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HOTLINE

The Princeton Plasma Physics Laboratory is a United States Department of Energy Facility

PPPL's Funding Increased for FY2000

By Anthony DeMeo

During the next year, PPPL will receive approximately $63 million in federal funding for research in fusion energy and plasma science — a 21 percent increase over the prior year.

"This funding increase is a wonderful boost to our program. Thanks to the support of Congressmen Rodney Frelinghuysen and Rush Holt and Senators Frank Lautenberg and Robert Torricelli, we will be able to accelerate our work on fusion energy and begin the removal of the successful Tokamak Fusion Test Reactor (TFTR) to make way for new research," noted PPPL Director Robert J. Goldston.

The new funding was effective October 1, with the start of the government's Fiscal Year (FY) 2000. It is part of approximately $249 million provided for the U.S. Fusion Energy Sciences Program in the FY 2000 budget.

The U.S. Department of Energy (DOE) is responsible for overseeing the Fusion Energy Sciences Program and provides PPPL's funding. The budget for fusion research was $222.6 million in FY 1999. In providing the increase for FY 2000, Congress commended DOE for its efforts to pursue the most promising paths toward producing electricity from fusion. Members also expressed their pleasure with the fusion program's emphasis on innovation.

The funding provided in FY 2000 will allow Princeton researchers to conduct experiments on the National Spherical Torus Experiment, while proceeding with the disassembly of TFTR. Its dismantling and removal will take three years and cost $46 million. Of this total, $9.9 million is included in PPPL's FY 2000 funding. The space occupied by TFTR will be available for a future fusion experiment.

PPPL Physicists Work to Improve TV Technology

By Anthony DeMeo

Anyone touring Circuit City or The Wiz cannot help being drawn to the myriad of video entertainment systems for sale. Television has come a long way from the days of 10-inch tubes, offering snowy black-and-white images, to today's 50-inch rear-screen projection systems. But the image quality of projection TV is inferior to that of picture tubes, and both systems require a considerable amount of space.

All of this is about to change with the advent of High Definition Television (HDTV), in particular, the flat-panel, hang-on-the-wall televisions that have been a staple of science fiction and viewers' fantasies. At first glance, a plasma set is arresting. Anyone spying it invariably walks up and peers around the back to be sure there isn't an attached piece of equipment built into the wall somewhere.

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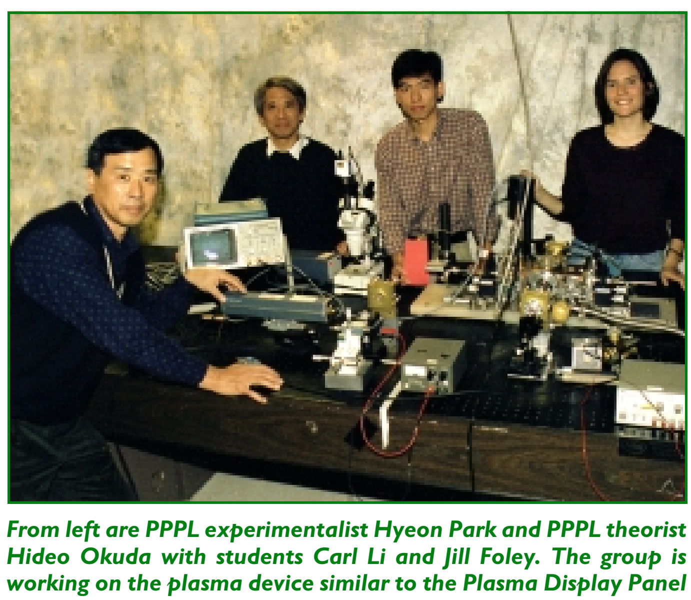

From left are PPPL experimentalist Hyeon Park and PPPL theorist Hideo Okuda with students Carl Li and Jill Foley. The group is working on the plasma device similar to the Plasma Display Panel Cell, which is on the table.

