compared with Murphy's theory. The more accurate models used for characterization and control of fabricators are also discussed. In addition, the methodology of dealing with photolithographic defects is explored. Some of the finer details of the historical development of this topic have often been overlooked, but are treated here in detail with references to the earlier work.

High-performance optics—fundamental constituent of equipment for VLSI circuit fabrication. Klaus-Dieter Gattnar, Klaus Merkel, Hans-Joachim Schilling and Wolfgang Seide. *Jena Rev.* **1**, 6 (1989). The increased integration level in microelectronics—such as in memory devices in the Mbit range—necessitates the rational and precise generation of submicron features, which is not readily possible with existing photolithographic equipment, the line resolving power of which is limited by the now-common exposure wavelength of 436 nm and apertures of 0.2 to 0.4. With our present top-of-the-line lens, the UM-AÜR 1:5/ 0.25...0.40, feature widths of 0.8 μm can be generated under laboratory conditions of fields sized 8 mm × 8 mm.

Three-dimensional process and device modeling. S. Selberherr and E. Langer. *Microelectron. J.* **20**(1–2), 113 (1989). This contribution is intended to review the international state-of-the-art in three-dimensional process and device modeling. As one particular example, results for ion implantation into a three-dimensional trench are presented. Redistribution of dopants, interstitials and vacancies with fully coupled models is discussed. The recent refinements to carrier transport models in semiconductor devices are presented. As a particular example for three-dimensional device simulation the influence of the shape of the field-oxide in the width direction is discussed. Some remarks on the computational requirements are made.

Multiplexing input options of VLSI circuits implemented in four-phase dynamic logic technology. D. C. Patel. *Microelectron. J.* **20**(3), 1 (1989). Four-phase dynamic logic has been widely used to implement VLSI circuits. A technique which allows system designers to operate a custom-designed integrated circuit in different modes is to connect an input option pin to either a logic level 1 or a logic level 0 according to the specification by connecting it to V_{cc} or ground respectively. This method allows the designer to configure the operation of the circuit in one of the two modes. In this paper it is shown that each pin can be used to offer four modes of operation instead of two by the use of a simple multiplexing circuit. The circuit was simulated and its operation verified using the industry-standard program SPICE. The additional area required to implement the demultiplexing circuit on the chip may be offset by the saving achieved by the use of one pin to input four variables instead of two pins. Removal of an input pin from the integrated package results in the saving of silicon area on the chip as it eliminates the contact pad area and the associated input gate protection circuitry.

Application-specific integrated circuits (ASICs)—a mainstream line of VLSI device fabrication. Peter Winkler and Michael Hentschel. *Jena Rev.* **1**, 18 (1989). Compared with standard ICs, application-specific integrated circuits represent an entirely new quality of application. The user of a standard IC such as a microprocessor purchases a device with manufacturer-defined properties. Its application, therefore, is nothing else but the utilization of these given properties. The user of an ASIC has a substantial share in its development; the ASIC is fabricated in a version that is adapted to the specific application.

Application, thus, has adopted a new dimension for the electronic device designer: as the application of ICs is replaced by the application of fabrication processes, it is possible for users to design electronic devices in the form of semiconductor chips. Depending on

- the technical specifications (complexity, parameters),
- the required quantity and
- the time by which functional prototypes are required,

the user may resort to different classes of ASICs, viz.

- programmable logic devices (PLD),
- gate arrays,
- standard cells, and
- custom circuits.

New effects resulting from the co-operation between process engineering and equipment design in IC fabrication. Ulf Gottschling. *Jena Rev.* 1, 10 (1989). The fabrication of microelectronic devices of ever-greater complexity and ever-smaller features would not be possible without a close interdisciplinary co-operation between all operations involved, i.e.

- circuit design,
- fabrication process development,
- fabrication equipment development and
- the development of new process materials.

With reference to the development of fabrication equipment, a number of problems have to be solved, which are partially interlinked. These include

- the increasing precision, homogeneity and repeatability of all machine and process parameters,
- the continuous minimization of particle generation in the fabricating machines,
- automatic sequence control of the machines, with *in situ* measurement of some of the process parameters,
- progressive automation by interfaces to computer networks affording automatic control and monitoring of the fabrication,
- automatic reading of wafer or magazine codes,
- loose or rigid interconnection between fabricating machines, and
- improved reliability and availability of the machines.

6. MICROELECTRONICS—COMPONENTS, SYSTEMS AND EQUIPMENTS

Three-dimensional integrated circuit: technology and application prospect. Yoichi Akasaka. *Microelectron. J.* **20**(1–2), 105 (1989). This paper describes the features and state-of-the-art of process and device technologies of three-dimensional ICs. Various kinds of application proposals for three-dimensional structures are also presented and discussed. One of the most promising application areas in future is believed to be image sensing and processing. The SOI and some other new technologies are applied to fabricate a functional model of an intelligent image processor with a three-layer structure, resulting in a new synthetic operation consisting of light sensing, quantization, and signal processing. The capabilities of multi-functional operation and the parallel processing verified in this miniature system give a clear image of the future of three-dimensional ICs.