NAND-based conventional implementations. Considering all 81 non-equivalent Boolean functions included in the study, it was found that in 63 percent of the cases, fewer logic gates (and, hence, fewer transistors) would be needed in the G^{4}FET-based implementations.

Web-Enabled Optoelectronic Particle-Fallout Monitor

A user can interrogate this instrument from a remote location.

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A Web-enabled optoelectronic particle-fallout monitor has been developed as a prototype of future such instruments that (l) would be installed in multiple locations for which assurance of cleanliness is required and (2) could be interrogated and controlled in nearly real time by multiple remote users. Like prior particle-fallout monitors, this instrument provides a measure of particles that accumulate on a surface as an indication of the quantity of airborne particulate contaminants. The design of this instrument reflects requirements to:

- Reduce the cost and complexity of its optoelectronic sensory subsystem relative to those of prior optoelectronic particle fallout monitors while maintaining or improving capabilities;
- Use existing network and office computers for distributed display and control;
- Derive electric power for the instrument from a computer network, a wall outlet, or a battery;
- Provide for Web-based retrieval and analysis of measurement data and of a file containing such ancillary data as a log of command attempts at remote units; and
- Use the User Datagram Protocol (UDP) for maximum performance and minimal network overhead.

The sensory subsystem of the Web-enabled optoelectronic particle-fallout monitor includes an infrared light-emitting diode (LED) that illuminates a silicon wafer. Highly discriminating photodiodes measure the light scattered at right angles to the illumination. The scattered light is measured both (1) during illumination by the LED and (2) when the LED is turned off so that only ambient light is present. The ambient infrared scattered-light reading is subtracted from the illumination scattered-light reading to obtain a net scattered-light reading. In principle, the amount of scattering attributable to particles on the wafer, and thus the number of particles on the wafer, is closely related to the ratio between the net scattered-light reading and the LED output, with a correction for temperature that affects the photodiode junction and a small additional correction for ambient light. Photodiode readings of the LED output are taken for eventual use in calculating the ratio, and temperature is measured for eventual use in calculating photodiode junction corrections, but at the present prototype stage of development, the ratio and corrections are not calculated and, instead, the number of particles accumulated on the wafer is estimated as being simply proportional to the net scattered-light reading. Other features of the instrument design include the following:

- The instrument includes a built-in Ethernet/Web server communication subsystem and a microprocessor tied directly to this subsystem.
- A power-over-Ethernet feature provides for the use of one wire for control, data communication, and power supply. This feature is also compatible with battery or wall-outlet power.
- The microprocessor receives commands via the Web and/or the Ethernet, initiates and controls operation of the sensory subsystem, and collects data.
- The instrument communicates with a desktop personal computer that is capable of gathering information from as many as 1,000 instruments like this one. The personal computer, in turn, provides information to a Web server computer for archiving and analysis.
- Photodiode outputs are sampled by 24-bit analog-to-digital converters (ADCs), controlled by the microprocessor, at a repetition rate of 20 Hz. Included within the ADCs are filters that suppress, by more than 80 dB, interfering signal components at the 60-Hz power-line frequency that have been found to be present in photodetector outputs of similar prior instruments. An ADC output exhibits a differential count of >25,000 between the clean and 0.5-percent-obscured wafer conditions. The normal sample-to-sample range is within 32 counts.
- Optionally, the instrument can be set to send an electronic-mail message directly to a designated person when an out-of-bounds condition (e.g., a particle count in excess of a prescribed limit) occurs.
- Integrity of data is ensured by use of both UDP checksums and cyclical redundancy checks.