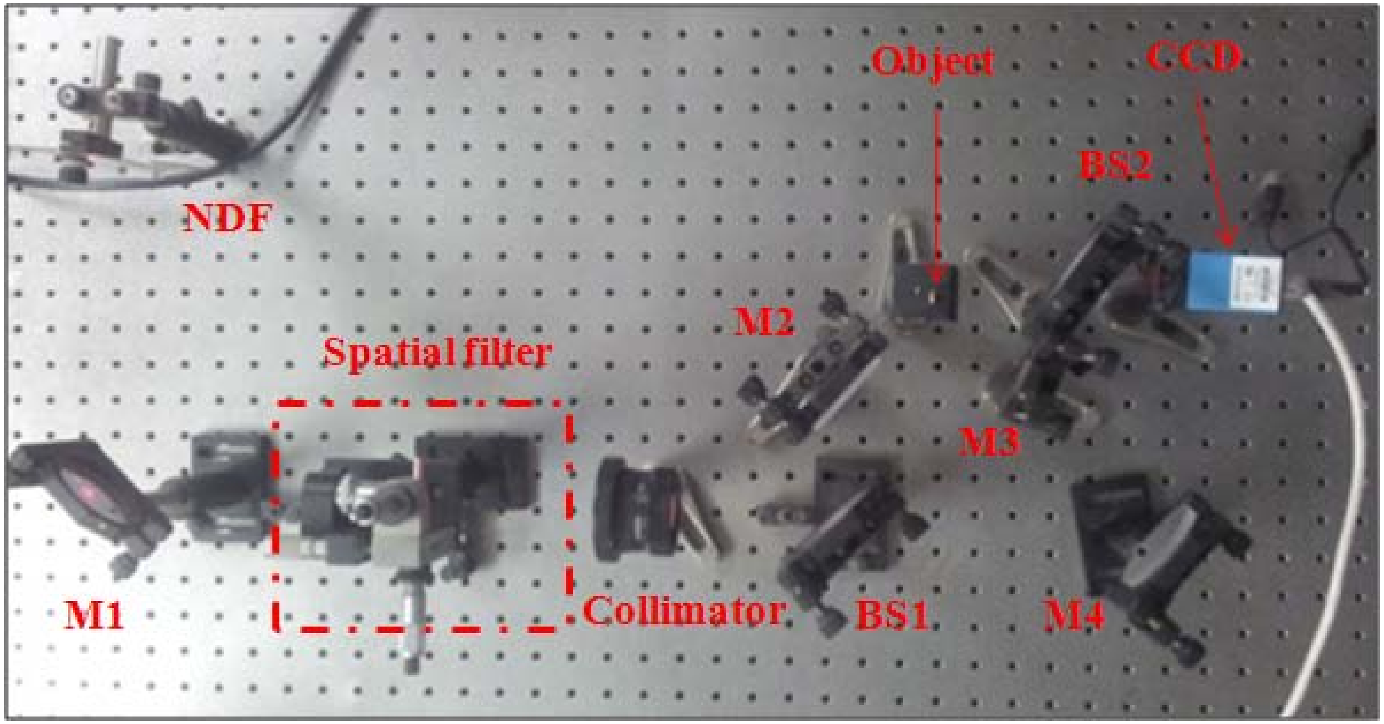


Decryption with one of the wrong keys – Any User

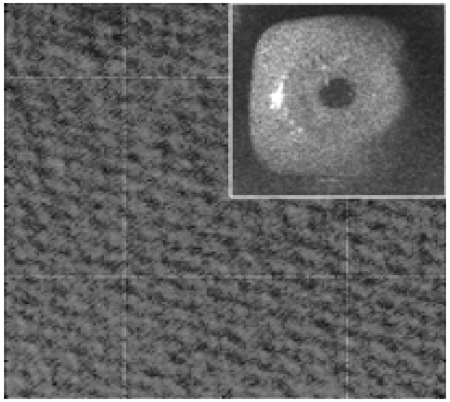
Experimental Set-up



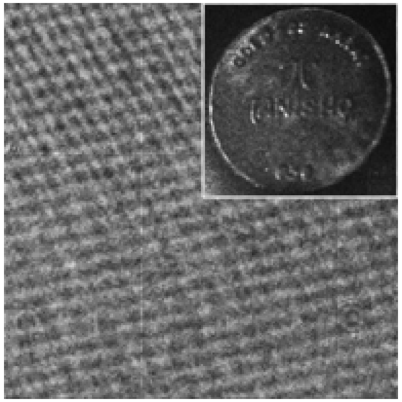
Snapshots



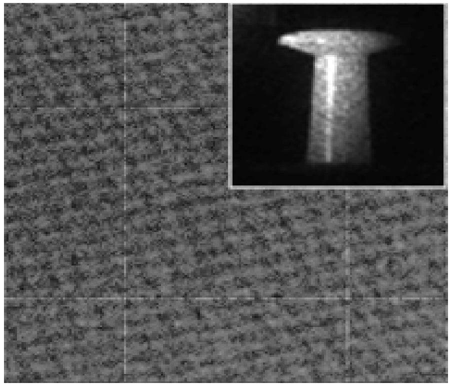
Optical Recording & Reconstruction



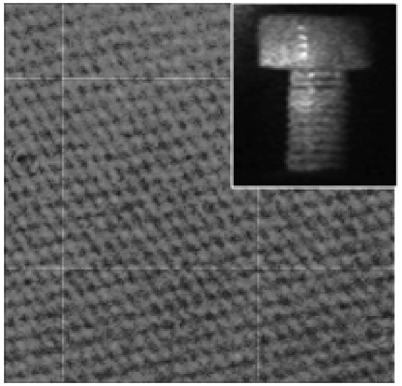
Dice



Coin

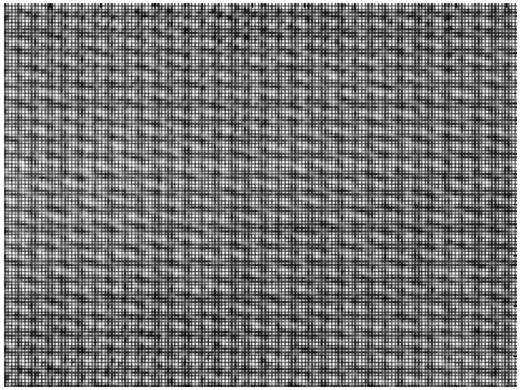


Pin-cover

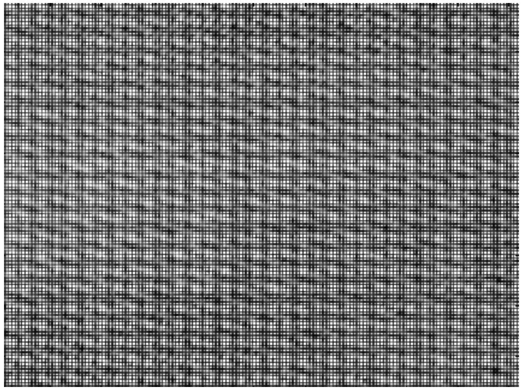


Bolt

