Since a wedge acts like a prism, an angular chirp can be induced while the beams are passing through wedges. In Fig. 4, the angle of the transmitted beam with respect to an incident beam is calculated for a wedge angle of 2 degrees. The slope of the curve indicates the angular chirp C_a due to the optical property of fused silica,

$$C_a = \left| \left(\frac{\partial \varphi}{\partial \lambda} \right)_{\lambda_0} \right| \quad (1)$$

where φ is the propagation angle and λ is the wavelength in the vacuum. The angular chirp is 2.4 μrad/nm at 800 nm. The maximum angular spread for the current bandwidth (100 nm) is about 0.25 mrad, which is smaller than far-field beam divergence. The presence of angular chirp can be interpreted as a pulse front tilt. But a standard autocorrelator cannot measure the pulse front tilt except for the case of the inverted-field autocorrelator [14]. Still the angular chirp can affect the autocorrelation result via a bandwidth narrowing for each propagation direction. In our case, the bandwidth narrowing is only about 0.1%, which is practically negligible. However, the angular chirp significantly extends pulse duration around a focal position when the laser beam is focused for the second harmonic generation [14]. Thus the double wedge autocorrelator may not be appropriate to a weak laser beam which requires focusing to generate the second harmonic beam. The angular dispersion is proportional to the wedge angle and can be minimized by decreasing the wedge angle. However, the angle between multiple reflections also decreases so that it requires a longer propagating distance to distinguish the test beams from the other stray lights.

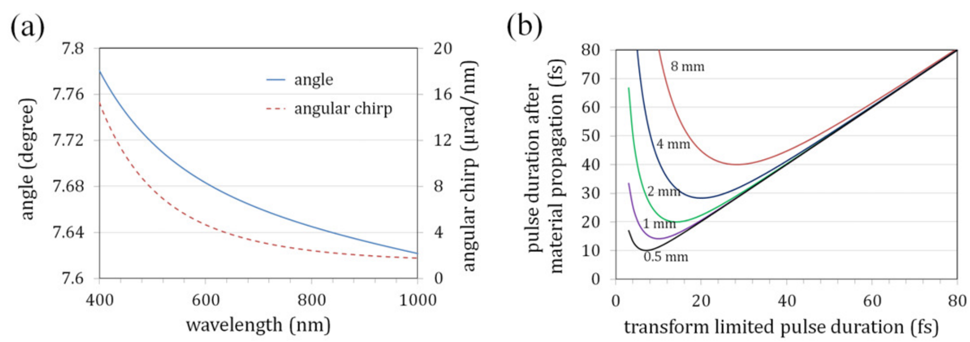

Fig. 4. (a) Wavelength dependence of propagation angle and angular chirp for a fused silica wedge pair ($\theta = 2°$) (b) Pulse durations after propagating through a fused silica window of various thickness

With respect to the measurement of a few-cycle laser pulse with an autocorrelator, one needs to consider the material dispersion introduced by propagating through an optical medium such as a beam splitter. In the double wedge autocorrelator, each beam passes 4 times through a wedge. To reduce or get rid of dispersion introduced by wedges, one can reduce the thickness of the wedge or place a proper chirped mirror to compensate the positive dispersion. If a thickness of a wedge is 0.5 mm, which is commercially available, the overall propagation length through materials is about 2 mm. According to Fig. 4(b), this double wedge autocorrelator can approximately measure the pulse duration down to 20 fs without significant pulse broadening (< 10%). Thus, the double wedge autocorrelator can be properly used to measure a few-cycle pulse only with an aid of chirped mirrors, which eliminates a dispersion introduced by wedges. One may consider another variation of wedge autocorrelator, keeping the same concept of double wedge. The essence of the double wedge autocorrelator is not the wedge itself but the three interfaces with such an angled configuration. The problem of material dispersion can be avoided by using three thin pellicles instead of wedges. In this case, the angular dispersion also disappears completely as well.

4. Conclusions

We have presented the scanning autocorrelator using a double wedge, and measured the pulse duration of 28 fs by using the double wedge with a tilt angle of 2 degree. The double wedge replaces the Michelson interferometer in the conventional autocorrelator, so it provides compact and simple configuration for an autocorrelator. The angular chirp introduce by the double wedge is 1.3 μrad/nm and it has practically no influence to the autocorrelation measurement for the non-focusing case. By using 0.5 mm thickness wedges, one can measure the pulse duration down to 20 fs without significant pulse broadening.

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