Ultrashort Pulse Laser Propagation and Interactions with Solid Matter

S&T Campaign: Sciences for Lethality and Protection
Non-kinetic Lethality
High Energy Laser

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Research Objective

- Understand and be able to predict nonlinear effects of ultrashort pulse laser (USPL) propagation and interaction with solid matter
- Filamentation is a unique nonlinear propagation mode of USPLs that are able to transmit a condensed beam of laser light and plasma over long distances. We seek to understand the physics of filamentation, how filaments interact with other forms of EM energy and how filaments interact with solid targets.
- Advanced concepts include thermal waveguiding, Laser-Induced Periodic Structures, filamentation in transparent media, power beaming with filaments and channeling of electrical discharges with filaments

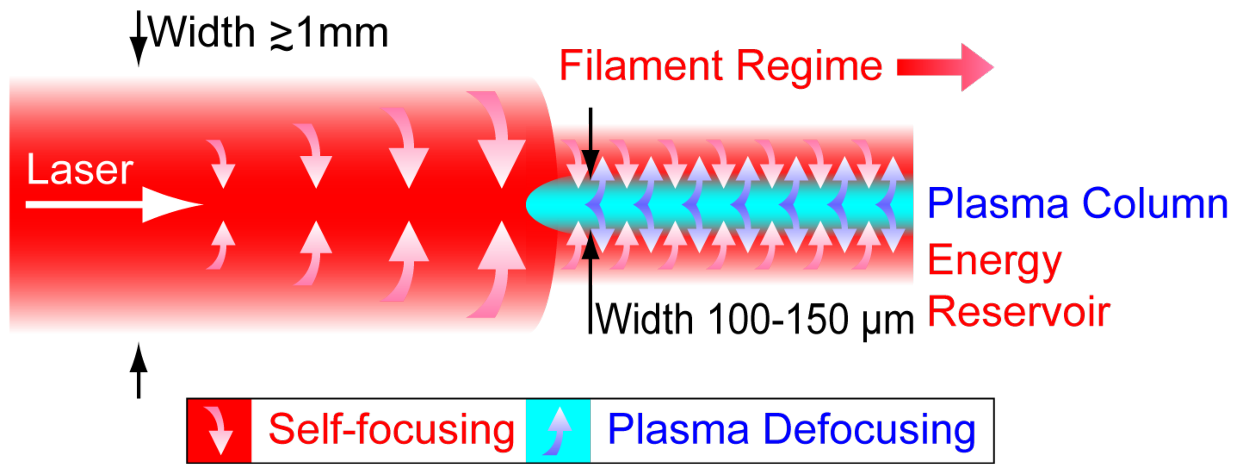
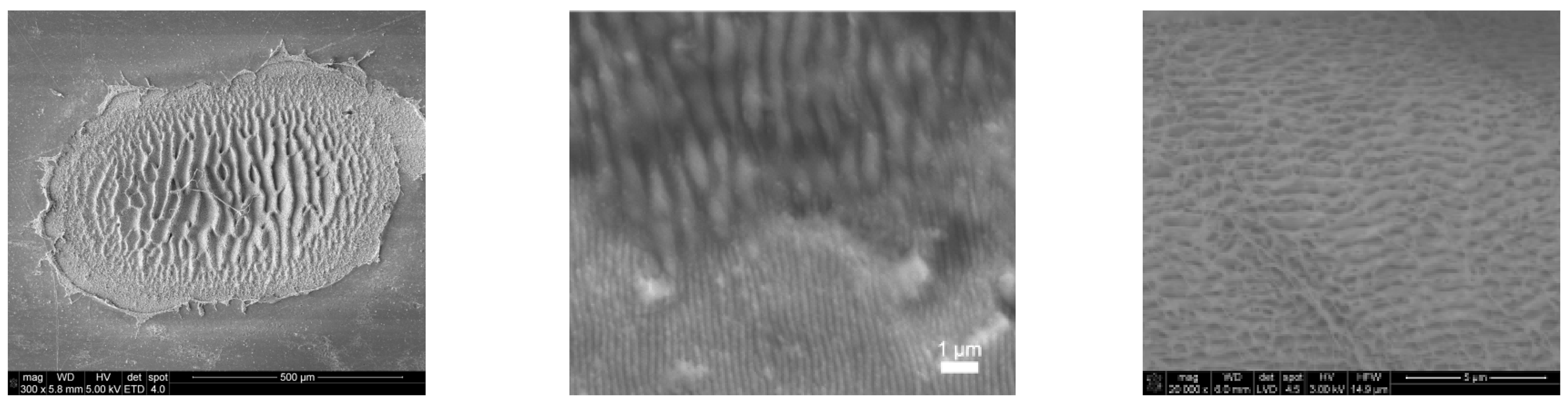


