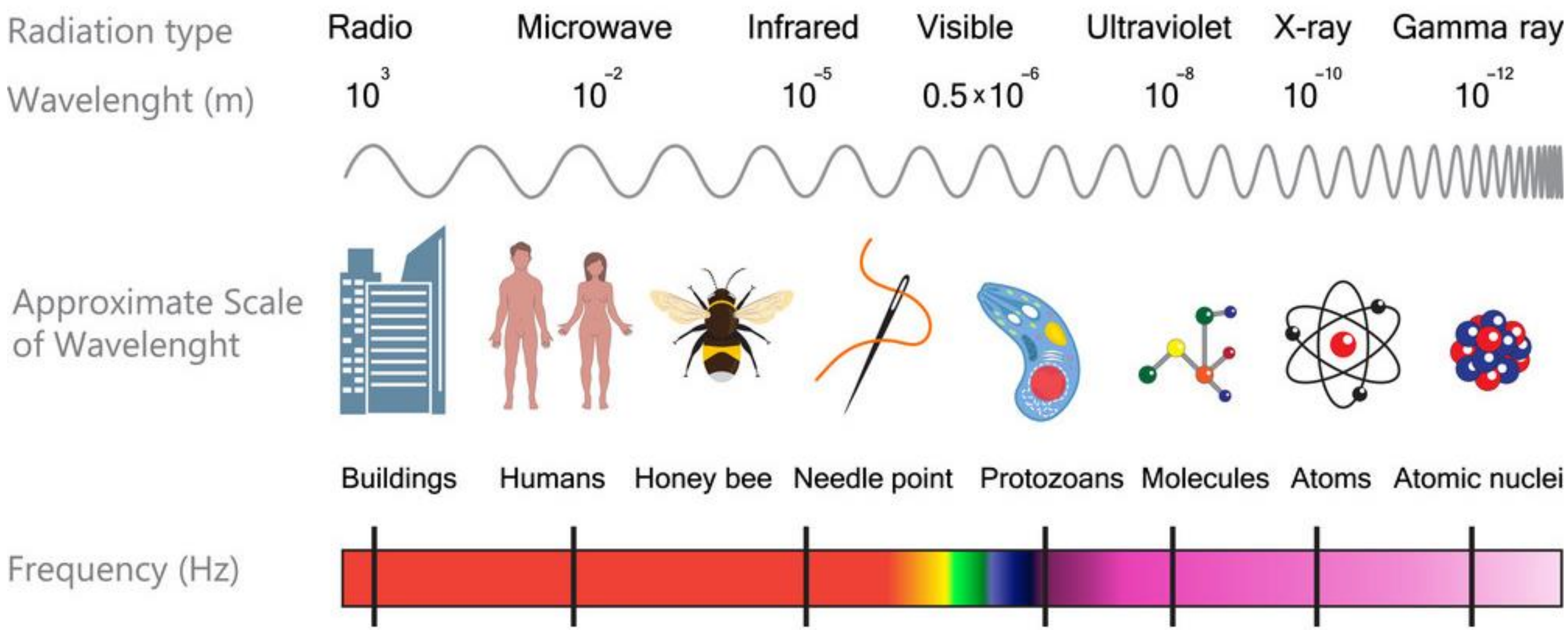
Photonic or Optical materials

Electromagnetic spectrum



$$E = \mathrm{h}v = \frac{\mathrm{h}c}{\lambda}$$

E: Energy of the photon

v : Frequency

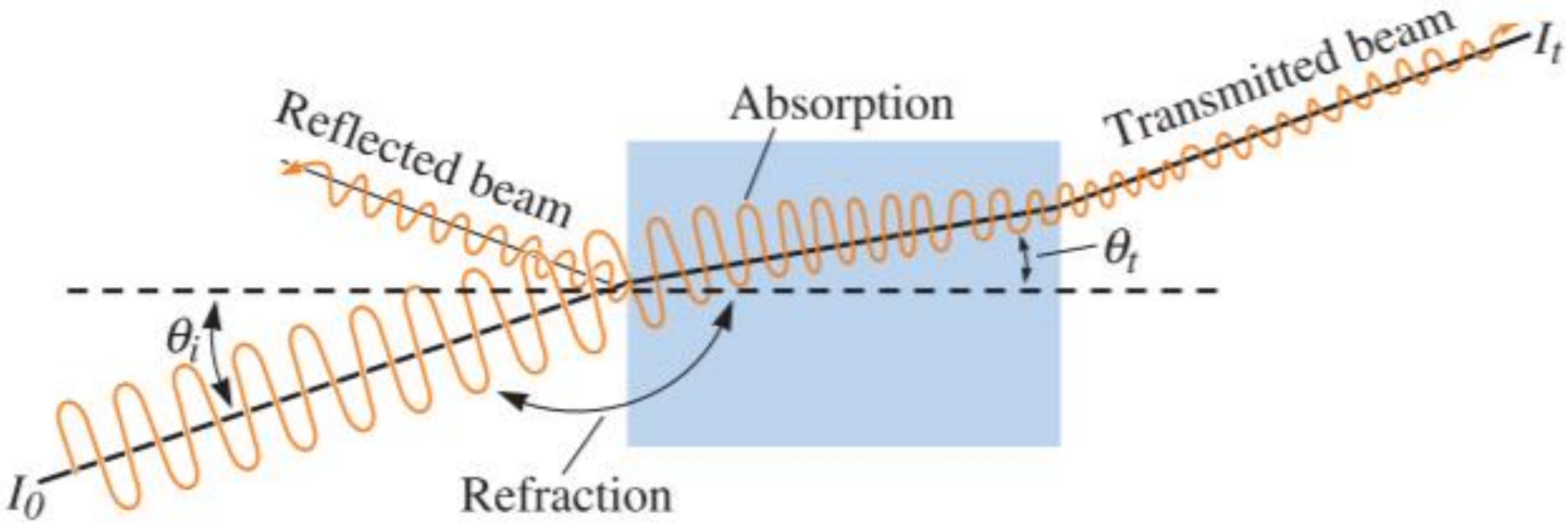
λ : Wavelength

c: Speed of light

h: Planck’s constant

h: $(6.626 \times 10^{-34}\mathrm{J} \cdot s \text{ or } 4.14 \times 10^{-15}\ eV \cdot s)$

