NextFlex

Flexible Hybrid Electronics Manufacturing

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NextFlex, America's Flexible Hybrid Electronics Manufacturing Innovation Institute, is a program formed out of a cooperative agreement awarded to the nonprofit FlexTech Alliance on Aug. 28, 2015. NextFlex is the seventh manufacturing innovation institute created to scale up emerging technologies, foster American innovation, and establish a U.S. manufacturing base to accelerate transition into both defense and commercial products. Headquartered in San Jose, California, the "capital of Silicon Valley," the Institute harnesses the region's electronic manufacturing entrepreneurs and innovators, along with a robust U.S. network of manufacturing nodes, to advance a national flexible hybrid electronics (FHE) manufacturing ecosystem. This positions the United States for continued leadership in a critical technology area.

NextFlex is built upon public-private partnerships, and its FHE focus area exists at the intersection of U.S. manufacturing strengths—electronics

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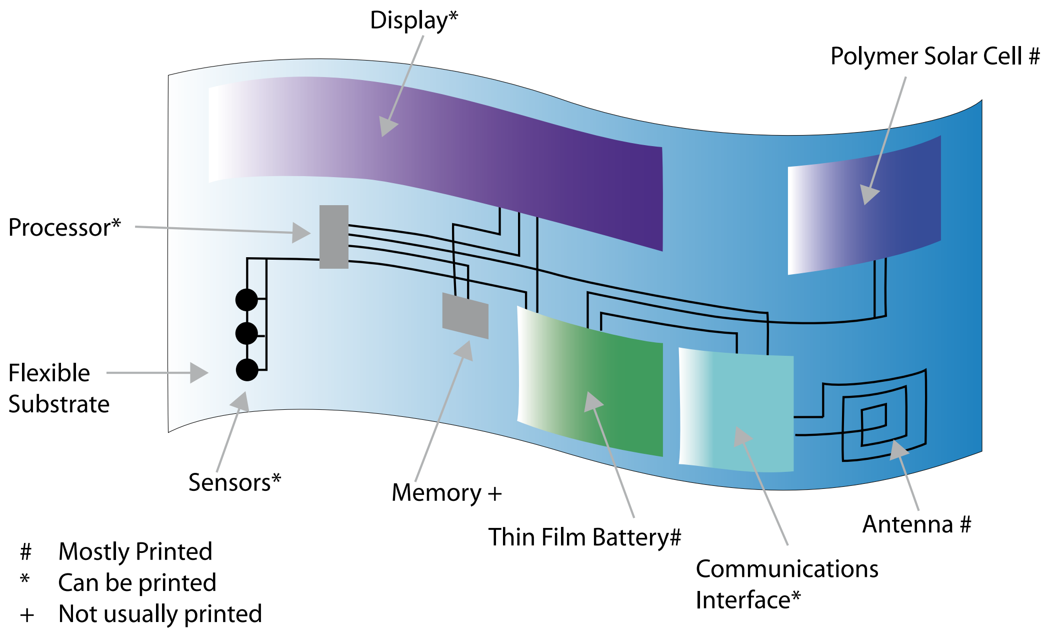
Figure 1. Flexible, Hybrid Electronics (Simplified)



Source: FlexTech Alliance

packaging and high-performance printing industries. In February 2016—just 6 months after its award was granted—NextFlex announced 32 Founding Members from these industry segments and academia. To date, the institute has 43 members from across these industry segments, as well as academic partners, with many more in the process of development. Its public-partnership team also includes more than 17 Department of Defense (DoD) and other government agencies across the country that provide technical support to advance FHE technology for their respective missions.

Manufacturing Innovation

FHE is best described as the intersection of additive circuitry, passive devices and sensor systems that may be manufactured using printing methods for flexible substrates—sometimes referred to as printed electronics—with thin, flexible silicon chips or multichip interposers inserted into devices. (See Figure 1 for a simplified view of FHE.) Together, these technologies can take advantage of the power of silicon and the economies and unique capabilities of printed circuitry to form a new class of devices for the Internet of Things (IoT), robotics, communications and medical markets.

