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# Filter Advancements for Automotive Sensing

## Epic Online Meeting on LIDARs on Chips


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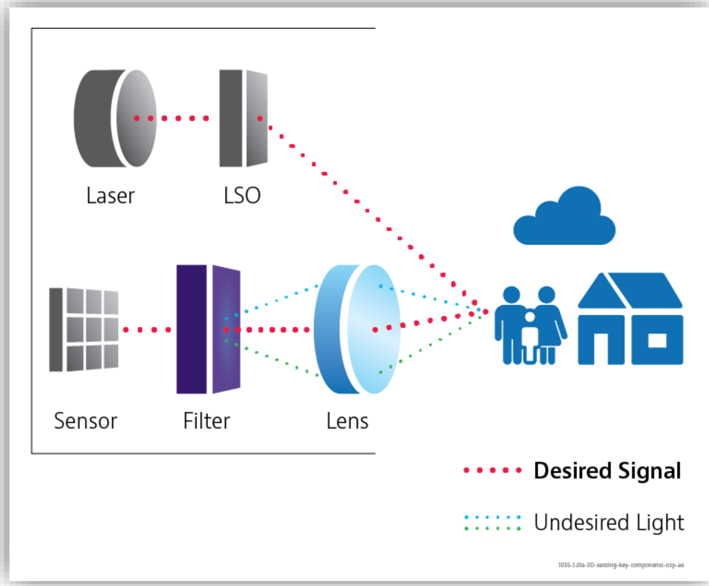
# Key Components in a 3D Sensing System

Key NIR Sensor Components:

- Light source (Laser)
- Lens system
- Filters

Each of these components must be matched to each other in an optimized design for optimal performance (maximize efficiency and signal-to-noise ratio)



# Viavi Low Angle Shift (LAS) Filters with Si:H

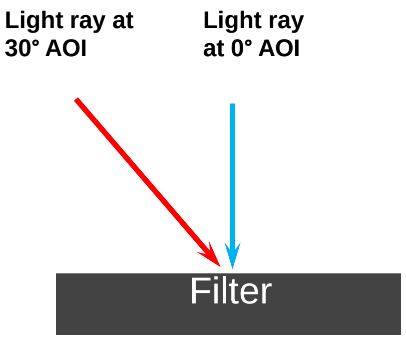
# Viavi Filters Constructed with Hydrogenated Silicon

## Hydrogen in amorphous Si moves the absorption edge lower into the low NIR wavelengths

- Usable transmission down to ~800nm

## The refractive index (n) of Si:H is 3.5 – 3.7 allows for:

- **#1:** Lower cost and higher performing NIR optical filters
  - cost is function of layers and thickness
- **#2:** Reduces blue shift for light rays at increasing angles of incidence (AOI)
  - Blue shift follows this equation




**AOI = angle of incidence**

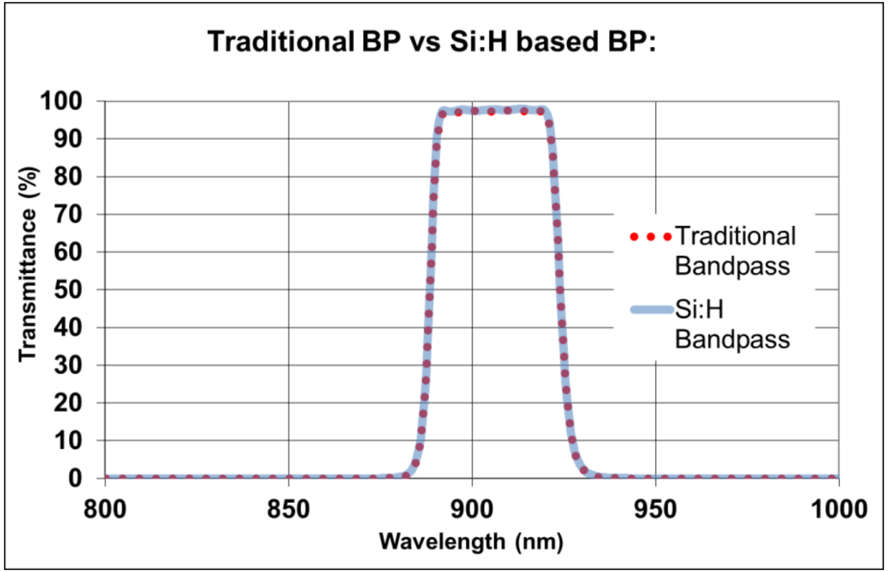
$$\lambda(\theta) = \lambda_0 \sqrt{1 - \left(\frac{\sin\theta}{n_{eff}}\right)^2}$$

# Benefit #1: Enables a Lower Manufacturing Cost

**Compared to bandpass filters constructed with traditional materials, filters made with Si:H can enable:**

- Filters at a lower cost
  - Si:H filters require less layers & thickness
  - cost is function of layers and thickness

| Materials: | # of Layers: | Coating thickness: |
|---|---|---|
| Traditional | 52 | 8.2um |
| Si:H | 28 | 3.2 |



