Automated Design of Microfluidics-Based Biochips: Connecting Biochemistry to Electronics CAD

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Microfluidics-based biochips are soon expected to revolutionize laboratory procedures involving molecular biology. Advances in microfluidics technology offer exciting possibilities in the realm of enzymatic analysis, DNA analysis, proteomic analysis involving proteins and peptides, immuno-assays, and environmental toxicity monitoring. Another emerging application area for microfluidics-based biochips is clinical diagnostics, especially the immediate point-of-care diagnosis of diseases.

As the use of microfluidics-based biochips increases, their complexity is expected to become significant due to the need for multiple and concurrent assays on the chip. There is a need to deliver the same level of computer-aided design (CAD) support to the biochip designer that the semiconductor industry now takes for granted. These CAD tools will allow designers to harness the new technology that is rapidly emerging for integrated biofluidics.

This talk presents early work on CAD tools that allow biochip users to describe bioassays at a sufficiently high level of abstraction. It describes synthesis tools that can map behavioral descriptions to a droplet-based microfluidic biochip and generate an optimized schedule of bioassay operations, the binding of assay operations to functional units, and the layout and droplet flow-paths for the biochip. Cost-effective testing techniques are presented to detect faults after manufacture and during field operation. It is shown how on-line and off-line reconfiguration techniques can be used to easily bypass faults once they are detected. Thus the biochip user can concentrate on the development of the nano- and micro-scale bioassays, leaving implementation details to design automation tools.

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