UHD's promise: "The future has just begun"

A new semiconducting material proves its mettle with increased size and current demands.

New format, high definition displays on the way to consumers will bring a level of verisimilitude to home television screens that beggars belief.

Graduate student Forough Mahmoudabadi is helping Hatalis improve the performance of IGZO transistors.

"The images on these new screens are just astonishingly beautiful," says Miltos Hatalis, professor of electrical and computer engineering. "You can get very close to the screen, and the image is like nature."

Current HD displays have about 2 million pixels, arrayed in 2,000 columns by 1,000 rows. A new display format, called Ultra High Definition (UHD), is coming out in two varieties: 4k UHD with 4,000 columns and 2,000 rows of pixels, or 8 million pixels, and 8k UHD, which boasts 16 million pixels. The 4k UHD versions are just beginning to hit the market, albeit at princely prices and shy of performance levels designers seek to deliver.

Hatalis, who is working on innovations to make UHD a reality, says the increased performance requirements of the new format present much more than a fourfold challenge.

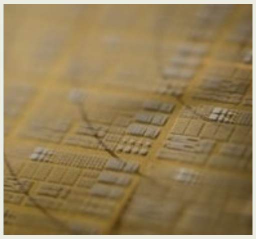
"UHD almost eliminates pixelation due to its higher resolution, but the amount of time given to address each row of pixels is proportionally reduced." This timeframe is compacted further by the quicker refresh rates the new screens need to render fast-moving 3-D images as vividly as life. With less time, the transistors and other components that activate each pixel must work faster and handle more current. However, given the higher resolution, the pixels must be smaller.

Bigger screens also require the display lines carrying the current to be longer, allowing increased parasitic resistance to sap signal strength.

These factors have outstripped the capacity of current HD display technologies, not to mention the inexorable demands of the future. The 8k UHD format—quadrupling the 4k UHD resolution and approaching that of IMAX—is already more than a concept.

To overcome these challenges, Hatalis is working with a new material—indium gallium zinc oxide, or IGZO—that can produce the smaller thin film transistor (TFT) components demanded by UHD formats while providing more than 10 times the current of TFTs now made with amorphous silicon.

Working in Lehigh's Display Research Laboratory, a unique facility that can produce prototype displays almost from scratch, Hatalis has improved the manufacturing process to increase the performance and reliability of IGZO transistors. The delicate procedure involves several deposition steps, photolithography, etching and other techniques.



"We have found some treatments that make the transistors very robust," he says. "You have to go through a lot of steps putting down the material, heating it, etc. If you don't get each step of the process just right, you fail."

Besides display components that create images, screens require drivers that process incoming signals and control pixels. Driver circuits are typically embedded into display panels, along the edges. Thin film transistors (TFTs)—common to all display technology and vital components of the drivers—ideally call for both N- and P-channel transistors. These transistors are complementary in that a charge that opens one will close the other, and vice versa—a useful quality in circuit design. IGZO lends itself only to N-channel transistors—at least for now.

"Working with Kamil Klier [University Distinguished Professor of Chemistry], we are exploring different materials to make the P-channel transistors, using elements in the IGZO family and amorphous metal oxides," says Hatalis. "We recently achieved interesting results doing computer simulations at Brookhaven National Lab."

In addition to the bigger format, new displays are being developed that will do away with the LED backlighting required by current LCD technology. Instead, AMOLED (active matrix organic LED) displays use diodes that produce light, rather than just modulate it, as do LCD diodes. AMOLED screens are used in smartphones and other small devices with pristine displays, but their production is expensive and not yet feasible for large TVs and monitors employing UHD for the consumer market.

Hatalis has received significant industry funding for his work with displays, and from the FlexTech Alliance for his flexible screen research. He was among the first to publish in the field of flexible displays, and is experimenting with techniques that could put displays on car dashboards, clothing or even paper.

"The applications of flexible screens," he says, "are countless. The future has just begun."