High Frequency Homogenization of Laser Illumination Through Stationary Multimode Optical Fiber.

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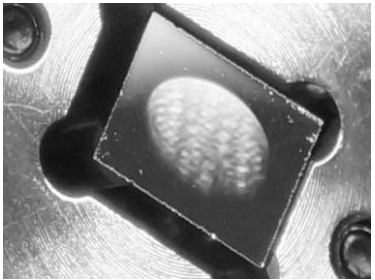
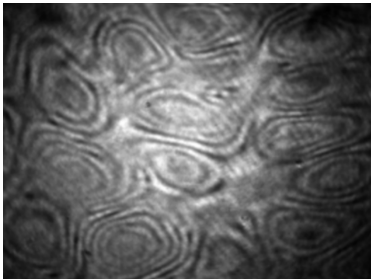
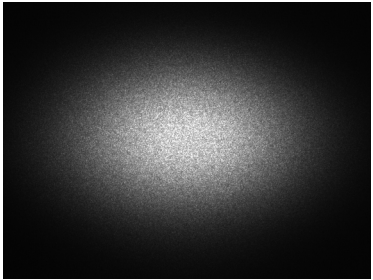
DYOPTYKA deformable mirror technology



Randomly-distributed surface deformations.



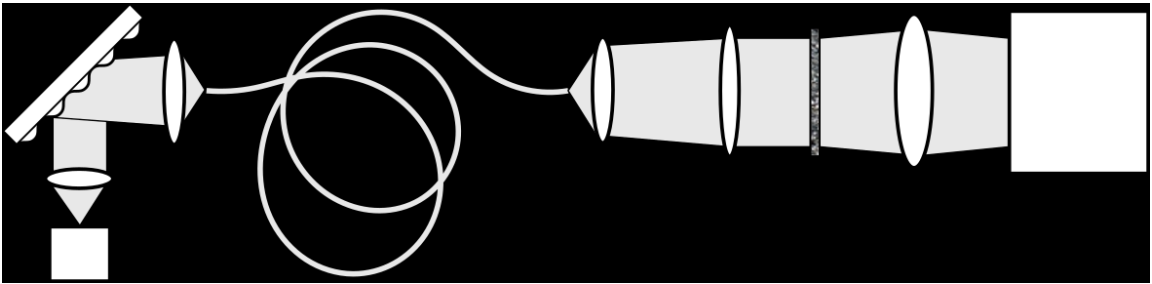
Interferometer fringes showing deformations.



Randomized divergence without scattering.

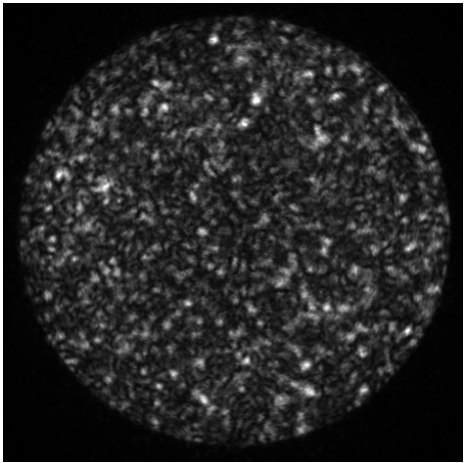
Typical specification: frequency $\geq 1\,\mathrm{MHz}$; area $3\,\mathrm{mm} \times 4.5\,\mathrm{mm}$; reflectance $\geq 96\%$; damage $\geq 1\,\mathrm{W\,mm^{-2}}$.

Fiber-coupled apparatus

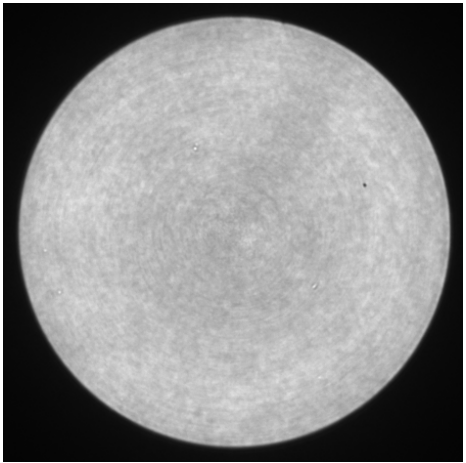


⌀1 mm *collimated beam; DM with approx.* 3° *full-angle divergence; coupling lens for approx.* 10× *angular and* 1/10× *size magnification; multimode optical fiber, length* 2 m, *coiled and stationary, N.A.*=0.39, ⌀200 µm *circular core or* □150 µm *square core; camera exposure period* 20 µs.

Circular core exit face

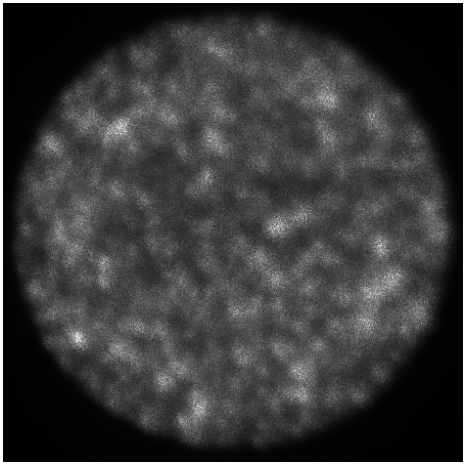


DM inactive, $C_S = 58.9\%$.