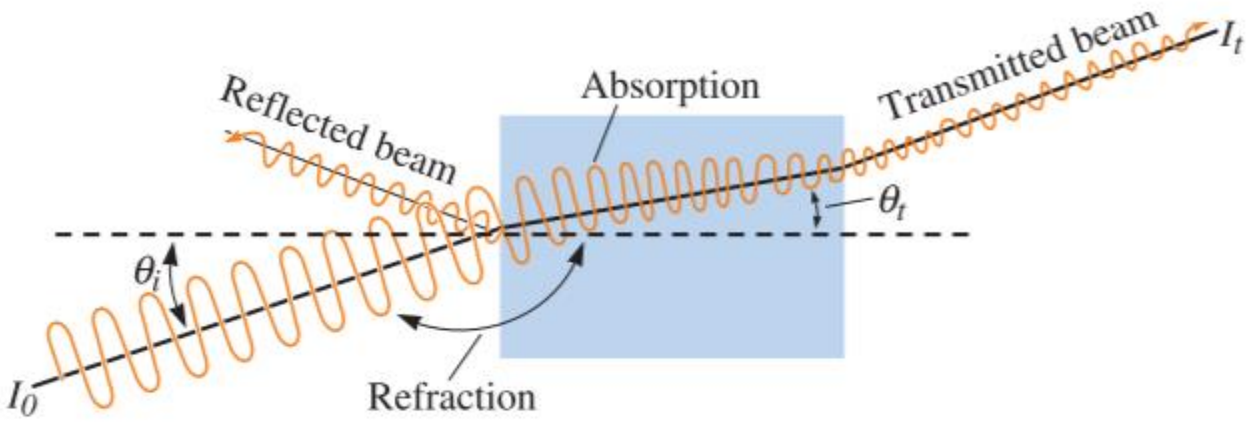
c_0: $3 \times 10^{10} cm/s$



I: Intensity (Watts/m^2)

$$I_0 = I_r + I_a + I_t$$

$$I_0 = I_r + I_a + I_t$$



Refraction

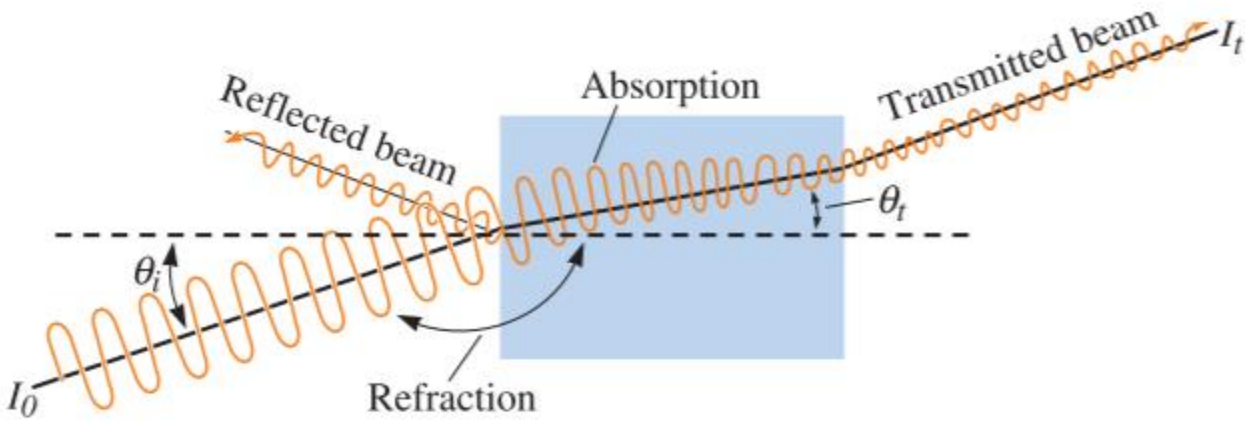
This refers to the bending of a light beam as it passes from one material into another.

The index of refraction is therefore a consequence of electrical polarization, especially electronic polarization

n: refraction index
c: Speed of light
c_0: Speed of light in vacuum
λ : Wavelength
θ_i: Incidence angle
θ_t: Transmitted angle

$$n = \frac{c_0}{c} = \frac{\lambda_{vacuum}}{\lambda} = \frac{\sin\theta_i}{\sin\theta_t}$$

$$I_0 = I_r + I_a + I_t$$



Refraction

n: refraction index
c: Speed of light
c_0: Speed of light in vacuum
λ : Wavelength
θ_i: Incidence angle
θ_t: Transmitted angle
μ: magnetic permeability
ε: Electrical permittivity
k: dielectric constant

$$n = \frac{c_0}{c} = \frac{\lambda_{vacuum}}{\lambda} = \frac{\sin\theta_i}{\sin\theta_t}$$

$$c = \frac{1}{\sqrt{\mu\varepsilon}} \quad ; \quad n = \frac{\sqrt{\mu\varepsilon}}{\sqrt{\mu_0\varepsilon_0}} = \sqrt{k}$$

Snell's law

$$\frac{c_1}{c_2} = \frac{n_2}{n_1} = \frac{\sin\theta_i}{\sin\theta_t}$$

$$I_0 = I_r + I_a + I_t$$

Reflection

Reflection occurs at the interface between two materials and is therefore related to index of refraction.

After the e- interact with photons, the energy released from the electron will have the same frequency of the initial photon.

In vacuum or air

$$R = \left(\frac{n-1}{n+1}\right)^2$$

Other materials

$$R_i = \left(\frac{n-n_i}{n+n_i}\right)^2$$

R: Reflectivity
n: refraction index

$$I_r = RI_0$$

$$I_0 = I_r + I_a + I_t$$

Absorption

The beam that is not reflected can be either absorbed or transmitted.

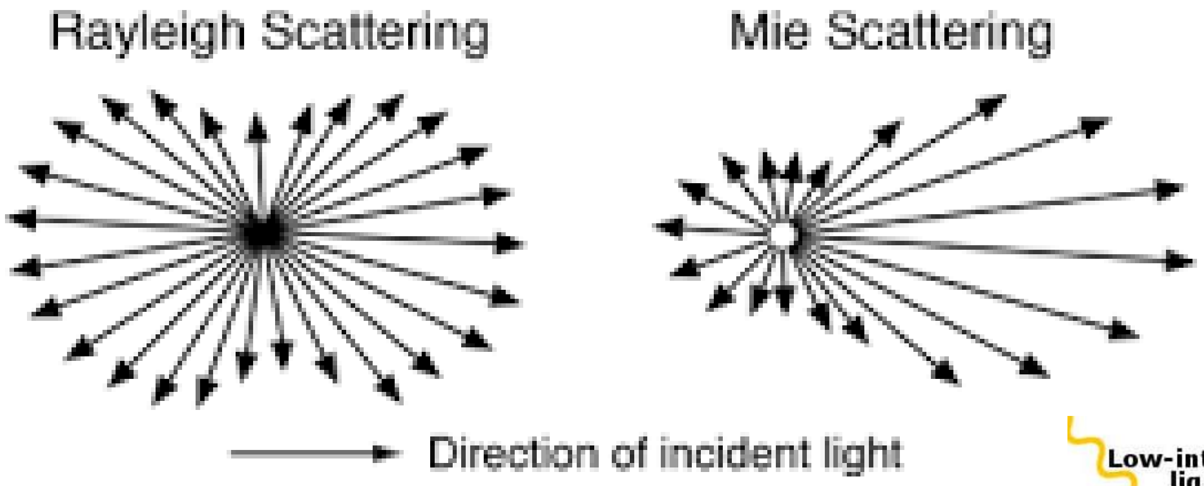
Depends on the thickness and the specific material.