TV

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The work of two PPPL physicists, one an experimentalist and the other a theoretician, may lead to flat-panel displays that are larger, last longer, provide higher resolution images, and are less expensive. "I expect plasma display panels (PDPs) to fill a large segment of the market beginning in the next decade," noted PPPL experimentalist Hyeon Park. For about one year, Park and PPPL theorist Hideo Okuda have been working on an experimental diagnostic method and a computational model that will aid designers of flat-panel displays to better characterize the plasmas used in these devices.

Presently, most flat displays employ one of three technologies to form the image — liquid crystals, light emitting diodes, or plasmas. Further down the road are more sophisticated technologies, including organic and biochemical displays. Liquid crystal displays (LCDs) are currently dominating the small display market where screen size is 15 inches or less, such as small screen TVs, toy game monitors, and lap-top computers. LCDs rely on a sophisticated switching technique that uses an array of thin film transistors (TFTs) to set up electric fields which allow the normally opaque liquid crystals to transmit light. The TFT arrays are costly in the larger sizes desired for desk-top monitors and entertainment systems. Light emitting diodes, or LEDs, are used in enormous display panels, such as those mounted on buildings in New York City's Times Square. At the present time, small LEDs cannot compete economically with LCDs. Because of fabrication difficulties and cost, neither LEDs nor LCDs are economically viable for the size of screens required for entertainment and business presentation applications. These are the provinces of plasma displays, which involve relatively simple fabrication processes compared to the other flat panels.

Typical Plasma Display

Sony's Plasmatron display or Plasma Addressed Liquid Crystal is a large-scale LCD in which the intricate TFT array has been replaced by plasma cells. Induced charges at the surface of a plasma cell set up an electric field that aligns the liquid crystals, allowing them to transmit light. White light, incident from the rear of the display, is filtered by the liquid crystal. Only one of the three primary colors — red, green, or blue — is allowed to pass through it to the front surface of the display. The strength of the field determines which primary color is admitted. Colors comprising the image are determined by mixing the primary colors from different cells.

In all other commercially available plasma displays, a plasma is created by energizing electrodes directly underneath the front glass plate of the display (see diagram) where Xenon gas is mixed with buffer gas (inert gases such as neon and helium) to optimize ultraviolet emission. When ultraviolet light emitted by the plasma strikes a phosphor, visible light is generated. The color of the light depends on the phosphor contained in a particular plasma cell.

The display screen is comprised of pixels, which are groups of three plasma cells, one for each of the primary colors. The color output of a pixel is determined by the combination of cells triggered and the intensity to which each cell is energized. The resolution of the image ultimately depends upon the number of pixels it contains. To meet a true HDTV condition, a screen must contain at least 1,200 pixels along a horizontal line of the screen and 900 in the vertical direction. An easy way to satisfy this condition is to make the screen larger with the present cell size. However, market analysts expect the demand to be greatest for flat screens measuring 40 inches or less. Consequently, a 50 percent reduction in the size of the pixels is necessary for manufacturers who wish to dominate the flat-panel TV market in the coming decades.

Park said, "The clarity of state-of-the-art plasma displays is marginal. The electrical process is extremely

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inefficient. As a result, plasma displays are dimmer than conventional television sets. To meet the clarity requirements for true HDTV, a PDP must sustain or improve the brightness in a smaller plasma cell, so that the gray scale and resolution can compete with HDTV based on CRT and other techniques. As plasma physicists, we are not trained to fabricate complex TV sets, but we do have knowledge and ideas to improve the efficiency of plasma discharges allowing true PDP HDTV at an affordable price."

