ICSS Research Needs: Circuit Design

Addressing the Grand Challenges listed in the 2005 International Technology Roadmap for Semiconductors (http://public.itrs.net) requires circuit design research to focus on six main areas: management and optimization of circuit power and energy, design of robust circuits, the design of high performance circuits, circuit design in advanced technologies, applications for advanced circuits, and cross-disciplinary research. These categories and their respective sub-categories are highlighted in page 2 of this document.

Technology scaling allows increasingly higher levels of integration but with the drawback of significantly increasing levels of leakage current. This requires renewed focus on power optimization that is exercised at every level of circuit design; from the selection of devices, to the circuit topologies used, to the methods of interconnecting the circuits. Technology scaling also results in reduced control over feature sizes and reduced reliability of devices. This requires robust circuits that can tolerate device parameter variations due to process spread. It also requires circuits that will continue to operate when a portion of its devices are not functional, or where there is excessive coupling from other devices and interconnects due to the high density of implemented circuits.

Technology scaling also allows the design of higher performance circuits either through increases in circuit frequency or integration including the integration of multiprocessors and several levels of memory hierarchies on the same chip. This requires improving the performance of the core digital circuits as well as addressing the issues of clock scalability that arise in highly integrated silicon ICs. In addition to these focus areas, SRC continues to be interested in specific application areas for advanced circuit design including memory, analog/RF circuits, and energy-efficient high speed communications. SRC also continues to strongly encourage work in topics that bridge multiple research areas including semiconductor device processing and modeling, packaging, and CAD tools.

Finally, with the continuing trend towards SoC integration of past discrete and disparate designs, testing and post silicon validation has become increasingly complex. Complete controllability and observability for embedded functions within a highly complex and integrated design is both unrealistic due to limited I/O and unwanted for purposes of security and IP protection. For those designs that are targeted for SoC, PIs are encouraged to address on chip functional and performance testing as designers must shoulder more responsibility for the post silicon validation of their work.

2006 Circuit Design Needs Categories	
C1	**Circuit Power/Energy Management/Optimization**
C1.1	Minimize circuit, device, and interconnect power; multiple voltage/multiple threshold domain designs
C1.2	Control or exploitation of gate and channel leakage
C1.3	Thermal management circuitry
C1.4	Circuits techniques for energy storage
C1.5	Energy scavenging
C2	**Circuit Design Robustness**
C2.1	Tolerance and increased reliability for manufacturing/process variability, including random and systematic fluctuations
C2.2	Design for increasing reliability with unreliable components and soft errors
C2.3	Noise tolerant circuits/isolation techniques and signal integrity
C2.4	Adaptive analog, digital, and memory circuits
C3	**High Performance Circuits**
C3.1	High performance digital circuit design
C3.2	Circuits for high-speed communications
C3.3	Clocking: Scaling, multiple clock domains, and asynchronous
C3.4	On-chip interconnect scaling, including high-speed signaling techniques and interconnect driven design techniques
C3.5	Circuits for analog/RF BIST
C4	**Circuits in Advanced Technologies**
C4.1	Low voltage circuit design including subthreshold design
C4.2	Analog/RF design in scaled “digital” technologies
C4.3	Digital circuits with low I_{on}/I_{off} in extreme scaled CMOS
C4.4	Circuit design techniques with advanced CMOS device structures
C5	**Application Areas for Advanced Circuit Research**
C5.1	Digital equivalent implementations of analog/RF circuit designs
C5.2	On-chip memory circuits
C5.3	Silicon CMOS integration and electrical interface for on-chip photonics and MEMs circuits
C6	**Bridging Research Across Disciplines**
C6.1	Semiconductor materials/processes/device and circuit design interactions/co-development
C6.2	Design productivity – CAD and circuit interactions
C6.3	Device modeling in advanced technologies
C6.4	Package and circuit interactions – high frequency, low noise, EMI management, cost effective packaging
C6.5	Mixed-signal isolation technologies for SoC and SiP