$$I = I_0 e^{-\alpha x}$$

I: intensity of the beam at the end of the material.
I_0: intensity of beam after reflection
α:linear absorption coefficient
x: photon’s path

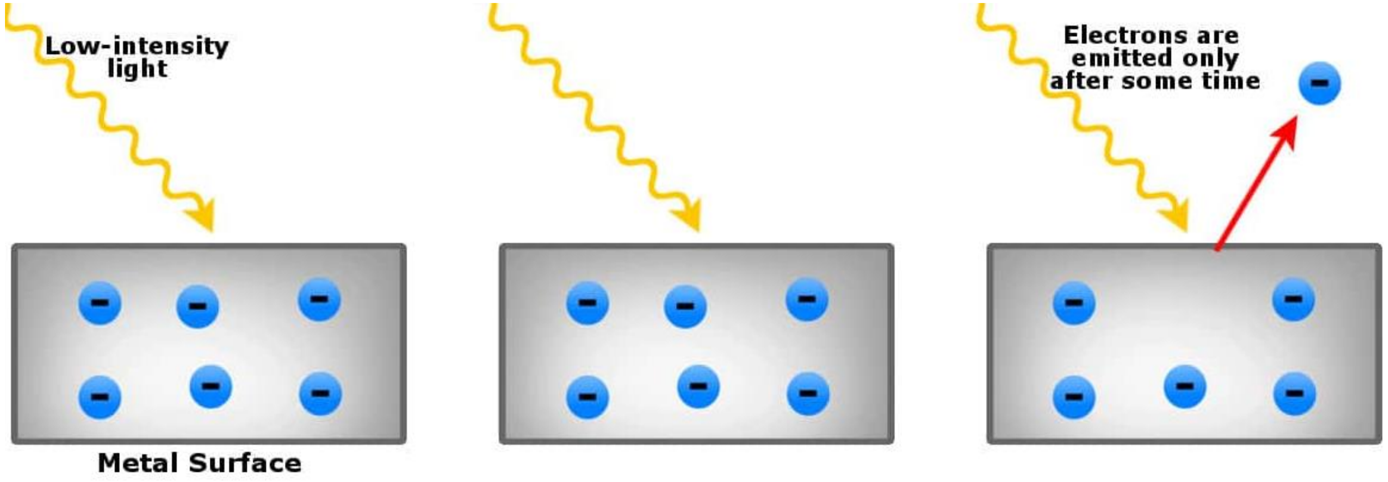
$$I_0 = I_r + I_a + I_t$$

Absorption



Scattering

Photoelectric effect



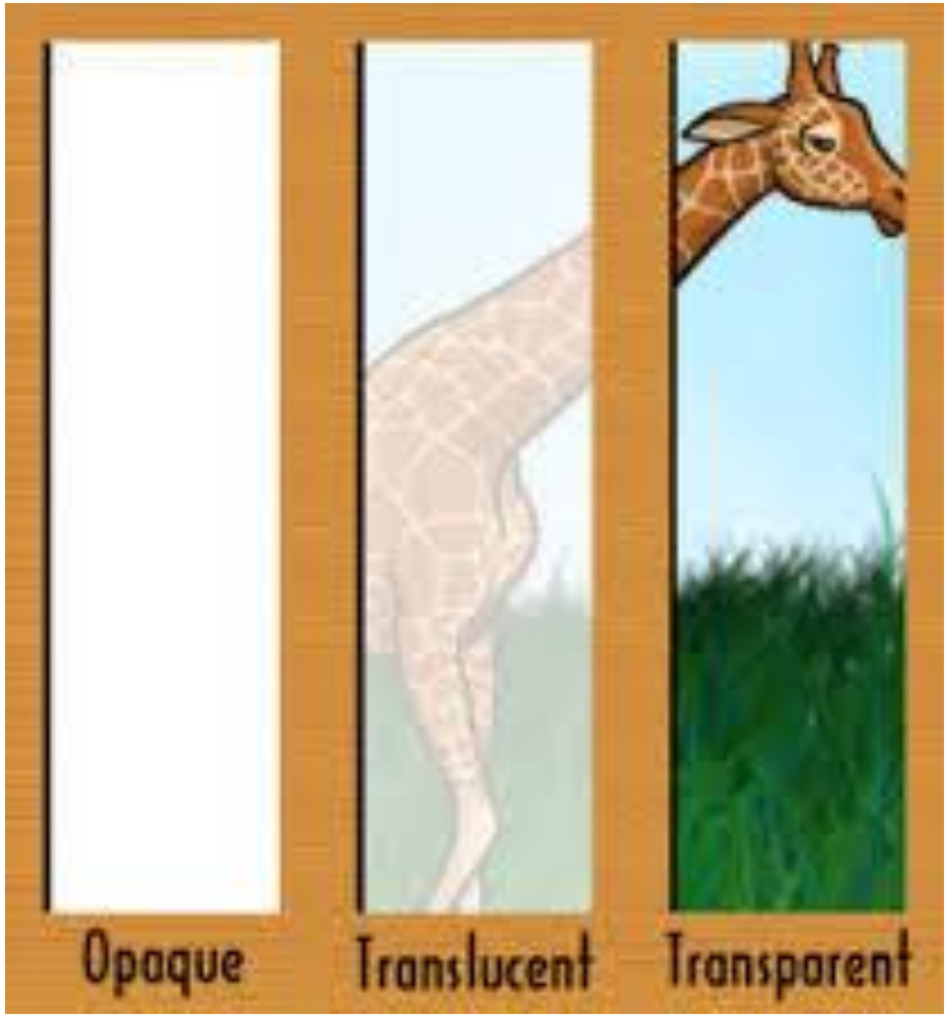
$$I_0 = I_r + I_a + I_t$$

Absorption

Transparent: relatively little absorption and reflection.

Translucent: light scattered within the material.

Opaque: relatively little transmission.



