

Top-hat beam output with 100 μ J pulses from a linearly polarized all-fiber system

Pierre Calvet^{1,2}

Constance Valentin², Pierre Gouriou^{1,2}, Yves Quiquempois², Géraud Bouwmans²,
Laurent Bigot², Marc Douay², Arnaud Mussot², et Emmanuel Hugonnot¹

¹Commissariat à l'Énergie Atomique et aux Énergies Alternatives, Centre d'Études Scientifiques et
Techniques d'Aquitaine,

²Laboratoire de Physique des Lasers, Atomes et Molécules, UMR 8523, IRCICA

Abstract :

The compactness, long term stability, versatility and ease of use capabilities are important advantages of fiber lasers and amplifiers over bulky systems [1]. Their optical performances and ability to deliver high power or energy pulses find widespread applications in various industrial areas, for laser-biological tissues interactions, for fundamental studies of laser-matter interaction processes or for seeding large-scale laser facilities like the Laser MegaJoule (LMJ) [2]. For many of these applications, specific spatial beam shaping and more particularly a flattened profile is often a decisive requirement. Unfortunately until recently, optical fibers only deliver Gaussian-like beam, constraining the use of free-space beam shaping techniques at the output of laser systems [3]. To overcome alignment difficulties inherent to free space beam shaping, an elegant solution is to use an optical fiber directly delivering the desired spatial beam shape. Of course, an efficient solution is to use highly multimode fibers [4–6] but it leads to a low spatial coherence inducing very low depth of focus which is often detrimental for many applications, such as cutting or marking. To overcome these drawbacks, single-mode fibers supporting a flattened fundamental mode have been developed [7–10]. Despite their promising designs, these proposed fibers were still multimode. However, very recently we have developed a new strategy to obtain intrinsically single-mode fibers with very good intensity flatness by using a refractive index-depressed core [11]. Accordingly, we have realized and characterized a truly single-mode passive few-meters long fiber able to deliver a top-hat beam output [12]. We report on an all-fiber system delivering more than 100 μ J pulses with a top-hat beam output in the few nanoseconds regime at 10 kHz. The linearly polarized flattened beam is obtained thanks to a 3-mm-long single-mode microstructured fiber spliced to the amplifier's output [13].

References:

1. D. J. Richardson, J. Nilsson, and W. A. Clarkson, *J. Opt. Soc. Am. B* 27, B63 (2010).
2. L. Lago, D. Bigourd, A. Mussot, M. Douay, and E. Hugonnot, *Opt. Lett.* 36, 734 (2011).
3. F. M. Dickey and S. C. Holswade, *Theory and Techniques* (Marcel Dekker Inc., 2000).
4. Y. Matsuura, M. Miyagi, A. German, L. Nagli, and A. Katzir, *Opt. Lett.* 22, 1308 (1997).
5. Y. Matsuura, D. Akiyama, and M. Miyagi, *Appl. Opt.* 42, 3505 (2003).
6. J. R. Hayes, J. C. Flanagan, T. M. Monro, D. J. Richardson, P. Grunewald, and R. Allott, *Opt. Express* 14, 10345 (2006).
7. A. K. Ghatak, I. C. Goyal, and R. Jindal, *Proc. SPIE* 3666, 40 (1999).
8. J. W. Dawson, R. Beach, I. Jovanovic, B. Wattellier, Z. M. Liao, S. A. Payne, and C. P. J. Barty, *Proc. SPIE* 5335, 132 (2004).
9. J. W. Dawson, Z. M. Liao, I. Jovanovic, B. Wattellier, R. Beach, S. A. Payne, and C. P. J. Barty, in *Proceedings of CLEO (2003)*, paper CWD5.
10. F. Kong, G. Gu, T. W. Hawkins, J. Parsons, M. Jones, C. Dunn, M. T. Kalichevsky-Dong, K. Wei, B. Samson, and L. Dong, *Opt. Express* 21, 32371 (2013).
11. C. Valentin, P. Calvet, Y. Quiquempois, G. Bouwmans, L. Bigot, Q. Coulombier, M. Douay, K. Delplace, A. Mussot, and E. Hugonnot, *Opt. Express* 21, 23250 (2013).
12. P. Calvet, C. Valentin, Y. Quiquempois, G. Bouwmans, L. Bigot, M. Douay, A. Mussot, and E. Hugonnot, *Proc. SPIE* 8433, 84330K (2012).
13. P. Calvet, C. Valentin, P. Gouriou, Y. Quiquempois, G. Bouwmans, L. Bigot, Q. Coulombier, M. Douay, R. Habert, K. Delplace, A. Mussot, and E. Hugonnot, *Opt. Letters* 39, 4780 (2014)