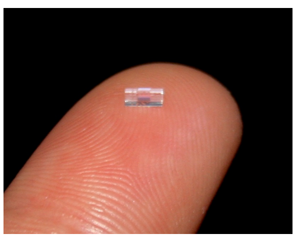
SLAC NATIONAL ACCELERATOR LABORATORY

E163 DIELECTRIC LASER ACCELERATION

www.slac.stanford.edu/dla

The Dielectric Laser Acceleration (DLA) group, operating under SLAC Experiment E163, is a collaborative program with Stanford University for conducting small-scale student-led experiments using lasers to power dielectric micron-scale particle accelerators, a concept recently termed an “accelerator on a chip.”



Example of a prototype silica accelerator structure fabricated at the Stanford Nanofabrication Facility and recently demonstrated to produce accelerating fields 10 times higher than the SLAC main linac.
[*Nature* **503**, 91-94 (2014)]

Why Make Tiny Accelerators?

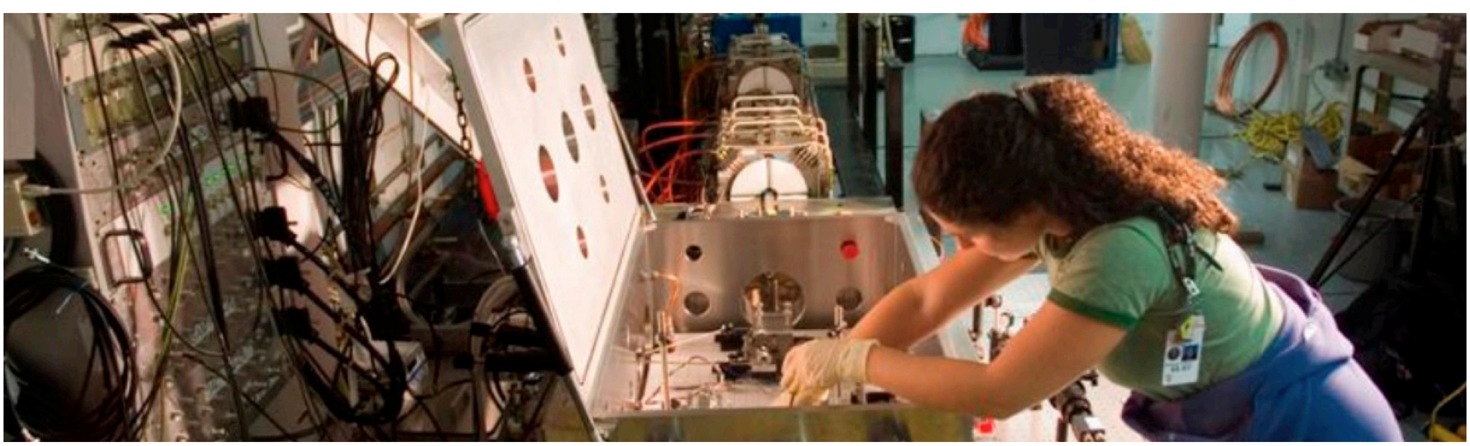
Applications for these new particle accelerators would go well beyond particle physics research. Laser accelerators could drive compact X-ray free-electron lasers, comparable to SLAC’s Linac Coherent Light Source, that are all-purpose tools for a wide range of research. Another possible application is small, portable X-ray sources to improve medical care for people injured in combat, as well as provide more affordable medical imaging for hospitals and laboratories.

How It Works

Dielectric laser acceleration uses techniques from the microchip industry to make micron-scale accelerator structures from dielectric materials, which have high laser-damage thresholds and low ohmic losses. By accelerating particles using the energy from lasers instead of microwaves, gradients of billions of electron volt per metre are possible. In principle this would allow us to shrink conventional accelerators by a factor of 100 or more for a given particle energy.

Dielectric Laser Acceleration

The idea of using light to accelerate particles dates back to the 1960s, and a variety of all-dielectric high-gradient structures have been proposed. But it is only recently that it became possible to fabricate and test the first laser-accelerator prototypes, thanks to high-power solid-state lasers, optical fibers and photolithographic techniques driven by the communications and semiconductor industries.