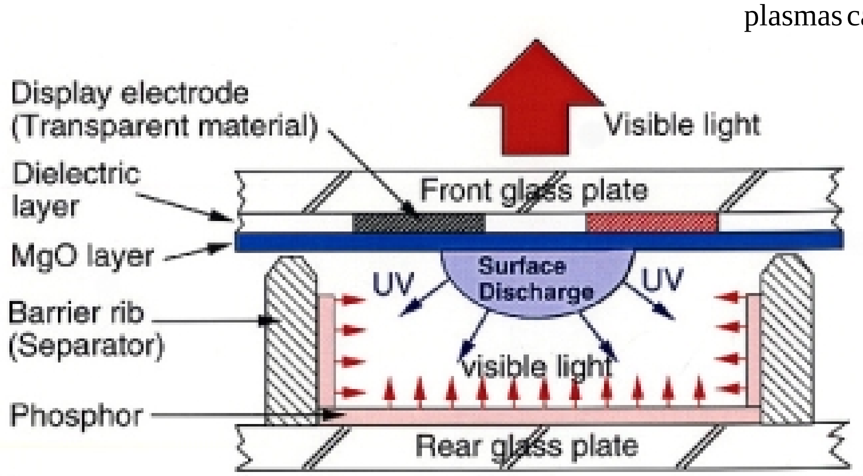
Park noted that there are many computational models available for plasmas used in displays, but none of these has been verified by direct measurement of plasma parameters. Futhermore, these models, which are based on plasma mobility and diffusion, may not be adequate for the kinds of discharges used in displays. A better theoretical understanding that can accurately predict performance is essential.

Park and Okuda believe that experimental and theoretical techniques developed for fusion research can be applied. But the challenge is substantial. Display plasmas are not only miniscule, but also highly transient. Whereas the size of fusion plasmas may be measured in meters, those found in a display have dimensions of 200 microns or less. Fusion plasmas last a few seconds, while those in a display have about a one-microsecond lifetime.

Okuda is developing a computational code which will provide a realistic model that can predict the brightness of the ultraviolet light produced by the plasma. To do this, he must determine the density and energy distributions of the Xenon ions and the electrons comprising the plasma. Each cell contains a few million electrons in a plasma pulse of one-microsecond duration. Okuda's calculations require the development of a kinetic model to compute the energy distribution in a transient plasma — one that never has time to reach steady state. Okuda is developing a technique that can handle this by clamping many particles into super-particles, thereby reducing computational time considerably. "With this method, as the size of the PDP cell becomes smaller, it actually becomes easier to model the device on a computer," Okuda said.

Tests of Okuda's theories will require precise, direct measurements of electron density in a one-microsecond plasma measuring 200 micrometers — a formidable task. Most of the conventional direct diagnostic methods cannot be applied. Fortunately, Park has invented a new interferometric technique, which has a potential to make the necessary measurements. Park employs a visible-light laser, rather than longer-wavelength (microwave or far-infrared lasers) conventionally used for the range of plasma density expected in a PDP cell. The short-pulse, continuous-wave visible laser not only allows measurements to be made on the tiny cells of a plasma display, but provides adequate spatial resolution, because the visible beam can be focused to a spot much smaller than cell size. Park's method, in principle, has the potential to determine both the electron density and temperature of the plasma cell.

Plasma displays are the most vivid example of what plasmas can do for people and society in addition to fusion energy research. "At this point, a plasma TV is as expensive as a new car, and therefore limited to those who can afford it. Since plasma technology is evolving fast, plasma displays will eventually become a mainstream product for consumers not interested in deciding between a new car and a new television. Therefore, long-term research on the fundamentals of a PDP cell for true HDTV is inevitable in order to make a quantum jump from the current generation of a PDP cell. It is fitting that PPPL, one of the world's leading centers for plasma science and technology, plays a prominent role in the development of this highly visible application," said Park. ●



Cross-section of a plasma cell of a typical plasma display panel. MgO is magnesium oxide.

Season's Greetings

from the

Princeton Plasma Physics Laboratory

The PPPL Holiday Party and Luncheon is scheduled for Wednesday, December 22, beginning at noon in the LSB Lobby and Cafeteria. There will be food, soft drinks, entertainment, and raffles. The festivities are open to everyone at PPPL. So come share and share in the fun!