Characterization and simulation of an integrated optical pulse shaper

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The optical performance of an integrated microoptical pulse shaper was simulated and verified experimentally [1]–[3]. Figure 1 illustrates the PIFSO-based (planar-integrated free-space optics) design, which consists of a folded 8f-system. Due to its symmetry, the design is self-compensating for certain aberrations.

Fig. 1: Microoptical pulse shaper in PIFSO-technology using an 8f setup with four reflective lenses.

These are, in part, caused by fabrication errors. In our case, the part with the four lenses was fabricated by using ultraprecision micromachining. The lenses were characterized by optical interferometry (Fig. 2). The interferograms indicate centro-symmetric aberrations.

Fig. 2: Profile of the sag deviation of the four parabolic mirrors. The overall deviation is $+1\ \mu m$ to $-0.5\ \mu m$.

The data from the measurement of the lens profiles were transferred to standard Zernike coefficients $(m, n)$ that here are significant for astigmatism $(2/2, -2, 2, 3, 3)$ and coma $(1, 3)$. Then a ray-tracing simulation model calculated the effect of the fabrication errors. In the computer simulation, we used the separation distance $d$ of the two substrates (Fig. 1) as a parameter.

Fig. 3: Simulation results: Input beam with constant phase profile (left). After adjustment (right) the phase deviation is less than $\pi$.

By varying $d$, it was possible to find an optimized configuration where the influence of the fabrication errors could be essentially compensated (Fig. 3). Tests with the real system confirmed this result.