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Being flexible is key to making display truly mobile

Building flexibility into information displays has always been the goal of the Flexible Display Center (FDC) at Arizona State University. But building flexible displays has also meant being flexible in organization as well as technology.

In its first five years of operation, FDC has advanced flexible display technology but maybe one its greatest accomplishments is getting the key players to the table, according to FDC Director Gregory Raupp. With funding from the U.S. Army and a mandate to drive the technology towards commercialization, the FDC has become an engineering and R&D hub for advancing all that is needed to manufacture flexible displays.

"We have developed a dynamic partnership model that is not found anywhere else as far as technology development, implementation and transition through a university led organization," Raupp said of the center's industry engagement.

"Our partners are critically important to what we are trying to do," he added. "They have worked with us to co-develop and deploy several key technologies."

The Flexible Display Center was established in February 2004 with a 10-year cooperative agreement with the U.S. Army Research Laboratory and $43.7 million in funding for the first five years. The Army's interest in flexible displays is as an enabling technology that can improve performance of its people on the ground by providing instantaneous information to even the most remote of locations.

But developing flexible displays has meant reworking them from the ground up. In order to make flexible displays – flexible enough to be body contouring or even folded or rolled up – FDC researchers and their industrial partners have developed new display designs, worked with new materials for the displays and associated electronics, and re-worked existing manufacturing methods.

Glass ceiling

A major step towards flexible displays is to get the glass out. Today, all conventional displays – from cell phones to desktop computers – are manufactured on thin glass. It's the reason why the displays are so vivid and reliable. It's also the reason why they are rigid and fragile.

Because flexible displays are so different from traditional displays, entirely new methods of manufacture (and modifications to present semiconductor methods) are needed to build them. With the goal to deliver rollable displays, the electronics behind the display must be flexible too so they need to be manufactured on plastic or thin metal foil substrates with new thin film transistor technologies.

The first displays developed by the FDC incorporate "electronic ink," which uses an electric field to move negatively charged black particles and positively charged white particles. This technology produces reflective

displays that have the look and feel of paper, and require extremely low power to operate.

FDC has successfully produced four-inch flexible screens with this technology that have QVGA (quarter video graphics array) resolution and 16 shades of grey, Raupp said. Some of these displays already have been integrated into Army technology demonstrators, like the Future Force Warrior Soldier Flex-PDA and the General Dynamics Mission Briefer.

Future technology generations, Raupp added, will have larger screens and will incorporate color, as well as video capabilities. A greater focus in the future will be on emissive display technology through integration of organic light emitting diodes.

FDC also has developed enabling manufacturing advances critical to commercial success of flexible displays in collaboration with its industrial partners. Examples include a large area thin film coater with industrial partner EV Group, a high quality performance plastic substrate with DuPont Teijin Films and a low temperature planarizing thin film material with Honeywell Electronic Materials.

"Critical path technology" advances include materials, tools and processes for flexible systems, state of the art thin film transistors, and flexible displays that are rugged, conformal, bendable and rollable.

"In our first five years, we covered considerable technical ground in development of flexible displays and integrating them into Army technology demonstrators," Raupp said. "For the next five years we want to create technology demonstrators that have even greater performance capabilities, including displays up to 15 inches diagonal, higher resolution, full color and possessing greater on substrate functionality, which means including more flexible electronics, like solar power, sensors and communications capabilities."

These all are attainable goals, Raupp added, because of the powerful capabilities of the FDC – including its pilot line, simulation and design model packages, and assembly and test capabilities. But they also are attainable because the FDC has assembled a great team of industry partners and ASU researchers, engineers and technical specialists who can make the revolutionary displays a reality.

<u>FDC industry members include (* indicates FDC charter members):</u>
• Principal members – EV Group,* Universal Display Corp.* and Flextech Alliance (formerly USDC).*
• Associate members – E Ink Corp.,* LG Display, Hewlett Packard, DuPont Teijin Films, Kent Displays Inc.,* Honeywell,* AKT (Applied Materials), Ito America,* SSI, Etched in Time Inc., Litrex, Plextronics and Particle Measuring Systems.
• Technology user members – General Dynamics C4S,* Raytheon,* L3 Communications and Boeing.