The role of flexible medical devices in health monitoring and diagnosis

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The number of electronic devices and wearable sensors has rapidly increased in the past 5 years. The improved user interfaces and product functionality together with wireless connectivity has completely transformed how and where mobile devices are used. Wearable devices have become more popular, and today in addition to storing personal information such as credit cards, contact lists, location and email, these devices also monitor physical activity levels and heart rate. Further advances in hardware and software could enable in-home monitoring of vital signs and pre-existing medical conditions hopefully reducing the number of patients visit to clinics. While the way humans interact with electronic devices has evolved, innovation on the methods for design, fabrication and assembly of electronic devices has followed a slower pace. Today, discrete components are still assembled onto conventional electronic circuit boards and the final products exhibit a rigid form factor.

Medical devices, used for diagnosis and health monitoring, are fabricated with the same design rules and manufacturing technologies used in consumer electronic devices, with the added need for reliability and durability under the harsh hospital conditions. As a result, medical devices are heavy, intimidating and expensive. Considering that the human population is highly diverse, patients' ages and sizes span from tiny newborns to fully-grown elderly, it is surprising that up to date medical devices still follow the one-size-fits all approach. Often, signals are compromised by the mismatch between rigid and bulky medical hardware and the flexible soft human body. In some cases, medical conditions such as pressure ulcers and skin wounds cannot be monitored with electronic devices because the devices themselves would contribute to the advancement of the condition. In order cases, sophisticated diagnostic technologies, such as Magnetic Resonance Imaging (MRI) cannot be used in pediatric patients because of the weight of the hardware. The weight and bulkiness of medical devices can also limit augmented rehabilitation. Customized, made-to-fit, confortable medical devices could revolutionize the way medical conditions are diagnosed, treated and monitored. The realization of such vision requires the development of new sensing platforms, new manufacturing capabilities and a fresh look at design and packaging of medical devices.

Over the years, several approaches have been proposed as manufacturing solutions for flexible electronics. Amongst the approaches, direct deposition of electronic materials onto flexible substrate via printing technologies has gain momentum in large area displays and photovoltaics applications. This technique offers high through put manufacturing over large areas and facilitates design customization. Several printable electronic components such as light emitting diodes (LEDs),

photodetectors, capacitors, thin film transistors, inductors and resistors have been demonstrated and could be used as building block for sensing systems. In such devices, electronic materials are deposited from solution-processed materials using a combination of deposition techniques such as blade coating, screen-printing and inkjet printing. In order to obtain a truly flexible, wireless and wearable device, a system level approach that takes into consideration power, functionality, manufacturing and user case must be adopted. It has been demonstrated that signal to noise ratio is greatly improved when devices are placed in close proximity to the body. Flexible medical devices designed for monitoring human vital signs, such as body temperature, heart rate, respiration rate, blood pressure and pulse oxygenation with applications in both fitness monitoring and medical diagnostics have been demonstrated. But challenges with integration with existing electronics and power remain. In this talk devices developed for vital sign monitoring, MRI and bioimpedance will be used as case studies to highlight the advances and challenges in the adoption of flexible medical devices.