UltraFast Innovations

YOUR KEY to innovation and success

Dispersive mirrors with reduced thermal lensing

In recent years, ultrafast high-energy oscillators and amplifiers have become ubiquitous in research labs as well as in a number of industrial applications. Some of the most promising applications include laser ablation and micromachining in industry, and high harmonic generation in research. However, the theoretical limits of the maximal achievable pulse energy from mode-locked oscillators have not been reached yet due to experimental and technical constraints. A major constraint is the thermal effect and consequent thermal lensing. Thermal lensing, in the worst cases, results in a different mode profile, slightly distorted mode and beam-pointing drifts, caused by a slow and time-dependent misalignment of the cavity. Therefore, cavity designs with negligible thermal effects are a promising solution.
Inside the cavities both the active medium and the intracavity optics exhibit thermal effects. While there is less room for avoiding thermal effects in the active medium, smart design of intracavity optics offers a way around.

High dispersive (HD) mirrors constitute one of the key components of nowadays ultrafast oscillators, with their performance significantly affecting that of the laser.
Benefitting from recent advances in dispersive multilayer mirror technology and extensive experience, UFI® has released a family of high dispersion, low losses mirrors with negligible thermal effects: HD73 and HD64. These novel HD mirrors have been successfully applied for power scalable Kerr-lens mode locking of an Yb:YAG thin-disk laser [1].

Key Product Features of HD73 & HD64

- Spectral coverage @1030 nm
- Average reflectance › 99.8% for HD73 and ›99.95% for HD64
- Average GDD of -3000 fs² (HD73) and -1000 fs² (HD64)

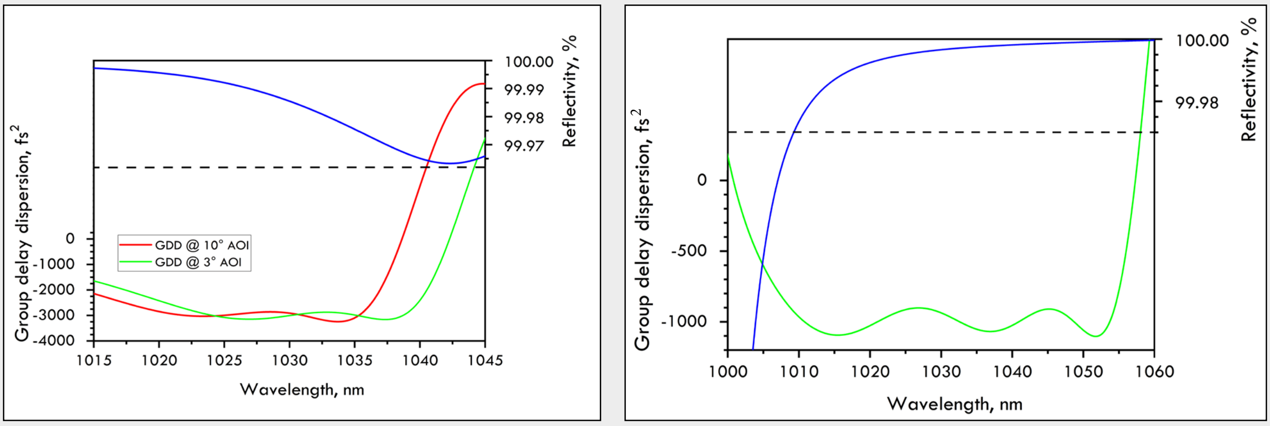

Fig. 1 High dispersion mirrors with low thermal lensing. Left: HD73 Right: HD64

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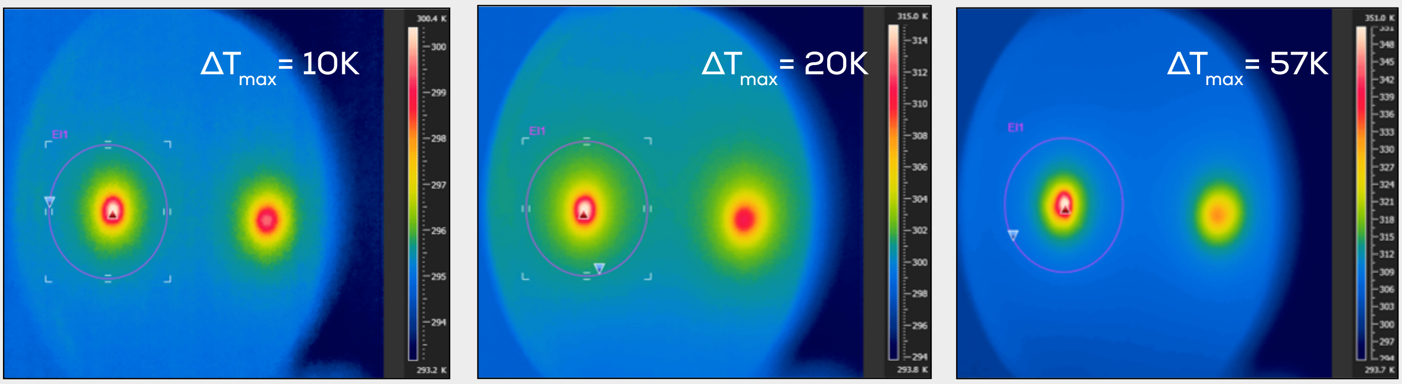
Dispersive mirrors with reduced thermal lensing – an experimental study

Different HD mirrors were experimentally studied and the presence of thermal effects was investigated. Typically, power-dependent effects start to appear at GDD values greater than -1000 fs². In Fig. 2 the surface temperature of different HD mirrors placed inside a cavity was measured in CW operation.

The measurements were done with an infrared camera (FLIR SC305) and indicate a certain temperature rise. The samples HD64 (-1000 fs²) and HD73 (-3000 fs²) exhibit a similar temperature rise of 10-20 K compared to the 298 K with no lasing, see Fig. 2 a and b. These mirrors show no noticeable temperature-dependent effects during oscillator operation. On the contrary, an "ordinary" HD mirror with -3000 fs² has a pronounced temperature rise of >50 K, causing the mode and the oscillator stability to deteriorate at high intracavity power, Fig. 2c.

High-reflectance mirrors (quarter- wave stack) typically exhibit much lower thermal lensing than HD mirrors.

To prove the reduced thermal lensing of our HD mirrors, a high-reflectance mirror made from the same alternating materials as the HD mirrors was examined. The temperature rise of 14 K [2] in comparison to the 10-20 K of the HD mirrors confirms once more the reduced thermal lensing property of the HD mirrors.



a) b) c)

Fig. 2 Analysis of the surface temperature of different HD mirrors inside a cavity in CW operation. The measurements reveal lower temperature gradients for the HD mirrors with low thermal lensing: a) HD64 (-1000 fs²), b) HD73 (-3000 fs²), compared to c) an "ordinary" HD mirror with -3000 fs²/bounce.

References:

[1] O. Pronin, J. Brons, C. Grasse, V. Pervak, G. Boehm, M.-C. Amann, V. L. Kalashnikov, A. Apolonski, and F. Krausz, "High-power 200 fs Kerr-lens mode-locked Yb:YAG thin-disk oscillator," Opt. Lett. **36**(24), 4746–4748 (2011).

[2] O. Pronin "Towards a Compact Thin-Disk-Based Femtosecond XUV Source", Dissertation an der Fakultät für Physik der Ludwig-Maximilians-Universität, München, 2012.