Effect of Peak Transmission on Performance of Optical Coatings and Interference Filters

Optical interference filters and optical coatings in general are one of the highest efficiency products made. Most optical thin film coatings have energy loss of less than one part per million, and many significantly less in the region of application.

In comparison to other devices and components this is impressive. Mechanical devices have quite limited efficiencies. A typical fossil fuel power plant can achieve about 42%. An internal combustion engine might reach 35%. An ideal wind turbine can achieve about 59%, and a solar panel 11 to 15% when the source is unlimited. Even LEDs with high quantum efficiency are only about 5% external efficiency.

With an optical coating or filter, efficiency is realized by the ability to pass the desired energy, while rejecting the unwanted portion (wavelengths). Not only do optical coatings and filters do this very effectively, but they can perform the requirements to a level of anywhere from a thousand to one to a billion to one in the desired direction.

Often consideration is given to the absolute peak transmission. Often requests are for values greater than 90% and at times for more than 99%. There are times when these high values are needed, either for the absolute minimum in acquisition time, or for the limitations when any absorption loss can result in catastrophic temperature rise. Otherwise, the moderate requirement of 80% throughput is probably indistinguishable in practice.

Most typical of a specification on a filter's throughput will be bounded by the Full Width at Half Maximum (FWHM) and the required minimum transmission. A tolerance on the FWHM is typically $\pm$20% of the value. This tolerancing allows an energy throughput to vary by 40%, so a limitation on peak transmission becomes inconsequential when comparing 80% to 95%.

The largest contributing factor to peak transmission is the optical matching of the substrate to the incidence medium. When a coating is used in air, the peak achievable throughput (transmission) of a protected coating is about 92% due to the Fresnel reflection losses at the two interfaces. When the coatings are on the outer surface of an optic, this loss can be dramatically reduced. This translates to a realistic value of 80% for protected coatings, and roughly 90%+ for surface coated sets of long and short pass coatings, needed to provide the final passband.

Signal to Noise is a most meaningful metric. To know this value, it is necessary to fully understand the nature of the source and detector, as their relative response will dramatically influence the ratio. Often, the noise is at a narrow region of the full spectral range of sensitivity of the detector. In these cases, this detail should be clearly communicated. Due to this complexity, a most meaningful input on a request for an ideal spectral solution is the details of the detector and the nature of the source, and other background. Note that on our Contact Request Form, we try to solicit as much information as is possible.

With a complete understanding of the source and detector, it is often quite possible to dramatically reduce the cost of an ideal solution.