THErganize in terms of its optical properties and its function within the system. Below I list the key materials and components, along with code in MATLAB that defines these materials with relevant optical properties.

1. Components and Materials of the LIDAR System

- **laser source**:
  - Material: **laser diode** (generally based on **gallium arsenide (GaAs)** the **gallium phosphide (GaP)**).
  - Properties: Wavelength, output power.
- **Lenses and collimators**:
  - Material: **Optical glass** (For example, **BK7** the **quartz**).
  - Properties: Refractive index, dispersion coefficient.
- **Photonic detector**:
  - Material: **Photodiode** of **silicon (Yes)** the **InGaAs** (galium arsenide and indium).
  - Properties: Sensitivity, spectral response.
- **Mirrors and prisms**:
  - Material: **coated aluminum** the **metal oxides**.
  - Properties: Reflectivity, absorption.

2. Code in MATLAB

Below is an example of how you could define these materials and their properties in MATLAB. The code is flexible so you can add more details based on your analysis of the optical components:

```
% Define materials and components of the LIDAR system

% 1. Laser Source: Gallium Arsenide Diode (GaAs)
laser_material = struct();
laser_material.name = 'GaAs';
laser_material.wavelength_nm = 905;   % Wavelength in nanometers (905
nm typical for LIDAR)
laser_material.power_mW = 100;        % Laser output power in
milliwatts

% 2. Lens: BK7 Optical Glass
lente_material = struct();
lente_material.name = 'BK7 Glass';
lens_material.refractive_index = 1.5168;  % Refractive index at 589
nm
lens_material.dispersion = 0.008;         % Dispersion coefficient
```

```
% 3. Photodetector: Silicon Photodiode (Si)
detector_material = struct();
detector_material.name = 'Silicon Photodiode';
detector_material.sensitivity_A_W = 0.6;   % Sensitivity in
Amperes/Watt
detector_material.response_range_nm = [400, 1100]; % Spectral
response range in nm

% 4. Reflective mirror: Coated aluminum
mirror_material = struct();
espejo_material.name = 'Aluminum Coated Mirror';
mirror_material.reflectivity = 0.90;       % Mirror reflectivity
(90%)
mirror_material.absorption = 0.05;         % Material absorption

% 5. Prism: Metal Oxide
prisma_material = struct();
prisma_material.name = 'Oxide-coated Prism';
prism_material.refractive_index = 1.65;   % Typical refractive index
for oxide prisms
prisma_material.reflection_coefficient = 0.95; % Reflection
coefficient

% Display the material structure
disp('LIDAR system components and their properties:');
disp(laser_material);
disp(lens_material);
disp(detector_material);
disp(material_mirror);
disp(prisma_material);

% Possible simulations
% Example: Calculation of total laser energy projected onto the
photodetector
% Assuming minimum distance and attenuation

distance_m = 100;  % LIDAR operating distance in meters
attenuation = 0.01;  % Attenuation by atmosphere (hypothetical)

% Power received in the photodetector (simplification)
received_power_mW = laser_material.power_mW *
mirror_material.reflectivity * (1 - attenuation);
disp(['Power received by the photodetector: ',
num2str(power_received_mW), ' mW']);
```

3. Code Description

- The code defines several key components of the LIDAR system, assigning physical properties to each. For example:
  - **Laser Source**: It has properties such as wavelength and power.
  - **Glasses**: It is defined by its refractive index and dispersion.
  - **Fotodetector**: Its sensitivity and spectral range are specified.
  - **Mirrors and prisms**: They are defined by their reflectivity and absorption properties.
- Then, a simple simulation is made of the calculation of the power that reaches the photodetector after passing through the reflecting mirror, considering attenuation.

4. Extensions

- You can extend this code to include more details about light transmission, atmospheric dispersion, or optical filters.
- You can use MATLAB functions to perform more advanced optical simulations, such as the propagation of light waves and interaction with materials.

This approach will allow you to both document the materials and simulate how they will work in your design.

1. Additional components in a LIDAR system

- **Laser**:
  - We add more relevant properties such as quantum efficiency and thermal resistance.
- **Glasses**:
  - We describe different types of lenses and materials used in laser beam collimation.
- **Photonic detectors**:
  - We analyze how a photodetector behaves depending on the intensity and wavelength received.
- **reflective materials**:
  - We incorporate more types of reflective coatings and mirrors, such as **multilayer dielectrics** and **metal mirrors**.
- **Optical filters**:
  - We add filters to control the passage of certain wavelengths.

