Ultra-fast laser filamentation in air has received considerable attention over the last decade, both for its intriguing properties as well as its tantalizing potential to open new paradigms in remote sensing, lightning-guiding communications and other applications. We have had a robust program exploring the creation and manipulation of filaments and their applications in a number of domains for some time, and have a number of laser systems capable of creating filaments in air. When the initial beam has sufficient power, multiple filaments can be created. Early experiments showed random distributions of filaments in high power fs laser beams. However engineering the intensity, phase and spectral content of the pulse allows for the creation of many new filamentation modalities.

We are exploring the control and ordering of multiple filament regimes for several applications. Curved filaments, known as ‘Airy filaments’ are created by imprinting a cubic phase to the beam and are explored for energy deposition and interrogation along interfaces and sustainability of the filament. We have also created Vortex Bessel intensity profiles to produce helical filaments by vortex plates or by constructive interference of Bessel beams. The influence of helical beams on the filament emissivity (white light generation and THz emission) useful for stand-off sensing is studied and advanced configurations are explored for control of white light generation at distance. A number of different optical techniques are used to generate these advanced filamentation structures including the use of reflective spatial light modulators and specially designed transmissive meta-optical components.

The interaction of filamented laser beams with dielectric, transparent and metallic materials is also being studied. The energetics of single filament interaction with solid surface interfaces is studied using high-resolution femtosecond optical backlight imaging. The influence of the carrier field on the plasma produced and on the light transmitted through the interface has been studied in detail. High frequency EM emission from the plasma has also been characterized in spectrum and intensity.

Filamentation of ultra-short laser beams offers considerable potential for plasma-based stand-off detection and other applications. We will summarize research activities on a number of these applications. This work is funded under ARO contracts

6 N. Barbieri et al. (to be published)
7 M. Fisher et al. (to be published)
8 R. Bernath, M. Richardson, Proc. SPIE 7196, 71960C (Feb. 19, 2009)
13 M. Weidman et al. (to be published)