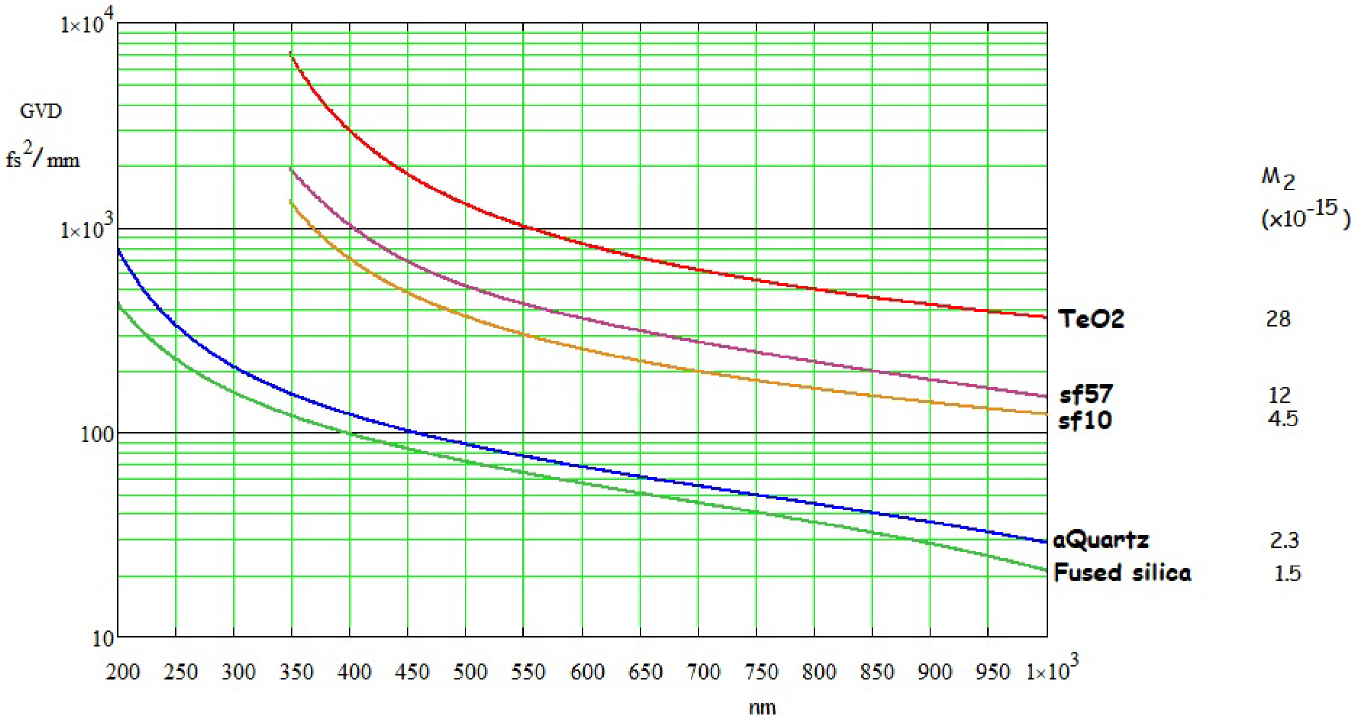
Pulse stretching in AO devices.

The plot below illustrates the Group Velocity Dispersion (GVD) data for some of the common AO materials used in Isomet AO modulators, pulse pickers and deflectors. GVD is the characteristic used to determine how the crystal medium will affect the duration of an optical pulse traveling through it. This is key consideration for AO applications involving ultrafast lasers where pulse durations are down in the femtosecond region.

To determine the temporal distortion effects and chromatic dispersion, the crystal optical path length for the AO device of interest must be known. This information is typically provided on the AO data sheet. As a rule of thumb, the optical path length in typical VIS-NIR AO devices is in the region of 10-25mm.



The M_2 figures on right hand vertical axis = the AO figure of Merit at ~1um.

It illustrates one compromise that is required. Low GVD crystals have poor figure of merit which in turn dictates relatively high peak RF drive powers.

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Short pulse width laser, Spatial and Temporally compensated AO Scanner.

Group velocity dispersion (GVD) is caused by index change with wavelength in physical material. For very short optical pulses (femtosecond region), the spectrum or frequency components will not travel at the same velocity through the material, distorting the pulse and lengthening it. GVD is defined as,

$$GVD(\lambda) = \frac{\lambda^3}{2 \cdot \pi \cdot c^2} \cdot \frac{d^2 n(\lambda)}{d\lambda^2}$$

c is light velocity in vacuum

n(λ) is material index as a function of wavelength

Group delay dispersion is the product of the total optical path length, L, in the dispersive material and GVD.

$$GDD(\lambda) = L \cdot GVD(\lambda)$$

A means to provide negative GDD that will cancel the dispersion is necessary to maintain the integrity of the extremely narrow pulse modulation. Using prisms, gratings or an AOM can produce the necessary effect.

For an AOM, the spectral frequency components are diffracted at various angles, i.e.,

$$d\theta = \frac{F \cdot d\lambda}{va}$$

It can be shown that as the spectral components after the AOM travel in directions proportional to wavelength, the effect creates a negative GDD.

$$GDD(\lambda) = \frac{-\lambda^3}{2 \cdot \pi \cdot c^2} \cdot \frac{F^2}{va^2} \cdot D$$

F is the frequency in the AOM

va the acoustic velocity

D is the distance from the AOM

When the sum of the positive and negative delay dispersions is zero, the pulse shape is restored.

The distance D then can be found as,

$$D = L \cdot \left(\frac{va}{F}\right)^2 \cdot \frac{d^2 n(\lambda)}{d\lambda^2}$$