$$I_0 = I_r + I_a + I_t$$

Transmission

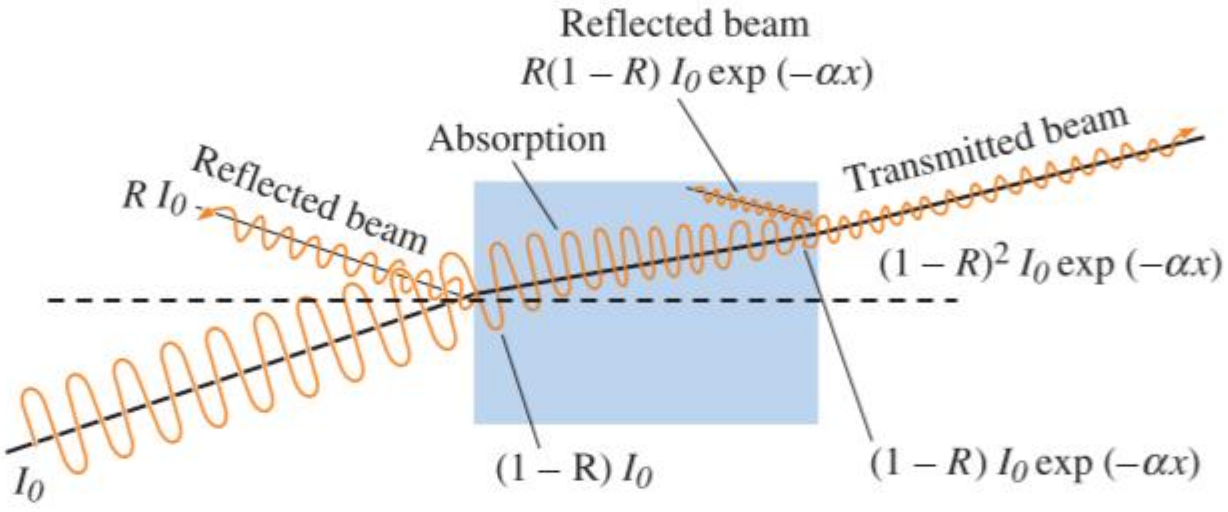
The beam that comes through at the end of the material.

Depends on the properties of the material and the photon's wavelength:

1. Microstructure
2. Presence of different phases
3. Porosity
4. Band gap

$$I_0 = I_r + I_a + I_t$$

Transmission

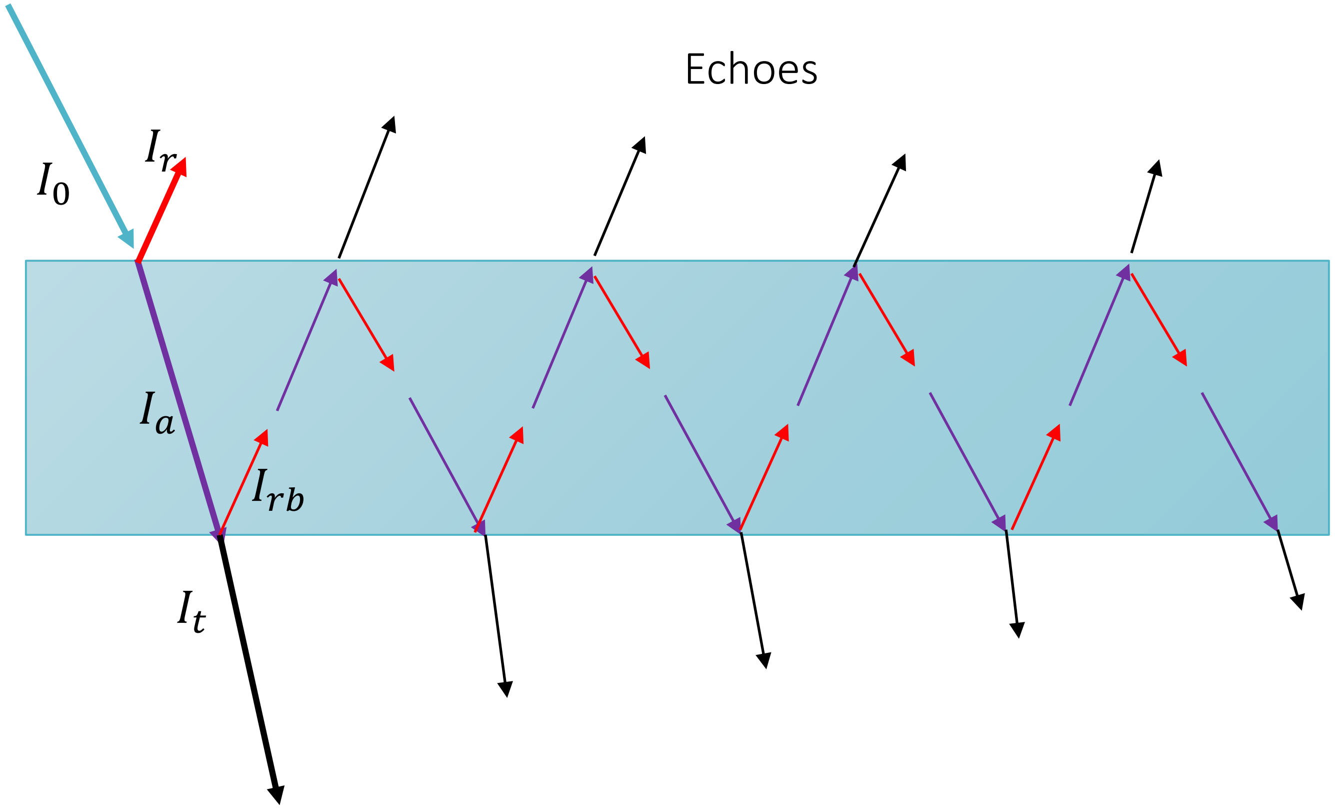


1. After reflection $\mathrm{I}_1 = (1-R)I_0$
2. After absorption $I_2 = I_1 e^{-\alpha x} = (1-R)I_0 e^{-\alpha x}$
3. Tacking into account the reflected beam $I_{rb} = RI_2 = R(1-R)I_0\, e^{-\alpha x}$
4. The difference between the absorbed and the reflected back

