Synthesis of on-chip control circuits for mVLSI biochips

Microfluidic VLSI (mVLSI) biochips help perform biochemistry at miniaturized scales, thus enabling cost, performance and other benefits. Although biochips are expected to replace biochemical labs, including point-of-care devices, the off-chip pressure actuators and pumps are bulky, thereby limiting them to laboratory environments. To address this issue, researchers have proposed methods to reduce the number of off-chip pressure sources, through integration of on-chip pneumatic control logic circuits fabricated using three-layer monolithic membrane valve technology. Traditionally, mVLSI biochip physical design was performed assuming that all of the control logic is off-chip. However, the problem of mVLSI biochip physical design changes significantly, with introduction of on-chip control, since along with physical synthesis, we also need to (i) perform on/off-chip control partitioning, (ii) on-chip control circuit design and (iii) the integration of on-chip control in the placement and routing design tasks. In this paper we present a design methodology for logic synthesis and physical synthesis of mVLSI biochips that use on-chip control. We show how the proposed methodology can be successfully applied to generate biochip layouts with integrated on-chip pneumatic control.