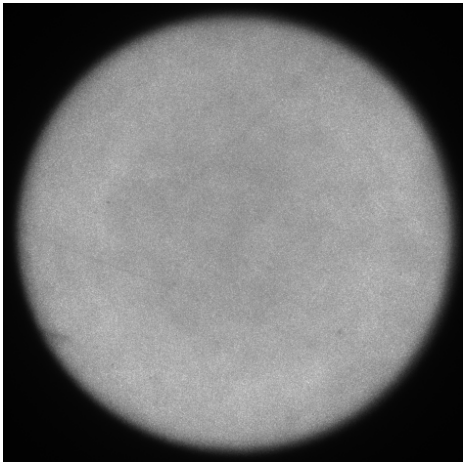


DM active, $C_S = 5.3\%$.

Scatterer illuminated through circular core

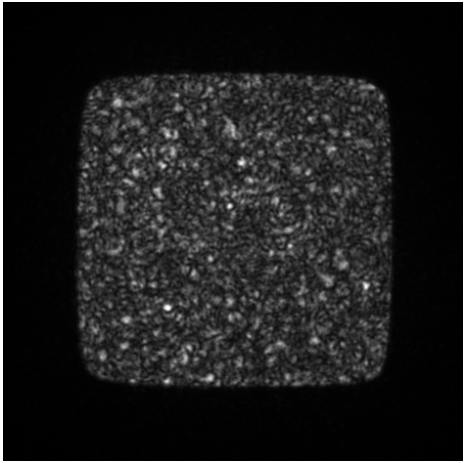


DM inactive, $C_S = 28.9\%$.

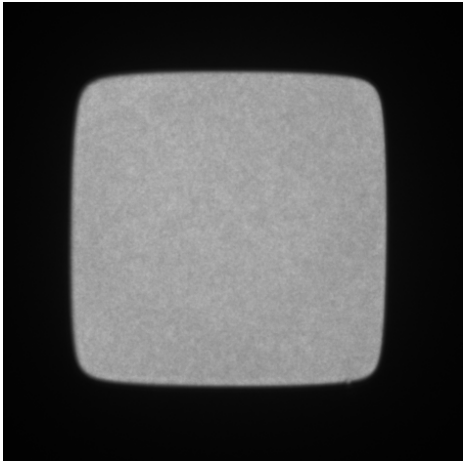


DM active, $C_S = 5.8\%$.

Square core exit face

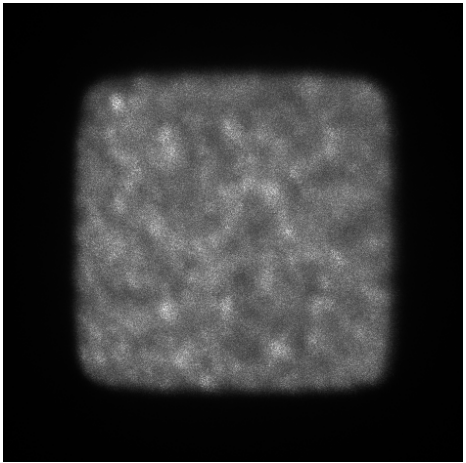


DM inactive, $C_S = 47.5\%$.

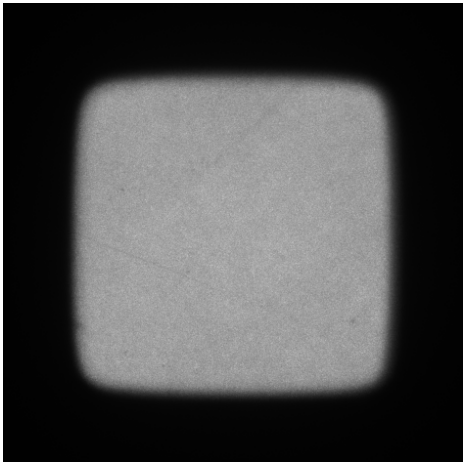


DM active, $C_S = 3.6\%$.

Scatterer illuminated through square core

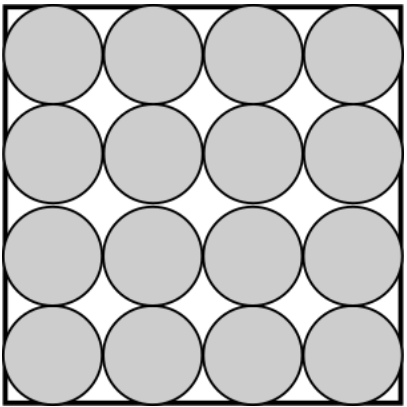


DM inactive, $C_S = 18.1\%$.

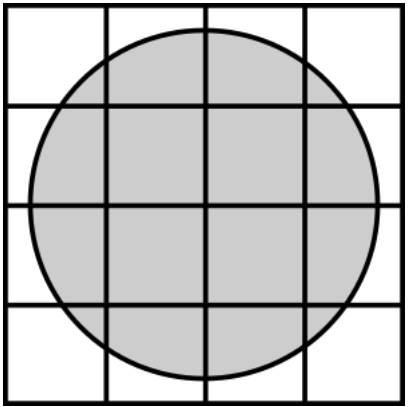


DM active, $C_S = 4.6\%$.

Performance limit is typically spatial, not temporal



Illumination spot size < sensor pixel size.



Illumination spot size > sensor pixel size.

$C_S = 1/\sqrt{n}$ so operating deformable mirror at e.g. 100 MHz is not necessarily beneficial.

Conclusions

- Excellent speckle reduction with multimode fiber and within 20 µs demonstrated without a diffuser or moving fiber.[1]
- Optical efficiency of $> 95\%$ has been reported by customers.
- Excellent temporal stability has been reported by customers.

[1] In other experimentation we have demonstrated good performance within individual 6 ns pulses.

Thank You!

Please contact me to discuss:

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