$$I_t = (1-R)I_0 e^{-\alpha x} - R(1-R)I_0\, e^{-\alpha x}$$

$$I_t = (1-R)^2\, I_0\, e^{-\alpha x}$$

$$I_0 = I_r + I_a + I_t$$



$$I_0 = I_r + I_a + I_t$$

$$1 = R + A + T$$

$$R = \frac{I_r}{I_0} = \left(\frac{n-1}{n+1}\right)^2$$

$$A = 1 - (1-R)e^{-\alpha x}$$

$$T = (1-R)^2 e^{-\alpha x}$$

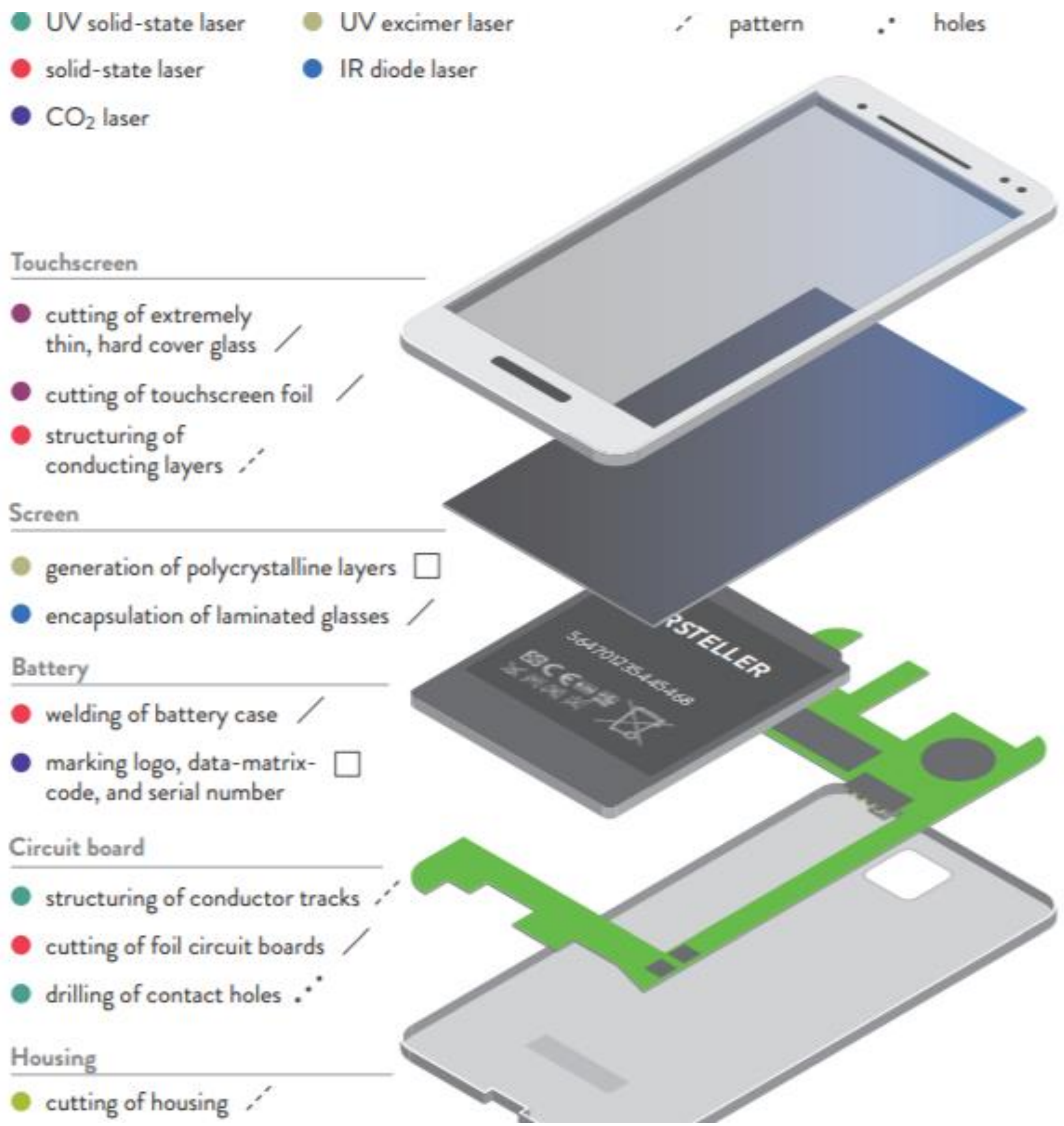
$$T = 1 - R - A$$

Applications

- Production technology
- Data transfer
- Image capture and display
- Medical technology
- Photovoltaics

