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Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

Efficient illumination of spatial light modulators for optical trapping and manipulation

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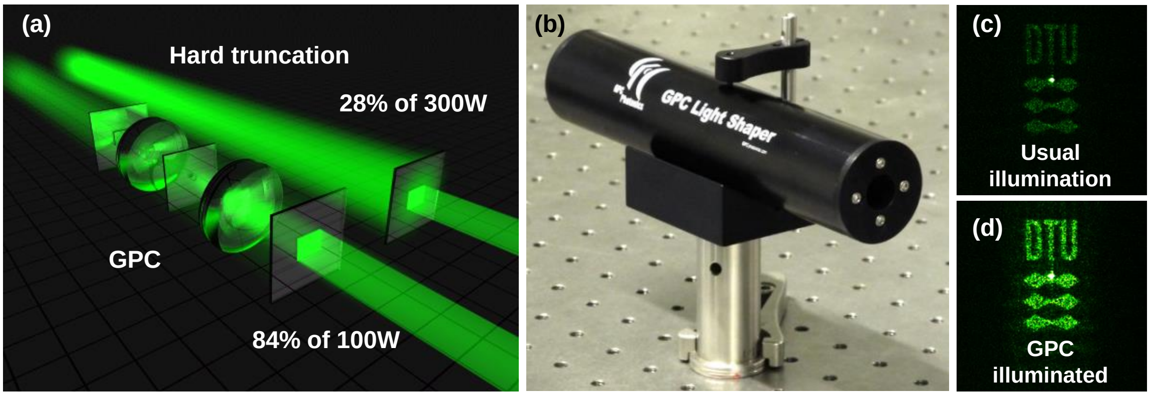
KEY WORDS: Beam shaping, illumination, spatial light modulators, GPC

Energy efficiency is always desirable. This is particularly true with lasers that find many applications in research and industry. Combined with spatial light modulators (SLMs) lasers are used for optical trapping and manipulation, sorting, microscopy or biological stimulation[1]. Besides efficiency, one wants to uniformly illuminate a specific shape such as the addressable area of an SLM. The common practice of truncating an expanded Gaussian source, however, is inefficient[2].

The Generalized Phase Contrast (GPC) enables illumination that inherits the efficiency advantages of phase-only light shaping while maintaining the speckle-free, high-contrast qualities of amplitude masking. Compared to a hard truncated Gaussian, a GPC Light Shaper (LS) saves up to 93% of typical losses[3]. We experimentally demonstrated shaped illumination with ~80% efficiency, ~3x intensity gain, and ~90% energy savings[4]. We have also shown dynamic SLM-generated patterns for materials processing and biological research.

To efficiently illuminate an SLM, we used a compact pen-sized GPC-LS in place of an iris. For the same input power, hologram reconstructions are ~3x brighter or alternatively ~3x more focal spots can be addressed. This allows better response or increased parallel addressing for e.g. optical manipulation and sorting. Simple yet effective, a GPC-LS could save substantial power in applications that truncate lasers to a specific shape.



To obtain a uniformly illuminated rectangle with 84W, up to 216W is normally blocked. GPC, on the other hand can use 84W out of 100W, saving 200W (93%) (a). The compact GPC-LS is shown with an enclosure that prevents dust (b). Alternatively, a GPC-LS could increase the brightness by ~3x for the same input power as seen in the holographic reconstructions (c-d).

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[2] D. Palima et al., *Opt. Express*, **15**, (2007) 11971–7.
[3] A.Bañas et al., *Opt. Express*, **22**, (2014) 5299–5310.
[4] A.Bañas et al., *Opt. Express*, **22**, (2014) 23759–69.