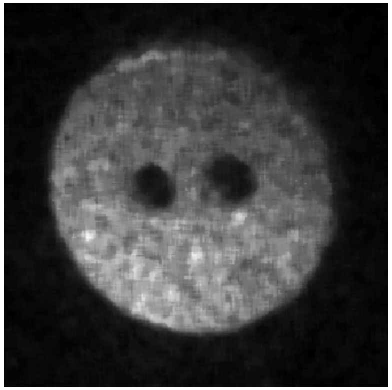
Optical Recording & Reconstruction



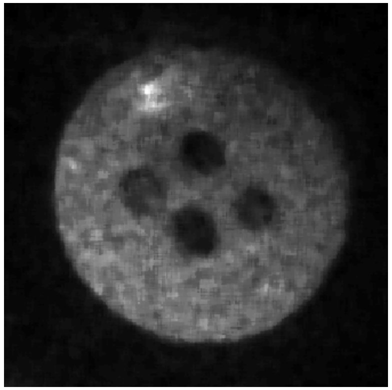
Reference Hologram



Target Hologram

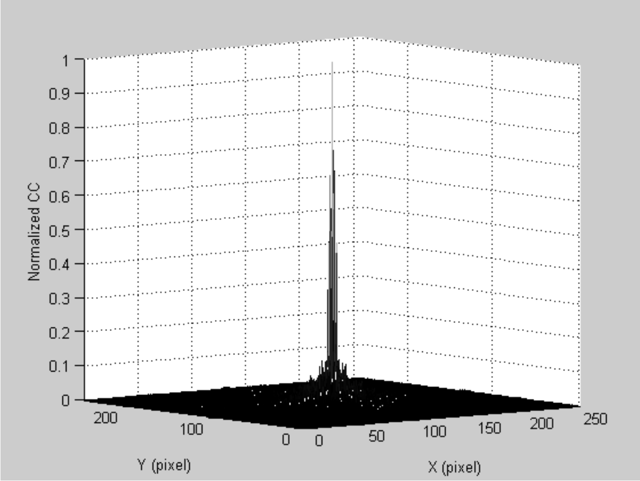


Reconstructed Reference

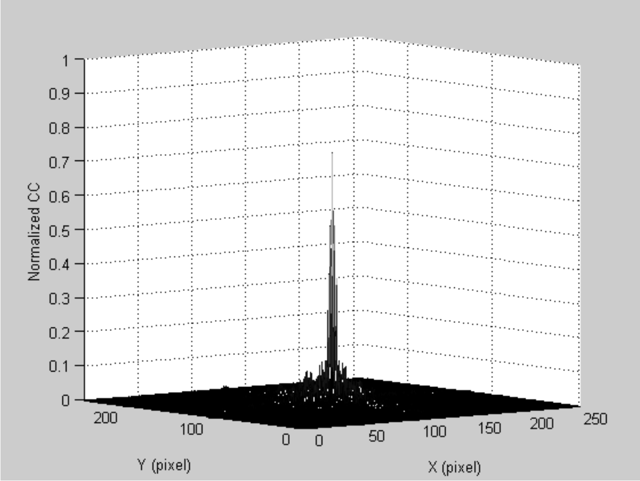


Reconstructed Target

Matching Holograms



Auto-correlation



Cross-correlation

Normalized CC obtained when reference hologram is matched with target hologram using conventional JFRTC