# Dichroic Beamsplitters

Application Notes

CVI Optical Components and Assemblies

## 1. Configurations and Terminology

Dichroic beamsplitters are used to combine or separate beams of two different wavelengths. An **LWP** long wave pass dichroic beamsplitter always transmits the longer wavelength and reflects the shorter wavelength. An **SWP** short wave pass dichroic beamsplitter transmits the shorter wavelength and reflects the longer wavelength.

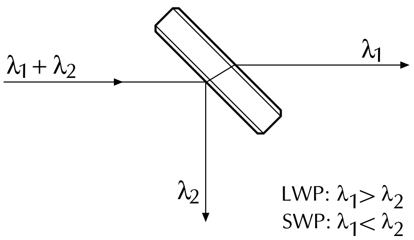


*Figure 1. Dichroic beamsplitter used as a beam separator. A beam with two wavelengths $\lambda_1$ and $\lambda_2$ is divided into separate, monochromatic beams. Generally $\lambda_1$ and $\lambda_2$ represent wavelength ranges. The user should be aware that it is easier to reflect with high efficiency.*

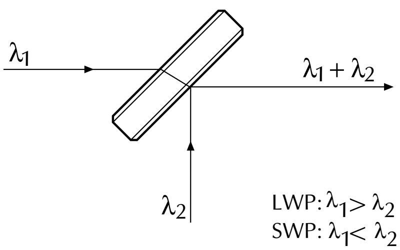


*Figure 2. Dichroic beamsplitter used as a beam combiner. This configuration is very common in nonlinear wave mixing and laser pumping experiments.*

Dichroic beamsplitters are also frequently used at normal, or near normal incidence. One very common application is in laser pumping. Usually, the pumping wavelength $\lambda_P$ is shorter than the lasing wavelength $\lambda_L$. Therefore, an **SWP** short wave pass dichroic beamsplitter is used to admit the pump beam into the laser cavity with high efficiency. Often, the **SWP** is curved since it is part of the laser resonator. Two examples are shown in Figures 3 and 4.

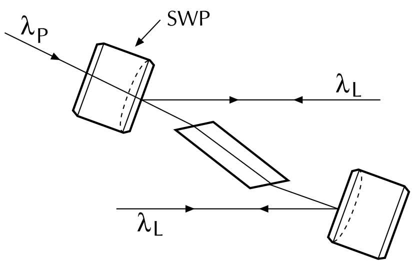


*Figure 3. Curved SWP dichroic beamsplitter used as a cavity mirror. Pump light $\lambda_P$ passes through the SWP mirror, pumping the laser rod. $\lambda_L$ represents the circulating intracavity laser power. A near-normal folded cavity design is used.*

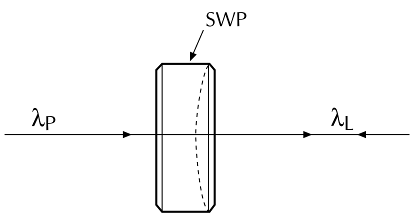


*Figure 4. Direct axial pumping using curved SWP dichroic beamsplitter as an end mirror.*

## 2. Bandwidth Considerations

The region of high reflectivity and low transmission of a dichroic beamsplitter is called the stop band. The region of high transmission is called the pass band. The region between these bands is called the transition region. The stop band and pass band of a 0° dichroic beamsplitter are labeled in Figure 5.

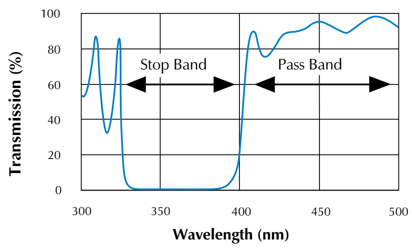


*Figure 5. The stop band and pass band of an LWP dichroic beamsplitter for use at normal incidence.*

The bandwidth of the stop band is similar to that of a laser mirror. For the **SWP** and **LWP** Series Dichroic Beamsplitters, the approximate bandwidths can be found by consulting the tables for the **TLM1** Narrowband Laser Mirrors.

Note that the transition region cannot be made infinitely sharp, and that there is some "ringing" in the pass band. Because of this, there may be a trade off between the reflectivity and transmission specifications possible when specifying a dichroic beamsplitter. Your CVI technical sales repersentative will be happy to assist you in determining an optimum design for your experiment.

## 3. Polarization Considerations

Below are graphs of transmission vs. wavelength for **SWP** and **LWP** dichroic beamsplitters at 45°.

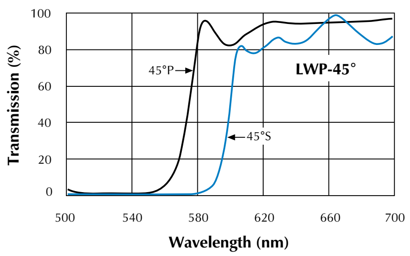


*Figure 6. LWP dichroic beamsplitter with transition region near 580nm.*

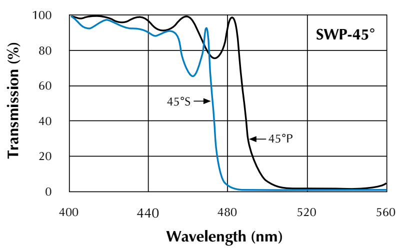


*Figure 7. SWP dichroic beamsplitter with transition region near 480nm.*

In each case, the region of high reflectivity for S polarized light is appreciably broader than for P polarized light. There is also generally more passband "ringing" for S polarized light at 45°, resulting in reduced average transmission for this polarization.

## 4. Suggestions When Specifying Dichroic Beamsplitters

The following is a general rule to be followed when combining or separating polarized laser beams at 45° incidence angle. Use of this rule becomes increasingly important as the reflected and transmitted wavelength bands move closer together spectrally.

**Polarization Rule For 45° Beamsplitters**

| | | |
|---|---|---|
| Best: | Reflect 45°S | Transmit 45°P |
| 2nd Best: | Reflect 45°P | Transmit 45°P |
| 3rd Best: | Reflect 45°S | Transmit 45°S |
| Avoid: | Reflect 45°P | Transmit 45°S |

The first choice maximizes both transmission and reflectance bandwidth while the second choice maximizes transmission bandwidth. The third choice maximizes reflection bandwidth and the fourth choice should be avoided unless the two wavelength bands in question are far enough apart.

The next rule concerns efficiency. Sometimes, it is most important to capture every available photon at one wavelength. An example is the common situation of preserving all the energy in a harmonic beam that is buried in a powerful beam at a longer wavelength. A contrasting situation occurs when it is more important to eliminate as many photons as possible at an interfering wavelength, even at the expense of losing some of the photons at the desired wavelength. This situation occurs when your signal is "large", but the obscuring beam is very powerful. The following rule, which handles both cases, follows from the fact that it is easy to make a dichroic beamsplitter with R > 99.5%, but it is often hard to guarantee T > 90%:

**Efficiency Rules For Dichroic Beam Separation**

When Absolute Efficiency at One Wavelength is Most Important, Reflect that Wavelength and Transmit the Other.

When Spectral Purity at One Wavelength is Most Important, Transmit that Wavelength and Reflect the Other.

Finally, a general rule is:

For Best Overall Transmission, prefer An **LWP** Over An **SWP** Dichroic Beamsplitter.

The origin of this rule pertains to there being generally less pass band "ringing" and problems with harmonic effects with **LWP** dichroic beamsplitters.

Your CVI technical sales representative will be happy to assist you in specifying dichroic beamsplitters. CVI stocks a wide selection of these beamsplitters based on an analysis of repeatedly requested specifications.