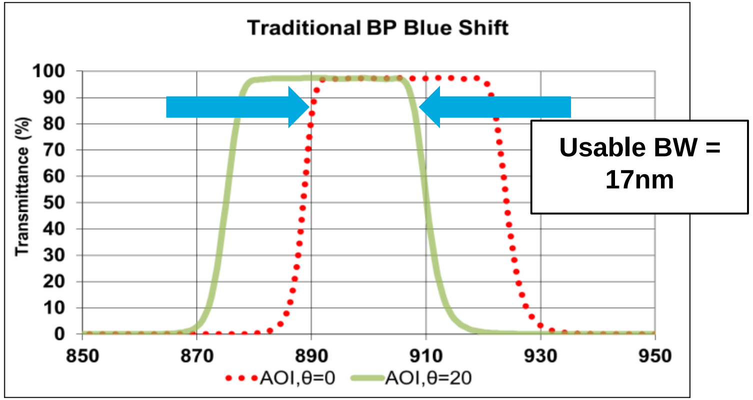
# Benefit #2: Enables a Lower Blue Shift

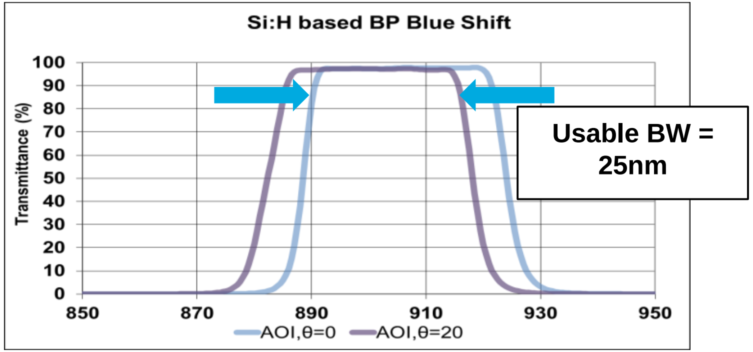
**Compared to bandpass filters constructed with traditional materials, filters made with Si:H can enable:**

- Less blue shift:
  - increases the usable BW
  - decreases the required overall BW

| Materials: | CWL Blue Shift: | Usable BW at T = 90% | Total BW at T = 50% |
|---|---|---|---|
| Traditional | -13 nm | 17 nm | 49 nm |
| Si:H | -5 nm | 25 nm | 41 nm |

***Filters with less BW have better signal to noise***



# Filters for Automotive Sensing - Other Trends

**NIR optical bandpass filters in automotive sensing need even narrower bandwidths to improve signal to noise**

Solutions that enable this:

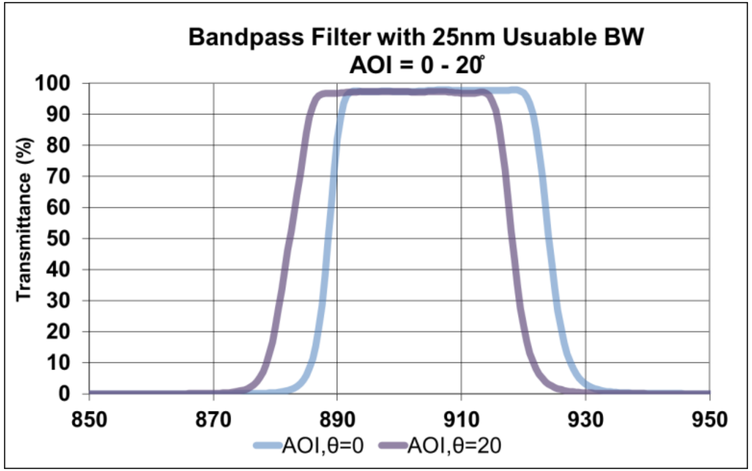
- Binning filters and lasers with matched center wavelengths
- Improving manufacturing tolerances

# Example: Filter Bandwidth with Typical Specifications

Lasers such as EELs and VCSELs have a CWL distribution due to manufacturing variations

- for VCSEL and EEL these commonly range from +/-5nm to +/10nm at 9xxnm

| Example for Common Specs: | | |
|---|---|---|
| **Factor:** | **Spec:** | **Filter BW to meet spec** |
| **Laser CWL specs** | **905 +/-6nm** | **12nm** |
| **Filter CWL specs** | **905 +/- 4nm** | **8nm** |
| **Total bandwidth required for these specs** | | **20nm** |




***Without binning, the entire laser tolerance must be considered in the BW of the filter***

# Example: Filter Bandwidth w/ Binning & Tight Tolerances

1. Bin the laser by sorting into +/-2nm bins - Filter BW can be reduced by 8nm
2. Bin the filter with tight CWL tolerances – Filter BW can be further reduced by 4nm

**Binning Example**

| Factor: | Bin #1 | Bin #2 | Bin #3 | Bin #4 |
|---|---|---|---|---|
| Laser CWL specs | 899 +/- 2nm | 903 +/- 2nm | 907 +/- 2nm | 911 +/- 2nm |
| Filter CWL specs | 899 +/- 2nm | 903 +/- 2nm | 907 +/- 2nm | 911 +/- 2nm |
| Total bandwidth required | 8nm | 8nm | 8nm | 8nm |

***The necessary filter BW is reduced by 12 nm! (60% narrower)***

- ***Sensor performance is improved***
- ***Cost is manageable with advanced filter production methods***

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*Thanks for your attention!*

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