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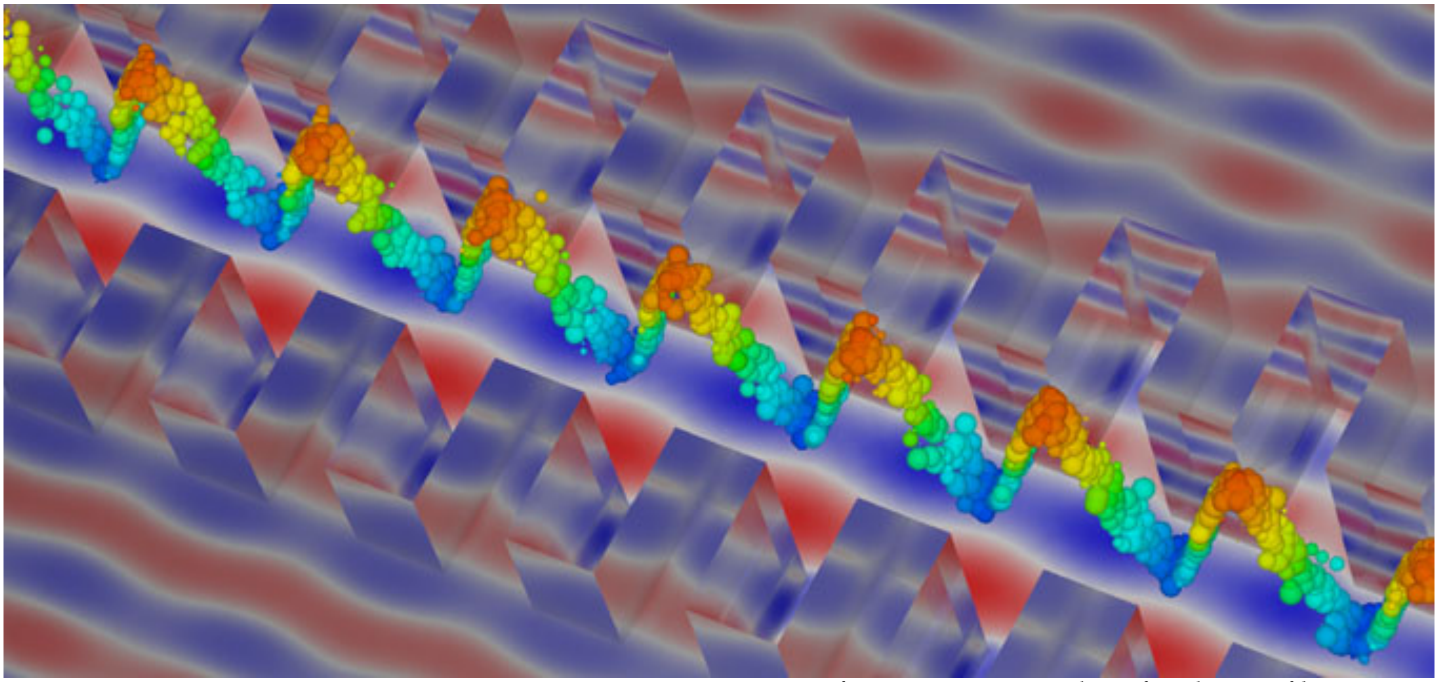
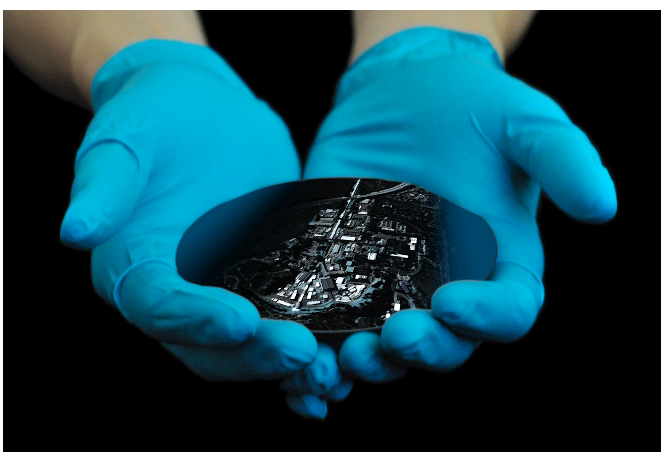


Surfing a wave -- a computer simulation of particles in one of the SLAC/Stanford microchip accelerators shows the accelerating (orange) and decelerating (blue) portions of the laser-induced wave in a nanostructured channel. [CREDIT: Ben Cowan, Tech-X Inc.]

Future Accelerators Based on Advanced Photonics

In order to reach useful particle energies, many micro-accelerators must be fabricated in succession and illuminated by a sequence of laser pulses that are precisely timed so that the particles see a continuous energy gain. The arrival times of the electrons and the laser must be synchronized and bunched to within a fraction of an optical period. Research in the DLA program includes development of light-guiding systems and of new attosecond-scale photonic systems to achieve this ultra-precise level of control.



Light work – we envision that a complete miniaturized particle accelerator system may be possible on a single wafer in the next 5—10 years.
[CREDIT: Ken Soong, Stanford University]

Research Opportunities

The E163 Test Facility and Next Linear Collider Test Accelerator provide unmatched capabilities and a world-unique center for scientific research on laser accelerators. Student and post-doctoral researchers have the opportunity to be involved in all aspects of the experiment, from design and modeling of new acceleration concepts, to fabrication, to direct electron and laser testing. Students in the program are eligible to apply for the **Siemann Graduate Fellowship**, which includes a stipend and $20k independent research fund. Two recent students of the DLA program have been recipients of this prestigious honor. Past graduates have gone on to successful careers in industry, academia, and national laboratory research.

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