2. More detailed MATLAB code

This code incorporates new properties for the materials and adds equations to simulate how these components interact with each other:

```
% Define detailed materials and components for the LIDAR system

% 1. Laser Source: Gallium Arsenide Diode (GaAs)
laser_material = struct();
laser_material.name = 'GaAs';
laser_material.wavelength_nm = 905;   % Wavelength in nanometers
laser_material.power_mW = 100;        % Output power in milliwatts
laser_material.efficiency_quantum = 0.75;  % Laser quantum efficiency
laser_material.thermal_resistance = 10;    % Thermal resistance in
degrees per watt

% 2. Lens: BK7 Optical Glass or Fused Silica
lente_material = struct();
lente_material.name = 'Fused Silica';
lens_material.refractive_index = 1.458;  % Refractive index at 500 nm
lente_material.dispersion = 0.005;        % Dispersion coefficient
lens_material.abbe_number = 67.82;       % Abbe number for color
dispersion

% 3. Photodetector: Silicon (Si) or InGaAs Photodiode
detector_material = struct();
detector_material.name = 'InGaAs Photodiode';
detector_material.sensitivity_A_W = 0.9;  % A/W sensitivity for InGaAs
detector_material.response_range_nm = [900, 1700]; % Response range in
nm
detector_material.dark_current_nA = 5;    % Dark current in nanoamperes

% 4. Reflective mirror: Multilayer dielectric
mirror_material = struct();
espejo_material.name = 'Multilayer Dielectric Mirror';
mirror_material.reflectivity = 0.99;      % Reflectivity (99%)
mirror_material.absorption = 0.01;        % Material absorption

% 5. Prism or filters: Optical filters for controlling wavelengths
filtro_material = struct();
filtro_material.name = 'Band-pass Filter';
filter_material.center_wavelength_nm = 905;  % Central wavelength in nm
filter_material.bandwidth_nm = 10;           % Bandwidth in nm
filter_material.transmittance = 0.95;        % Filter Transmittance

% 6. Optical fibers for laser signal transmission
fibra_material = struct();
fibra_material.name = 'Single-mode Fiber';
fiber_material.core_diameter_um = 9;      % Core diameter in
micrometers
```

```
fibra_material.numerical_aperture = 0.12;  % Numerical fiber opening

% 7. Metal mirror: Aluminum or silver mirror
metallic_mirror = struct();
metallic_mirror.name = 'Silver-coated Mirror';
metal_mirror.reflectivity = 0.95;       % Reflectivity of silver mirror
metal_mirror.thermal_conductivity_W_mK = 429;  % Thermal conductivity
of silver

% Display the material structure
disp('Advanced lidar system components:');
disp(laser_material);
disp(lens_material);
disp(detector_material);
disp(material_mirror);
disp(filter_material);
disp(fibra_material);
disp(metal_mirror);

% Advanced simulations
% Example: Calculate the overall efficiency of the system considering
losses in the mirrors and filters

% Initial laser power
initial_power_mW = laser_material.power_mW;

% Loss in reflective mirror
power_after_mirror_mW = initial_power_mW *
mirror_material.reflectivity;

% Loss in optical filter
power_after_filter_mW = power_after_mirror_mW *
filter_material.transmittance;

% Laser quantum efficiency applied to output power
effective_power_mW = power_after_filter_mW *
laser_material.efficiency_quantum;

% Show results
disp(['Final power in the system after mirror reflection and passing
through the filter: ', num2str(effective_power_mW), ' mW']);
```

3. Description of added properties

- **Laser (GaAs)**:
  - **Quantum efficiency**: Proportion of electrical energy converted into light.
  - **Thermal resistance**: Indicates how the laser handles the heat generated.
- **Lens (Fused Silica)**:
  - **Abbe's number**: Measurement of chromatic dispersion in optical material.

- **Photodetector (InGaAs)**:
  - **dark current**: Current produced by the detector in the absence of light, which affects the sensitivity of the system.
- **Reflective mirror (multilayer dielectric)**:
  - **Reflectivity**: Percentage of reflected light based on multi-layer design, highly efficient for LIDAR applications.
- **Optical filters**:
  - **band pass filter**: Allows a specific range of wavelengths to pass while blocking others, ideal for isolating the desired laser light.
- **Optical fibers**:
  - **Singlemode fiber**: Allows the precise transmission of light beams in communication systems or high-precision lasers.
- **Metal mirror (silver)**:
  - **Thermal conductivity**: Very high in silver, which allows the heat generated by the light reflected in the mirror to be dissipated.

4. Future expansions

- **Design optimization**: You can implement functions in MATLAB to optimize system performance by adjusting material properties, such as laser wavelength or lens refractive indices.
- **Thermal modeling**: MATLAB can help you simulate the thermal behavior of optical materials during laser operation, important to ensure the stability of the LIDAR system under extreme conditions