















efficient approach to mitigate self-action processes like self-focusing. Numerical results (Figs. 1 and 6) and experimental results testing this hypothesis (Fig. 6) demonstrate that square pulses, results in significantly more compact pulses in the time domain than corresponding linearly chirped pulses. Of particular importance is that the approach presented causes no spectral bandwidth loss and can be reversed to obtain the original input pulse by introducing the complementary phase to the one used to stretch the pulse (Figs. 7 and 8).

Applications of our findings range from an alternative to CPA amplification to other applications where self-action mitigation is important, for example, fiber optic communications and nonlinear optical imaging using a fiber-based endoscope. When comparing a chirped pulse to a square pulse with the same peak intensity, the square pulse has a three times smaller temporal dimension, and because it requires less stretching a smaller spectral dimension on the compression grating. Flat top picosecond laser pulses with fast rise and fall times are desirable for the production of high-brightness electron beams for free-electron lasers, Compton scattering light sources, and MeV electron microscopes [15–17]. There are other scientific applications for pulses with very fast turn on/off, for example, quasi-phase-matched conversion to soft x-ray photon energies, where the fast turn on initiates ionization and the flattop maintains high-peak intensity [18], and time-resolved coherent anti-Stokes Raman scattering [19]. The square pulses produced here can be made to slant from high to low intensity or vice versa. Doing so could optimize many other processes where a fast/slow-rise and slow/fast decay are needed. From a practical sense, while the use of a dedicated pulse shaper is ideal for the implementation of the approach presented here to create stretched square pulses, having an analytic solution should simplify the implementation of this approach for stretching and compressing ultrafast pulses using specially designed dispersive optics such as chirped mirrors and volume/fiber Bragg gratings that take into account the spectrum of the input pulse. One could also conceive of combinations of static optics or specially designed mirrors with the desired curvature for stretching and re-compression.

### **Acknowledgments**

This project is sponsored by the NSWC Crane N00164-14-1-1008. The information does not necessarily reflect the position or the policy of the Government, and no official endorsement should be inferred.