While primarily using the term "flexible," the institute covers manufacturing methods that fall into the categories of flexible, stretchable and conformable. The applications are nearly endless—imagine pushing electronics, which are typically housed in rigid, square boxes, into close contact with rounded, flexible parts of the world around us. Consider intelligent bandages, which are placed on a patient's skin and able to monitor vital signs and transmit data to a doctor. Or imagine peel-and-stick sensors that monitor temperature, vibration and other data for critical equipment, reporting location and status through the cloud. Finally, think about high-performance antennas and radios being printed on the wings of aircraft, or large safety sensors being adhered to structures to warn of danger. NextFlex is pursuing methods to scale up today's FHE laboratory experiments into smart, affordable products. FHE manufacturing encompasses innovative electronic packaging processes, such as automated high-speed pick and place, printing processes, and fabrication of sensing elements, with substrate handling and imprinting. These innovative manufacturing processes will integrate thin flexible silicon electronic devices, sensing elements such as biomedical devices, communication devices, and power into novel conformal, flexible and stretchable platforms. FHE will create novel sensor and device form factors through the convergence of traditional electronic packaging and high-precision printing industries that advance high-tech U.S. manufacturing.

Scale up of manufacturing processes to Manufacturing Readiness Level 7 will catalyze these disparate supply chain elements and enable a national ecosystem that creates novel products for the DoD and the larger commercial sectors across health and human monitoring, wearable electronics, and medical devices that interconnect the world around us through the IoT. Electronic Design Automation (EDA) software tool development is a critical focus area for the institute that brings together the printed circuit board (PCB) and integrated circuit (IC) industries with the mechanical design software packages. Suppliers only recently have begun adopting these design tools for new FHE materials sets, form factors, and applications. The software design tools will encompass multiphysics simulation (e.g., electrical, thermal, mechanical, etc., interactions based on first principles physics modeling to optimize device performance) to deliver a complete circuit layout supporting FHE component integration.

The technical manufacturing objectives will provide new abilities to the DoD and commercial products as dramatically reduced electronic systems size and weight lead to systems that can conform to complex shapes such as aircraft wings, unattended vehicle platforms, and human bodies. These advances are creating innovative medical devices that can take on human-soft robotic interfaces or be implanted or applied. They can monitor health or stimulate physiology for the benefit of many groups, such as warfighters, the elderly, and those with chronic conditions.

The institute technical strategy features nine technical roadmaps (see Figure 2), each developed and maintained by a separate Technical Working Group. Five of these represent Manufacturing Technology Areas (MTA): Device Integration, Materials, Printed Flexible Components and Microfluidics, Modeling and Design, and Test and Reliability. Supplementing these manufacturing topics are four Technology Platform Demonstrators (TPD), representative product platforms used to integrate the technologies proven by the MTAs and representing critical application sectors: Human Monitoring, Asset Monitoring, Integrate Array Antennas, and Soft Robotics. Cross-cutting influences exist between these two groups. Design requirement developed by TDP working groups are fed into the MTA working groups, which then develop a schedule of technical priorities and specifications for project calls. Project results from across all five MTAs are then brought into the definition of TDPs to demonstrate an integrated solution with associated production processes.

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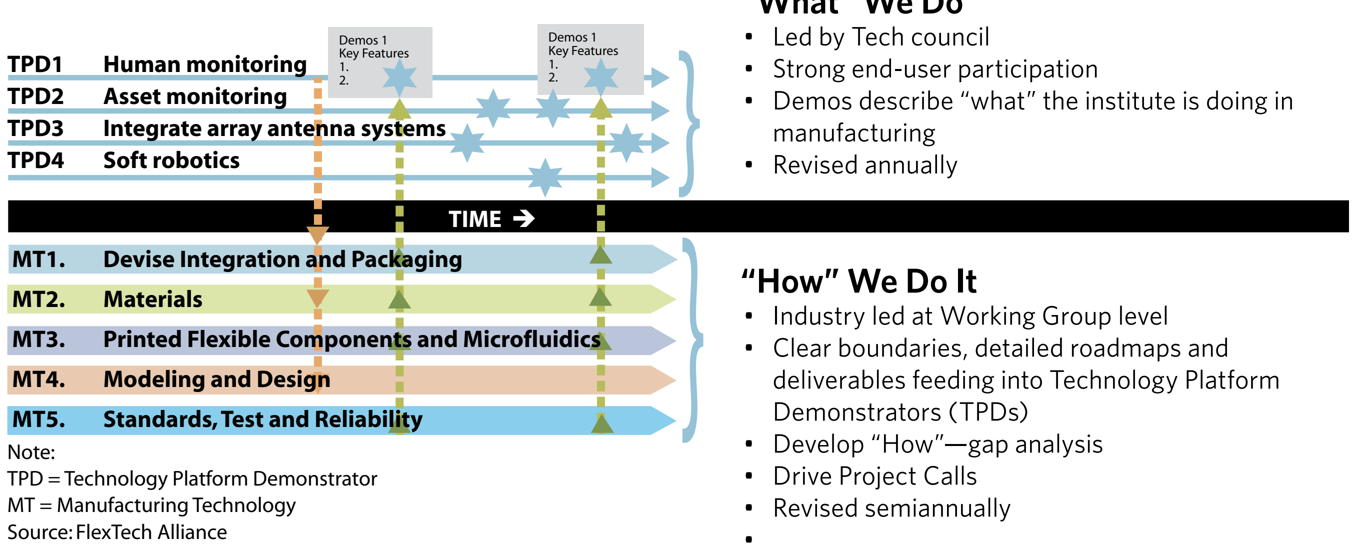
Accelerated Beginning Due to Previous Consortium Experience