Diagram of filamentation where high peak power USPL self-focuses to create a plasma that defocuses. If the defocusing is balanced against focusing, a filament can propagate over 10s of meters in air.

Challenges

- A comprehensive theory of filamentation is needed particularly one that accurately models propagation in a variety of atmospheric conditions. Expansion of this concept to include channeling of power, either photonic or electric, over long distances.
- Experimentation and modeling of thermal waveguides generated by filamentation and how these guides can be used to channel longer pulse and continuous wave lasers over long distances.
- Further experimentation of LIPSS patterns, particularly those created by filaments. This field lacks a cohesive theory to explain these patterns as related to laser parameters.



Filament-generated LIPSS on PVC (left), Boron carbide (center) and Kevlar® fiber (right)

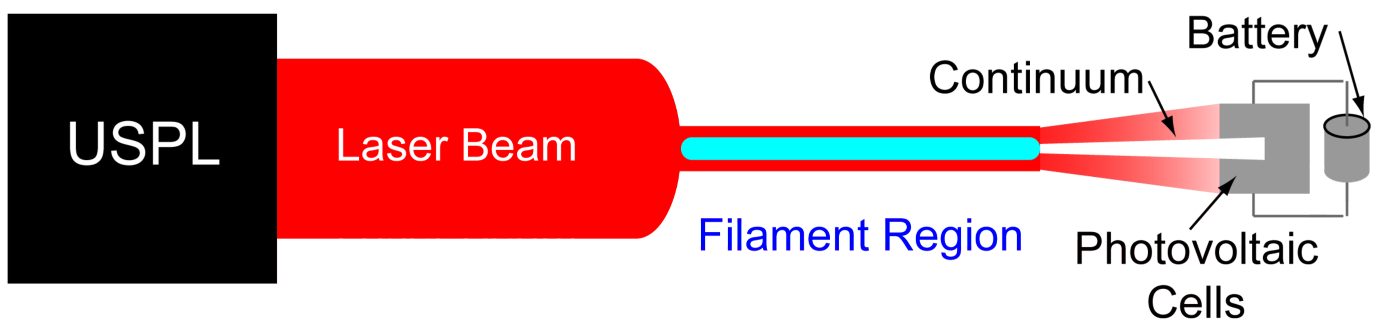
ARL Facilities and Capabilities Available to Support Collaborative Research

- ARL Laser Characterization of Energetic Materials Lab
- Coherent Hidra-25 Ti:Sapphire USPL: 800 nm wavelength, up to 25 mJ pulse energy, 10 Hz repetition rate, 100 fs pulse width
- Coherent Astrella Ti:Sapphire USPL: 800 nm wavelength, up to 6 mJ pulse energy, 1 kHz repetition rate, 30 fs pulse width
- Laser metrology including Grenouille, spectrometers, wavefront sensors
- Access to surface and chemical metrology systems including SEM, Raman, white-light interferometer

Image of Coherent Hidra-25 (left) and Coherent Astrella (right)

Complementary Expertise / Facilities / Capabilities Sought in Collaboration

- Longer distance (>20 m) indoor and outdoor laser propagation range facilities
- Higher energy 1 kHz USPL facilities
- Modeling and simulation capabilities for filament propagation
- Theory and modeling capabilities for LIPSS and filament interactions with solid matter
- Concepts and expertise on laser power beaming
- New laser technologies at different wavelengths, particularly coherently combined fiber lasers (CW and ultrashort) and mid-IR systems.



Filament-based power beaming concept using white light continuum generation to illuminate a photovoltaic cell