Design Team 12
Diamond Optical Properties Measurement System

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Light

- Travels at $3 \times 10^8$ m/s
- Light has vertical and horizontal component
- Light can be reflected or refracted when it hits a different medium
- We are interested in refracted light
Refractive Index

- Describes how light passes through a medium
  - \( N = \frac{C}{V} \) where
  - \( N \) = refractive index
  - \( C \) = Speed of light in vacuum
  - \( V \) = speed of light through the medium

- Angle of refracted light depends on angle of incident light
  - This is dictated by Snell's law \( N_1 \sin(\theta_1) = N_2 \sin(\theta_2) \)
    - \( \theta_1 \) = angle of incident light
    - \( \theta_2 \) = angle of reflected light
    - \( N_1 \) and \( N_2 \) are refractive indices
Birefringence

- When a material produces more than one angle of refraction, it is said to be birefringent
- Pure diamonds are not birefringent
- Diamonds with stresses are birefringent
- Using this property we can determine whether or not a diamond is pure
Birefringence

No refraction at normal incidence
When the incident angle $\theta_i = 0^\circ$, the transmitted angle $\theta_t = 0$
Transmitted light $T$ goes straight through

$n_1 > n_2$

$n_2 > n_1$
Birefringence

No refraction at normal incidence
When the incident angle $\theta_i = 0^\circ$, the transmitted angle $\theta_t = 0$
Transmitted light T goes straight through
(R’s not shown)
Birefringence

No refraction when incident light is along the optical axis
the transmitted angle $\theta_t = 0$
Transmitted light $T$ goes straight through
(R’s not shown)
Birefringence

No refraction when incident light is along the optical axis
the transmitted angle $\theta_t = 0$
Transmitted light $T$ goes straight through

(R’s not shown)
Calcite CaCO₃
An EM wave that is off the optic axis of a calcite crystal splits into two waves called ordinary and extraordinary waves. These waves have orthogonal polarizations and travel with different velocities. The o-wave has a polarization that is always perpendicular to the optical axis.

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Birefringence

A line viewed through a cubic sodium chloride (halite) (optically isotropic) and a calcite crystal (optically anisotropic)
Birefringence

- When a material produces more than one angle of refraction, it is said to be birefringent
- Pure diamonds are not birefringent
- Diamonds with stresses are birefringent
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Formula
Causes of Birefringence in Diamond

- Dislocations
- Lattice Parameter Variations
- Precipitates and Inclusions
- Fractures
- Plastic Deformation
Dislocation

extra net plane

direction of slip

dislocation core
Polarization

- Polarizers pass light of specific polarization while blocking light other polarizations
- Vertical polarizer blocks vertical component
- Horizontal polarizer blocks horizontal component
- Our project combines both to block out all light
(a) A linearly polarized wave has its electric field oscillations defined along perpendicular to the direction of propagation. The field vector $\mathbf{E}$ and define the plane of polarization.

(b) The electric field oscillations are contained in the plane of polarization. Linearly polarized light at any instant can be represented by the superposition of $E_x$ and $E_y$ with the right magnitude and phase.
Randomly polarized light is incident on a Polarizer 1 with a transmission angle θ1, and becomes linearly polarized light. Emerging from Polarizer 1 is linearly polarized light, polarized at angle θ1. A second Polarizer 2 (called "analyzer") with a transmission axis parallel to TA1. A detector measures the intensity of the incident light at TA2, which is normal to the direction.
Randomly polarized light is incident on a Polarizer 1 with a transmission angle $\Theta_1$ and becomes incident on Polarizer 2 (called "analyzer") with a transmission axis $TA_2$ to $TA_1$. The detector measures the intensity of the transmitted light $TA_2$. © 1999 S.O. Kasparov, *Optoelectronics* (Prentice Hall)
Stress Detection

- A stressed diamond is birefringent
- Light passing through pure diamond means camera detects no light
- Light passing through birefringent diamond means camera detects light
- Compare light intensities
Diamond
• Basic Birefringence
• Birefringence is caused from stress