NextFlex membership provides many ways for companies to participate in technical planning and activities—e.g., shaping and maintaining the NextFlex technology roadmap. Members also participate in institute-funded projects, education/workforce development, and institute governance. Other key aspects of membership include access to the Institute hub facility in San Jose and partner nodes throughout the United States, and participation in a friendly intellectual property (IP) policy designed to reward invention and speed commercialization. The tiered structure presents various opportunities to more directly influence the overall direction of the organization, especially at the higher levels.

NextFlex experienced a rapid start to membership and project calls due to previous industry consortium experience. In particular, the FlexTech alliance has a well-established membership agreement and IP policy that has been proven acceptable to both industry and academic institutions. This policy grants IP ownership to the inventor but balances the rights of the inventor with rights of institute members to experiment with

Figure 2. Strategic Roadmapping Framework



Note:
TPD = Technology Platform Demonstrator
MT = Manufacturing Technology
Source: FlexTech Alliance

NextFlex workforce development also is conducting a number of other pilot programs across the country that bring together academia and industry to create aligned education and work-based career pathways.

manufacturing advances. The NextFlex IP model allows all members access to IP developed using Institute funding for R&D purposes, but requires payment of licensing fees to the owner for purposes of commercialization. The IP policy also considers issues such as blocking IP, background IP, and reasonable levels for nonexclusive licensing costs. Through previous experience and by seeking feedback from representative members before the award, NextFlex was able to accelerate the development and validation of the membership agreement and ensure that advanced technology developed within the Institute was widely disseminated through the U.S. FHE Industrial base.

The institute is moving very fast and has released two Requests for Proposal (RFPs) in 9 months after their award was announced by Secretary of Defense Ashton Carter. There were 73 proposals received in response to the first RFP that focused on addressing these FHE manufacturing challenges.

Workforce Development

In lockstep with its technological initiatives, NextFlex is laying the groundwork for anticipated FHE talent needs through its workforce development program. Innovative partnerships with organizations such as the BMNT consultant group in Palo Alto, California, and the Defense Innovation Unit experimental (DIUx) in Mountain View, California, focus on a range of activities that include the development and execution of weeklong "sprint" courses in lean startup designs with a focus on DoD problems. Similarly, another workforce development project is the Hacking for Defense course at Stanford University, which trains students and the next generation of personnel to work on challenging DoD problems. During this course, graduate students learn how to apply lean startup principles to DoD problems through the design, development and, in some cases, manufacturing of minimum viable products (MVP) or prototypes to demonstrate the viability of their ideas (see Figure 3).

NextFlex workforce development also is conducting a number of other pilot programs across the country that bring together academia and industry to create aligned education and work-based career pathways at the technician and technologist level to develop and deliver people with the right skills for companies within local and regional FHE ecosystems.

Finally, to help better understand the state of the FHE workforce, the institute is conducting a taxonomy study of the supply and demand aspects of the full talent pipeline across the FHE ecosystem.

By building workforces and by working toward technical manufacturing objectives, NextFlex is cultivating a balanced and thriving manufacturing ecosystem to create the next generation of crucial electronic products for the DoD and commercial segments.

For more information, see the website at http://www.nextflex.us/

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Figure 3. Growing a Lean, Flexible Workforce