Making Light Go Through Tiny Holes

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This is BiG

- Infant universe from microwave background

Credit: NASA/WMAP Science Team
Planar defects in $\langle111\rangle$ GaAs nanowires

(111) planar twin boundary: Faulted stacking sequence (b).

The density of planar defects varies. The broader the nanowire, the higher the possibility for finding these defects.

Nanometers

are small.

- Dust on Si wafer
- SEM image
- contrast based on the emission of surface electrons

- 1 nanometer (nm) = 1x10^{-9} m
  ( = 1/1,000,000 mm = 1/1000 micron )
Latest Intel product line
Transmission Electron Micrograph of Intel's 90 nm Generation Transistor
Diffraction - Single Slit

(a) Plane waves approach from the left.
Circular waves spread out on the right.

(b) A beam of sunlight has a sharp edge.

The light spreads out behind the slit.

Viewing screen

2.5 cm

2 m

0.1-mm-wide slit in an opaque screen

Incident laser beam
Single Slit Experiment

\[ \tan \theta = \frac{y}{D} \]
\[ \tan \theta \approx \sin \theta \approx \theta \approx \frac{y}{D} \]

Condition for minimum
\[ a \sin \theta = m\lambda \]
\[ y \approx \frac{m\lambda D}{a} \]
Young’s Double-Slit Experiment

(a) Viewing screen

The drawing is not to scale: the distance to the screen is actually much greater than the distance between the slits.

(b) 1. A plane wave is incident on the double slit.
2. Waves spread out behind each slit.
3. The waves interfere in the region where they overlap.
4. Bright fringes occur where the antinodal lines intersect the viewing screen.
Single Slit Diffraction

(a) Greatly magnified view of slit

- A wave front passes through a narrow slit (width $a$). Note that narrow is important.
- Each point on the wave-front emits a spherical wave
- One slit becomes the source of many interfering wavelets.
- A single slit creates a diffraction pattern on the screen.

The wavelets from each point on the initial wave front overlap and interfere, creating a diffraction pattern on the screen.
H. Bethe (1944) Theory of Diffraction through small holes:

\[ T \propto \left( \frac{a}{\lambda} \right)^4 \]
Ebbesen et al. (Nature, 391, 1998)
"Extraordinary optical transmission through sub-wavelength hole arrays"

Hole diameter < 200 nm

Enhanced transmission attributed to surface plasmons
What’s a surface plasmon?

- light that propagates along the interface between a metal ($\varepsilon_1$) and an insulator ($\varepsilon_2$)
- wavevector: $$\vec{k}_s = \frac{\omega}{c} \sqrt{\frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2}}$$
- $\therefore$ wavelength is smaller than regular light of the same frequency
Early plasmonics research (1100's) 
glass stained with metallic salts and oxides

Text Courtesy of the Art Glass Association
Pictures courtesy of SGAA Slide Library
http://www.stainedglass.org/
Jeff Burnette

Joe Blow Glassworks, Vancouver
Focussed Ion Beam with a Scanning Electron Microscope

Samantha Grist, SFU Physics

Nauman Methani
SFU Chemistry

Samantha Grist, SFU Physics
Ga ion source

electrical feedthrough

coil

tungsten needle

liquid-metal source

extractor

suppressor

lens 1

octupole 1

deflector plate

aperture

lens 2

octupole 2

sample stage
Alma Lee’s Ball:
Written, sculpted, and published by Robert Chaplin
ISBN 0968818374
Cuneiform Tablets:
Persepolis (in Louvre)
(ancient Iran 500 BC)

Cuneiforms were written on clay tablets, on which symbols were drawn with a blunt reed called a stylus. The impressions left by the stylus were wedge shaped, thus giving rise to the name cuneiform ("wedge shaped").
Persepolis (ancient city 500 BC, ruins located 30 km north of Shiraz, Iran)
Thursday, April 12, 2007.
8:48am (AEST)

Teeny Ted's tale is world's smallest book
-Reuters

SEM photo of the entire book located close to a cross scratched in the Si wafer.
SEM image of a fibbed cross-section of electrodeposited Cu/Au/Ti/glass

Samantha Grist
Electrodeposited Co-GaAs

GaAs [001]

5 nm

Co

GaAs (011)

α-PtC
Array fibbed by Brian Leathem, M.Sc. 2004

Array C

Target spacing: 550 nm   Measured spacing: 760 nm
Target diameter: 71 nm   Measured diameter: 380x260 nm
Dwelltime: 300 ns
Ion current: pA ??
Magnification: 10k
Array B

Target spacing: ~ 1480 nm
Measured spacing: 1380 nm
Target diameter: ~ 500 nm
Measured diameter: 510 nm
Dwell time: ns ?
Ion current: 300 pA
Magnification: 1.2k
Strong Polarization in the Optical Transmission through Elliptical Nanohole Arrays,
R. Gordon, A. G. Brolo, (U. Victoria) and A. McKinnon, A. Rajora, B. Leathem, and K. L. Kavanagh (SFU)

23 × 23 arrays of ~200-nm holes in gold with variation in ellipticity and orientation of the holes
Enhanced polarization selectivity
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