

# JEFFERSON LAB FREE ELECTRON LASER

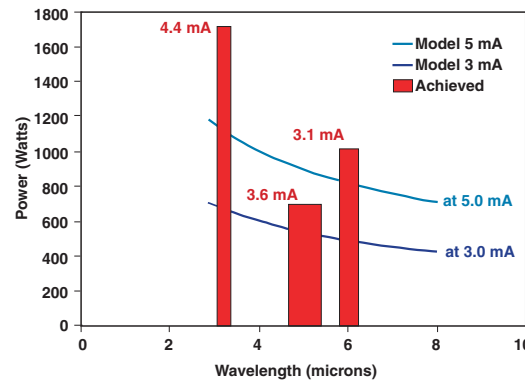
Jefferson Lab is a Department of Energy national lab in Newport News, VA. As a user facility for the international scientific community, the lab's primary mission is basic nuclear physics research. A derivative mission, the development and use of free electron lasers is based on the laboratory's key technology, superconducting RF accelerators.

## JEFFERSON LAB FEL TECHNOLOGY

The IR Demo FEL can be considered one of the first of the "Fourth Generation Light Sources" because of its high average brightness driven by the use of superconducting RF linear accelerator modules and a recirculating electron beam. This accelerator technology is capable of producing the extremely stable, high-brightness and high-average power electron beams that are advantageous for driving FELs.

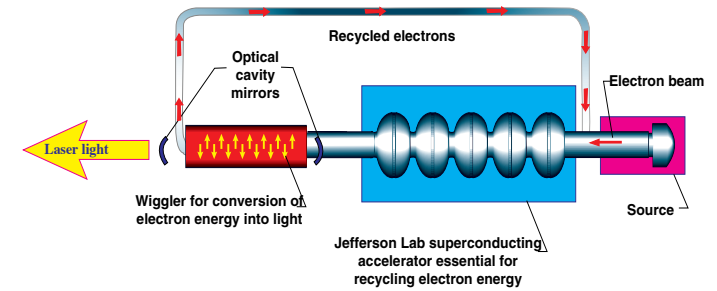
## FEL STATUS

The Jefferson Lab IR FEL is fully operational as a user facility and is the newest to be brought on-line. Its unique basis in superconducting technology allows it to operate at high average power levels. It recently achieved a new world's record exceeding its design goal (1 kW) by producing an average power of 1.72 kW of infrared light at a wavelength of 3.1 microns (July 15, 1999). The IR Demo FEL offers the scientific community a unique light source for basic and applied research because of the



broad tunability, high-average power and short pulse time structure.

The IR Demo FEL was designed to demonstrate several key advantages of superconducting RF technology: (1) high duty cycle (cw) linac operation, which enables multiple wigglers to be driven in FEL user facilities; (2) high-average optical power – in the kilowatt regime – which is useful for frontier basic science and laser materials processing; (3) power efficient production of laser light by recovering most of the non-radiated power in the electron beam, an important feature for scaling this FEL technology to larger user facilities and industrial applications; and (4) subpicosecond micropulses, ideal for maximizing coupling of laser light to materials.

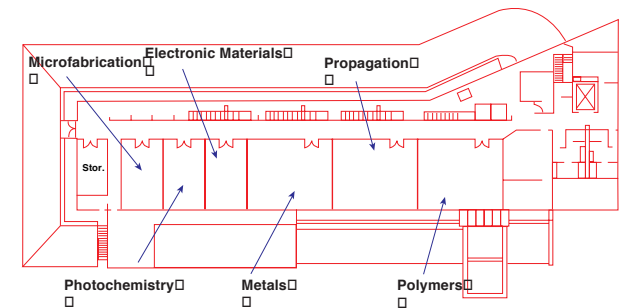


## APPLICATIONS

The FEL is used for materials research, for biological research and for applied studies. The high power, ultra-short light pulses are used to study energy flow in solids in experiments called dynamics. Understanding such energy flow is a common and important theme in many important applications such as information technology, nanotechnology and bio-technology. It is also important in materials processing in applications such as pulsed laser deposition. Industrial applications use the high power for experiments in the processing of materials and in the manufacture of materials in new forms.

## FEL USER FACILITY

The IR Demo FEL and its associated 6,600 sq. ft. User Labs are the result of a unique public-private partnership. The \$25M project was funded from



The FEL facility includes labs, a clean room, control room and optical control room.

contributions from DOD, DOE, the Commonwealth of Virginia, and several industrial partners. In 1993 the Laser Processing Consortium, a university-industry-National Lab partnership, was formed to guide the technical specifications and develop applications for the Demo FELs. Significant contributions have been made by industry and university partners for the initial fit-up of several of the User Labs. These User Labs have been configured for flexibility and rapid change-out of end-station hardware.

### APPLIED RESEARCH CENTER

The Demo FEL's expansion of the scientific mission of Jefferson Lab and the resulting potential for regional economic development prompted the City of Newport News to build an \$18M, 7-story Applied Research Center (ARC) to house research staff and equipment for FEL related research. The ARC provides space for faculty and students from the five local universities and houses over \$5M of materials analysis equipment and lasers donated by the local universities, Xerox, Kodak and DuPont.



Applied Research Center

Operated by Southeastern Universities Research Association under contract to the U.S. Department of Energy

Thomas Jefferson National Accelerator Facility

### UPGRADE OF THE IR DEMO FEL

The present FEL and User Facility has an incremental upgrade path for increasing the power in the IR and extending the short-wavelength limit to the deep UV. Two additional accelerating structures and an upgraded injector would provide a 10-fold increase in FEL power. The addition of multiple wigglers would extend the wavelength range to 60  $\mu\text{m}$  in the far-IR and 250 nm in the deep UV. Predicted average power levels are 10 kW in the mid-IR (1–10  $\mu\text{m}$ ) and 1 kW in UV (250–450 nm).

### 4TH GENERATION LIGHT SOURCE DEVELOPMENT

The use of a high brightness, cw superconducting linac for driving multiple wigglers in the Jefferson Lab FEL User Facility will test essential concepts in the development of 4th Generation Light Source technology and their operation as user facilities. The present IR Demo FEL and proposed upgrade provide a unique low cost facility for developing advanced light source applications over the full wavelength range, IR to x-ray.

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