What is Flexible Hybrid Electronics?

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Flexible electronics refer to integrated circuits implemented on bendable, rollable, conformable, or elastic substrates which are lighter, thinner, and inexpensive to manufacture [1]. Physical and low-cost advantages of flexible electronics have resulted in significant interest in recent years. Successful examples include flexible displays, sensors, photovoltaic cells, wireless tags, batteries, programmable logic circuits, simple micro-controllers, analog-to-digital converters (ADC) and radio frequency transmitters [2]. Due to its form factor advantages, flexible electronics technology has the potential to transform computing by enabling bendable and stretchable wearable systems at a low cost.

In spite of impressive progress in recent years, flexible electronics still suffer from significantly lower performance and larger parameter variations compared to silicon CMOS circuits [2]. For example, silicon technology offers more than 1 GHz frequency with features sizes as low as 14 nm, whereas the feature sizes of thin-film transistors (TFT) range from 8 μm to 50 μm, and frequencies hardly reach 10 MHz. **Flexible hybrid electronics (FHE)** technology addresses this problem by integrating rigid silicon integrated circuits and printed electronics. FHE can be used to combine rigid and flexible resources judiciously such that we can bridge the gap between the performance of flexible devices and conventional CMOS while preserving the form factor benefits of flexible electronics. Hence, FHE can drive the next big leap forward in device form factor, similar to the shift from laptop computers to smartphones and other hand-held devices.

FHE devices have attracted significant research interest in recent years due to their ability to combine the advantages of flexible electronics and conventional CMOS technologies. For instance, integration of CMOS devices on flexible substrates has recently been demonstrated at research centers including ASU Flexible Display Center. Circuits for interfacing flexible electronics and CMOS ICs have been also proposed [3]. Similarly, Khan et al. [4] developed devices that use FHE to monitor vital signs, such as heart rate and body temperature. While these studies show the advantages of FHE devices, there is still a need to develop standard methodologies for the design of FHE systems.

Design of FHE systems presents new challenges since we need to account for flexibility of the device as a new design metric [5]. The flexibility of an FHE device changes as a function of the substrate used, the number and size of rigid components, the location of components, and the flexibility of flexible components. Therefore, there is also a need for new flexibility-aware design tools and methodologies [6]. This will enable the development of standard design tools for FHE similar to the ones available for CMOS circuit design [7].

In summary, FHE can deliver a richer experience than currently available rigid wearable with the help of (1) physical flexibility (e.g., rollable or foldable devices become possible) and (2) wearable sensors that enable machines to understand and assist their users. Potential applications with high impact include human-computer interaction, health monitoring, gesture recognition, activity recognition, and patient rehabilitation.

References

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