

Critical reliability challenges for the international technology roadmap for semi...

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EXECUTIVE SUMMARY This document highlights the principal reliability challenges associated with key semiconductor technologies and identifies the research needs to assess and control the reliability risks. Based upon the consensus of the Reliability Technical Advisory Board (RTAB), the top five issues that deserve the most attention are high-k gate dielectrics, metal gate, copper/low-k interconnects, packaging, and design and test for reliability. Within high-k gate dielectrics, metal gate, copper/low-k interconnects, the introduction of new materials, processes, and devices presents challenges. Bulk material and interface properties usually define the intrinsic reliability characteristics while defects establish the extrinsic reliability characteristics.

Process integration flow, techniques, and process tools often create first order reliability effects (both intrinsic and extrinsic). The importance of characterizing these materials and processes for reliability as well as for performance during the early development stage cannot be overstated. System-on-chip (SOC) products that typically integrate new function and often include large memories (SRAM, DRAM, and Flash) bring about unique design, integration, and test challenges. Microsystems require consideration of a wider range of failure modes than microelectronics alone and introduce new failure modes because of the interaction of diverse technologies that would not be present if each technology were manufactured on a separate chip.

In addition, optical, chemical, and biometric sensors and micromachines (MEMs) require the development of new accelerated tests and failure

mechanism models. Electrostatic discharge (ESD), latchup, and packaging in the nanometer regime also raise reliability concerns. Even though ESD and latchup effects have been well characterized for many years, scaling brings about new issues and concerns. Similarly, the increased complexity and performance requirements for packaging these products act as an exponential multiplier for many of the failure mechanisms besides introducing new ones. Finally, two critical crosscut issues are related to design and test.

These may be the more difficult challenges as the work needed to reach solutions is typically dispersed across many organizations, sites, and partners. Integration efforts tend to be less focused than material and device issues. Although the challenges may be clear, the paths to find solutions tend to be fragmented and obscure; consequently, these items require special research focus. This document is neither a complete nor exhaustive list of reliability challenges for the ITRS. Certainly any area of technology advancement includes its own set of potential reliability problems and new challenges.

Instead, those broadest or most critical challenges are highlighted. It is hoped that this document can provide perspective and guidance as well as improve the dialog with other technologists working to develop the 2003 edition of the ITRS.