Fiber Computing

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ABSTRACT

A wide variety of everyday objects consist of textile fibers (clothes, wall paper, chairs). Their primary purpose is structural and aesthetic. Fibers can have added functions by the integration of computing power into the material that forms them. The purpose of the Fiber Computing project is to integrate this new dimension of functionality into fibers, thus turn everyday objects into artifacts. Initial step is selection of materials and development of fibers. Into the microstructure of selected fibers, the basic unit of standard computation, the transistor will be implemented. This is done by doping of individual grains within the microstructure, which results in junctions necessary for making a transistor. At the moment, we are in favor of parallel, distributed, fault-tolerant and configurable architectures. Configurable fibers can be interwoven into everyday objects to create artifacts, which could be interconnected with each other.

Keywords

Wearable, fiber, textile, fabric, electronics, ubiquitous, material science, physical layer.

INTRODUCTION

We share the vision that "eventually, whole computers might be made from materials people are comfortable wearing"[4]. In a similar vein, Lind et.al. believes that "it is only appropriate that the field of textiles take the next evolutionary step towards integrating textiles and computers by designing and producing a weavable computer that is also wearable like any other textiles"[7].

Related Work

Current state of the art in integrating electronics with ubiquitous or wearable systems involves starting with packaged integrated electronic components, interconnected with each other on a printed circuit and enclosed by protective material/casing. In the case of wearable computers, state-of-the-art even with clever packaging techniques developed by product designers [5], we end up with bricks attached to the body. In the case of ubiquitous computing, taking the media cup [6] an example, we have electronics and the cup as two separate entities and the electronics needs to be removed for washing the cup. Current solutions in the industry include utilizing flexible printed circuit boards for flexible body-conforming devices. At the microscale, using inorganic semiconductors, there exists low-cost all polymer devices fabricated on flexible substrates[2]. Printable circuits are also promising[1]. We are beginning to see interesting approaches towards novel integration of electronics and objects. Post and Orth utilized conductive steel fibers and saw these fibers into clothing to replace passive components (i.e., wiring) and pointed in the direction of higher-scale integration. D. De Rossi et.al coated conventional fabrics with a thin layer of conducting polymer and observed interesting properties such as strain and temperature sensing. They demonstrated the sensing and actuation capabilities of these polymers with a glove prototype[3].

Potential Directions

In the framework of the European Commission Disappearing Computer project, along with National Microelectronics Research Center (NMRC), Ireland and Swiss Material Testing and Research Lab (EMPA), Switzerland, we will explore how to integrate electronics with objects containing fibers in their structure. At this point, we believe that instead of creating a new package for existing flat-substrate silicon devices, we should exploit the opportunities resulting from distributing sensing, processing and actuation over clothing. One possibility is to fabricate self-contained modules in large quantities, distributed along the length of a given fiber, where each module would have a power source, sensor, small amount of processing power and an actuator. This would not result in a 'computer' that would do arithmetic. It could, however, accomplish tasks for the wearer without the wearer explicity demanding the task to be accomplished. Simple tasks, as an example, could be changing visual patterns on a shirt based on certain local conditions, or thermal regulation could be another one. Another interesting architecture is the cell matrix[8]. Cell matrix is a parallel, fault-tolerant, scalable and configurable architecture which seems to be a good match for our physical implementation plan and requirements.

Two approaches will be taken, differing in the method of fiber production. One will be based on cutting strips from the single-crystal Si-wafer, and the other will be extrusion of semiconductor ceramic/polymer fibers. In the latter case, the ceramic will be polycrystalline and the polymer will be a mixture of amorphous and crystalline phases. In both approaches the transistor lay-out will be based on lithography. Packaging in each case will be custom.

The resulting physical implementation has implications on the human-computer interaction issues. Basic question is that, how can the user interact with modules that are distributed over clothing? Should we implement explicit control of the modules or build some knowledge into the system for autonomous decision making? How can the user stay in control at all times while having the system minimize unnecessary interruptions?

In conclusion, our first (bottom-up) target is to provide techniques for fabricating solid state devices on fibers. Different architectures could simplify the wiring and fault tolerance problems considerably. From a top-down perspective, as the promise of these devices are to enrich everyday life in a simple way, interfaces will impose constraints and/or requirements on the architecture.

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REFERENCES

1. Brent A. Ridley, Babak Nivi, and Joseph M. Jacobson. All-Inorganic Field Effect Transistors Fabricated by Printing. *Science* 1999 October 22;286: 746-749.
2. C. J. Drury, C. M. J. Mutsaers, C. M. Hart, M. Matters, and D. M. de Leeuw. Low-cost all-polymer integrated circuits. *Applied Physics Letters*, VOLUME 73, NUMBER 1, 1998.
3. D. DeRossi et. al "Dressware: Wearable Hardware," *Mat. Sci. Eng.* C7, 31-35, 1999.
4. E.R. Post and M. Orth. Smart Fabric, or "Wearable Clothing". Proc. *First International Symposium on Wearable Computers*, Pittsburgh, PA, October 1997.
5. F. Gemperle, C. Kasabach, J. Stivoric, M. Bauer, R. Martin. Design for Wearability. Proc. *Second International Symposium on Wearable Computers*, Pittsburgh, PA, October 1998.
6. Hans-Werner Gellersen, Michael Beigl, Holger Krull. The MediaCup: Awareness Technology embedded in an Everyday Object. *1th Int. Sym. Handheld and Ubiquitous Computing* (HUC99) Karlsruhe, Germany, 1999.
7. J. Lind, S. Jayaraman, S. Park, R. Rajamanickam, R. Eisler, G. Burghart, and T. Mckee. A Sensate Liner for Personnel Monitoring Applications. Proc. *Second International Symposium on Wearable Computers*, Pittsburgh, PA, October 1998.
8. N.J. Macias, L.B. Henry, and M.D. Raju. Self-Configurable Parallel Processor Made From Regularly-Connected Self-Dual Code/Data Processing Cells. U.S. Pat. 5,886, 537.