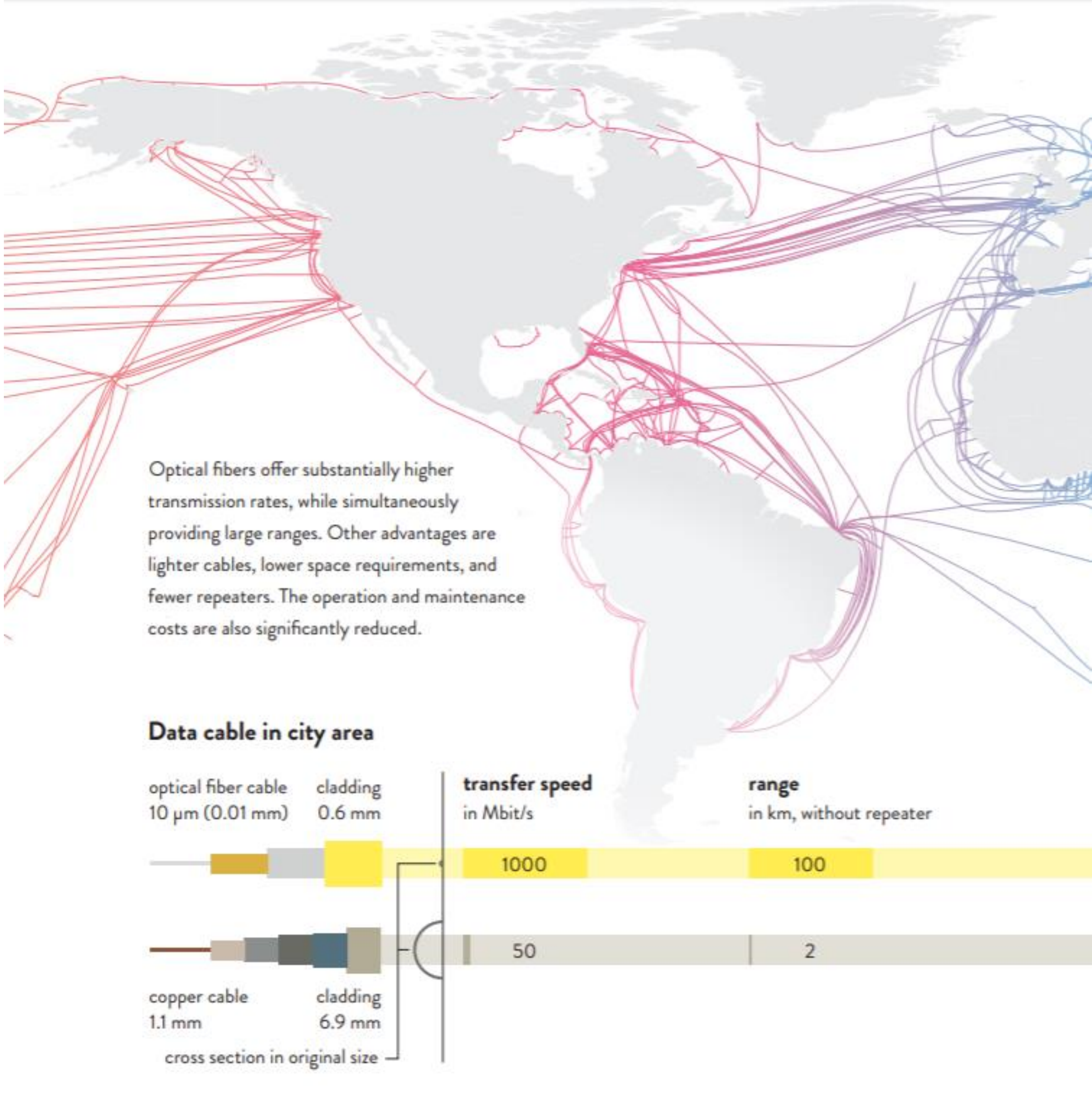
Applications: Production technology

SMARTPHONES THANKS TO THE LASER



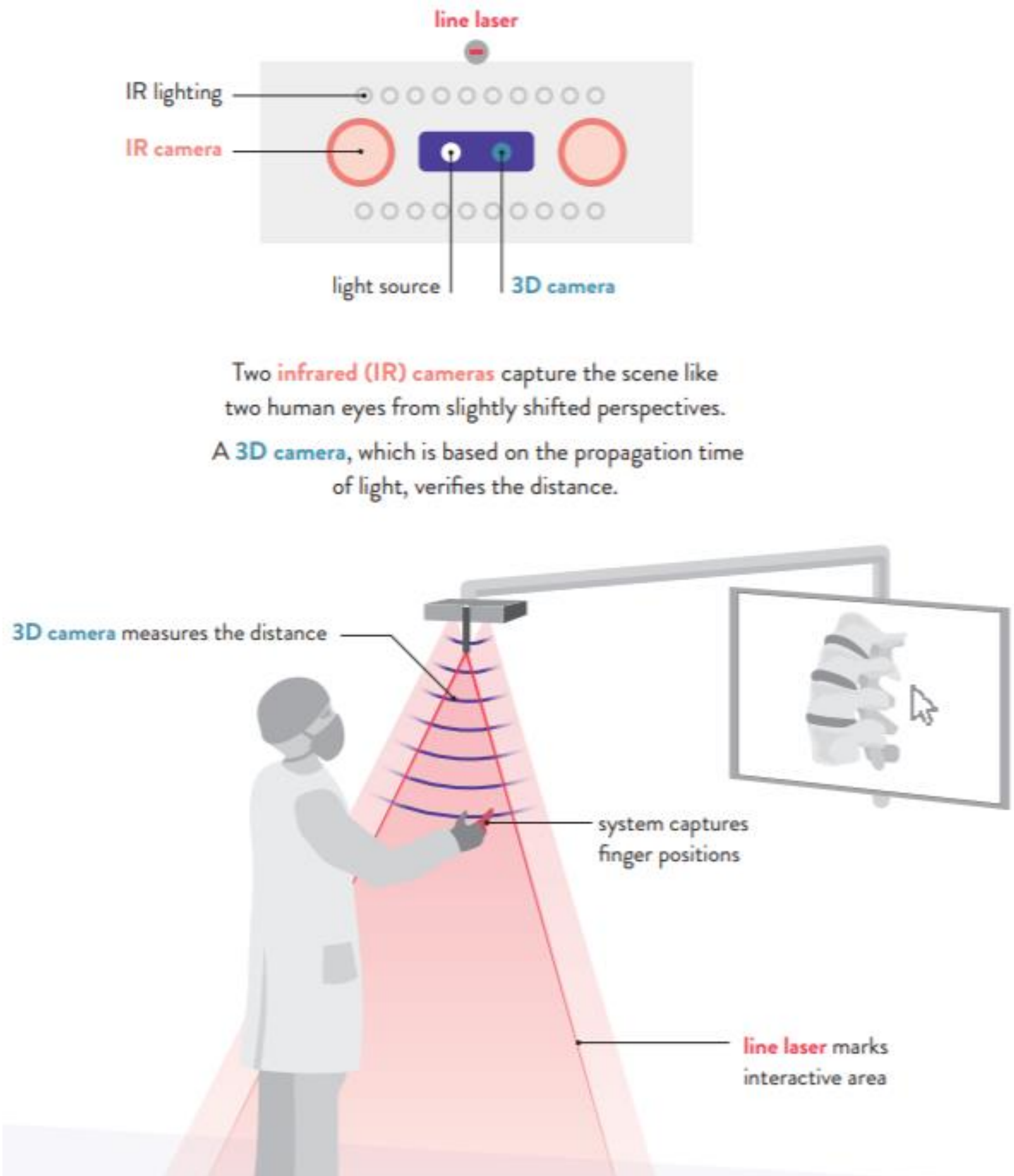
Applications: Data transfer

OPTICAL CABLES



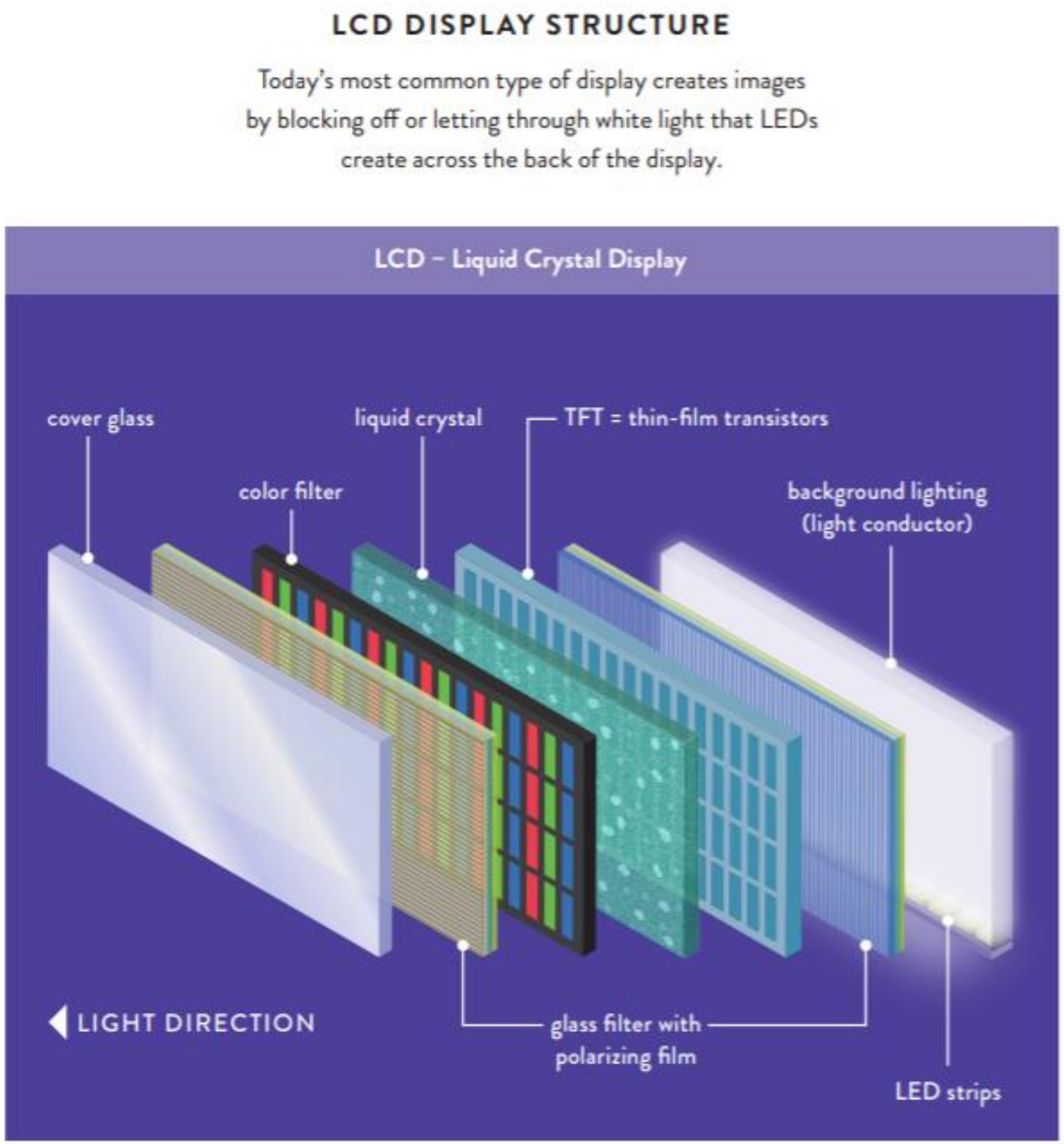
Applications: Image capture and display

GESTURE CAPTURE



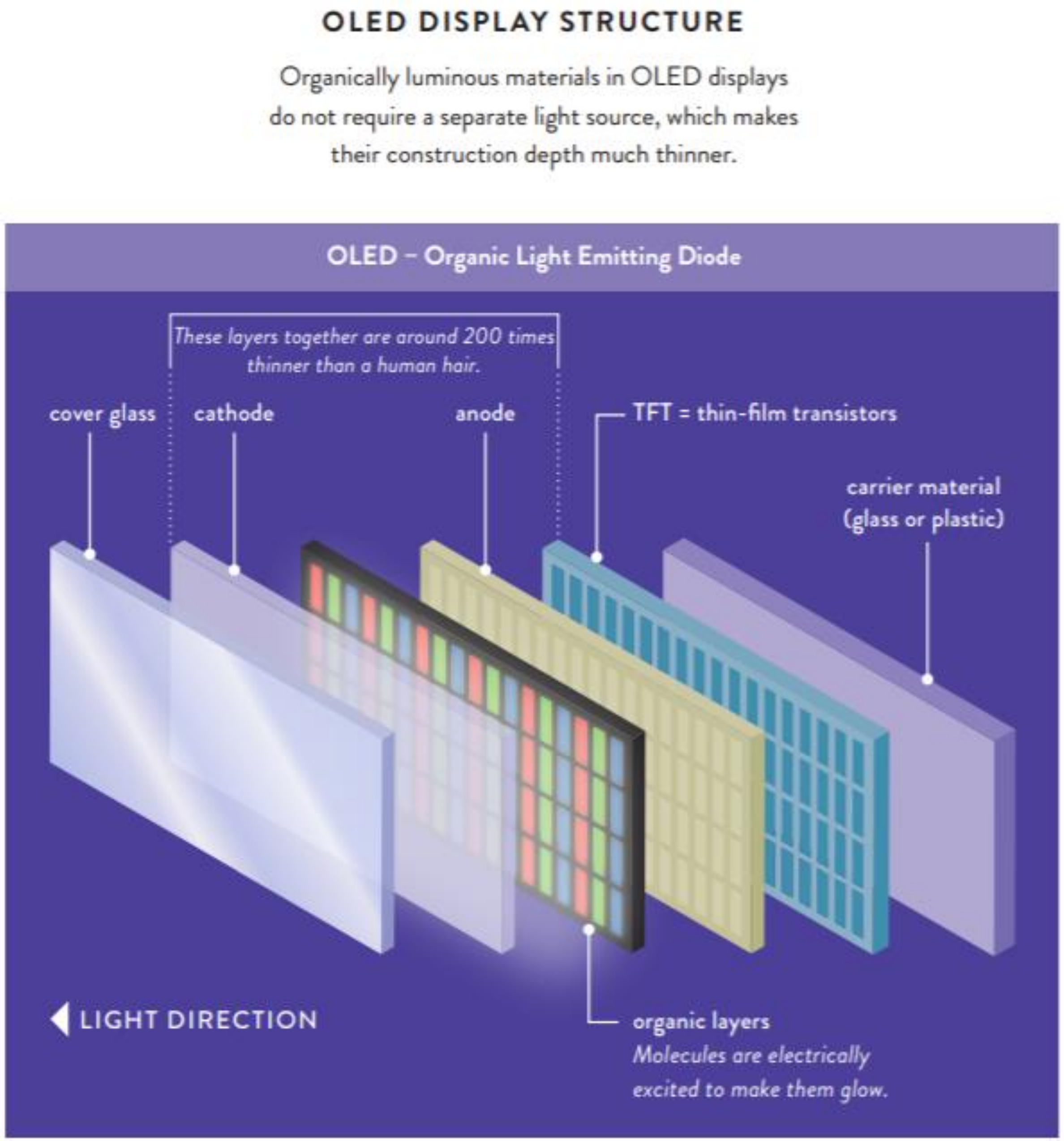
Applications: Image capture and display

LCD Vs O-LED



Applications: Image capture and display

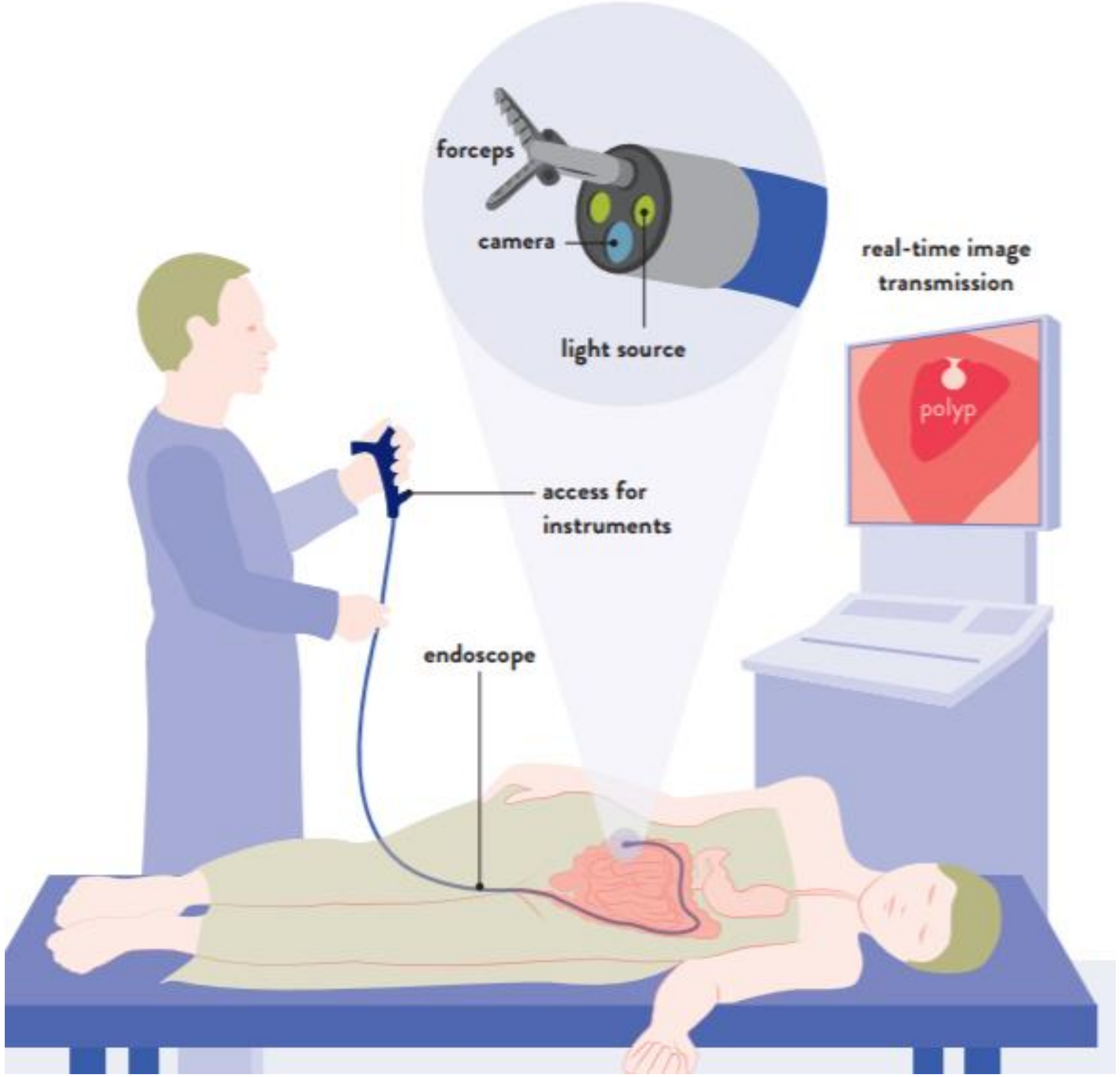
LCD Vs O-LED



Applications: Medical technology

ENDOSCOPY

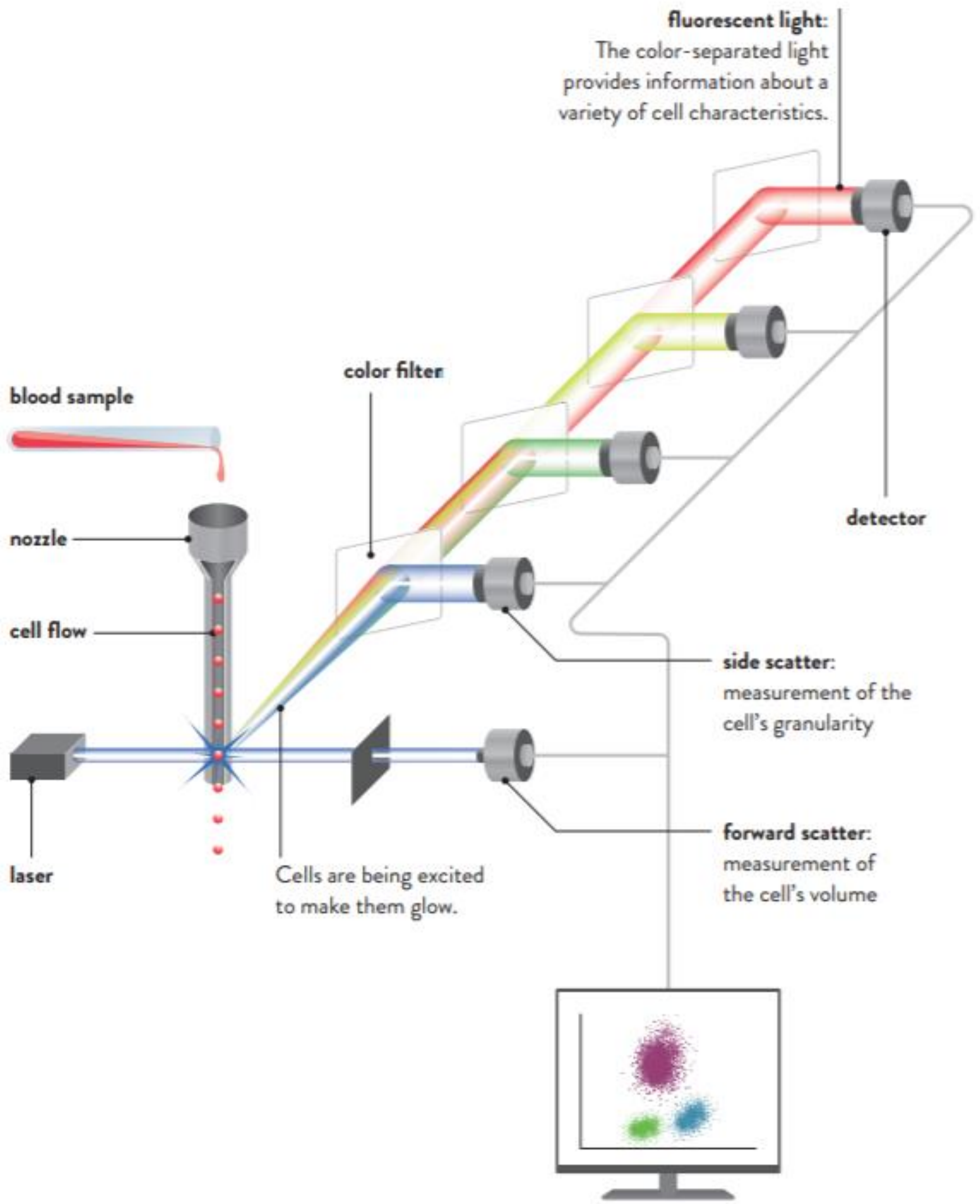
Endoscopes enable doctors to examine body cavities and hollow organs, detect illnesses, and treat them with minimal invasion at the same time, if required. The tubes, which are only a few millimeters thick, transfer illumination in one direction and high-resolution images in real time in the other direction.



Applications: Medical technology

BLOOD CELL COUNTS

Thousands of cells per second are counted and characterized in medical and biotechnical analytics with laser-based flow cytometry. This enables the fast and secure detection of blood anomalies.



Applications: Photovoltaics

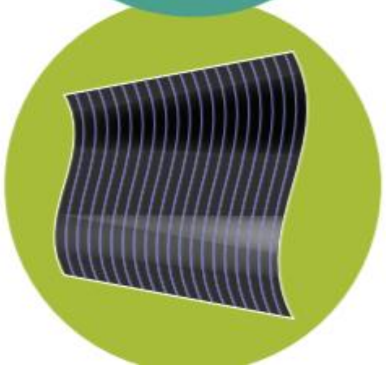
SOLAR CELLS

Solar cells can transform sunlight directly into electricity. An efficiency of around 45% has already been achieved under laboratory conditions. In commercial use, efficiency has to be weighed against acquisition costs.

BASIC COMMERCIAL TYPES

Monocrystalline silicon cells are cut out from a round silicon crystal. The missing corners of the squares are characteristic. This form is created because the round cross section of the raw material is exploited in the best possible way.

Polycrystalline silicon cells feature a characteristic texture that comes from crystal borders that are very close together.



Thin-film cells consist of amorphous silicone or other material compounds. They can be vapor deposited onto carrier materials, even onto flexible material.