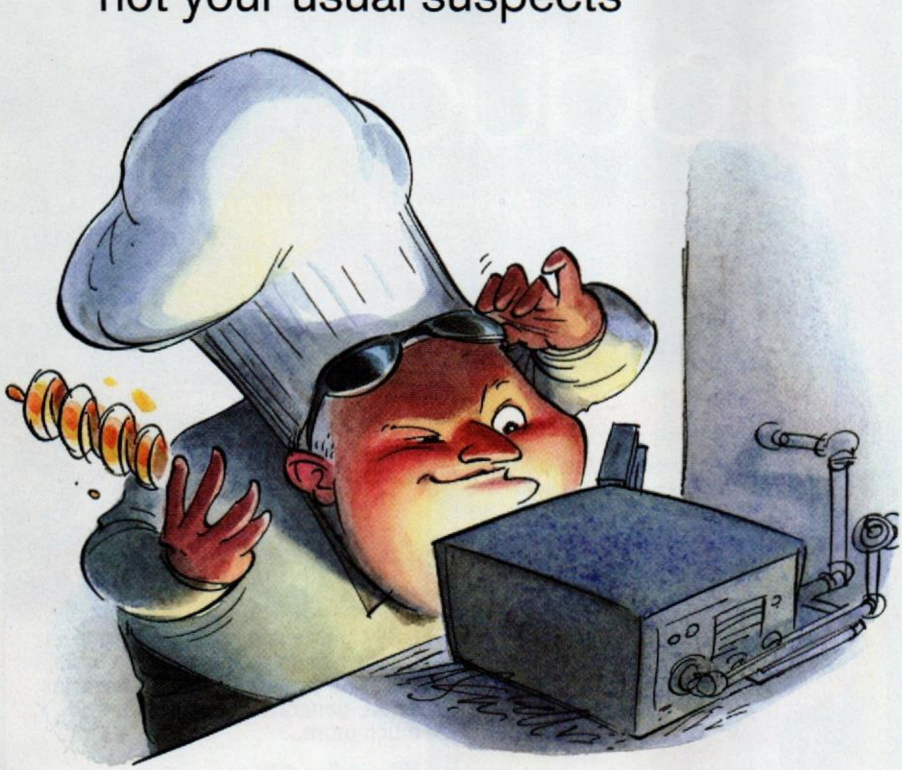
BY MARTIN DELATEUR • CONSULTANT

Contamination: not your usual suspects



While working in the 1980s for a major semiconductor manufacturer, we had a major yield problem that was baffling the production team. Yields were decreasing on a daily basis because of high leakage failures. The usual suspects in this case are positive ions (sodium) or heavy-metal contamination causing leakage in the oxide layers. Sources for these ionic contaminants can range from a defective dopant bottle to a bag of chips an operator sneaks into the fabrication facility. We applied all the usual approaches to correcting the problem, including changing diffusion sources and cleaning all the glassware, and the yields improved.

We used CV (capacitance-versus-voltage) plots to determine that heavy metal was the source of the decrease in yields and determined that, after cleaning, we had eliminated the source. Unfortunately, only a week later, the problem returned. The CV plots once again confirmed the presence of heavy metal. The next step was to replace all the large, expensive quartz tubes in the diffusion oven. Wafers sat in these tubes while the oven heated and diffusion gases flowed over the wafers. Replacing these tubes upset the production-team members, but they felt that they had at least cured the contamination problem.

The transistors inside the new quartz tubes were good ones and met all the specifications. Everything was fine for three months. Then the exact same problem developed again. Transistor yields plunged, and it seemed that heavy metal was again the problem. The team ran many experiments and tried several approaches to determine the source of the contamination. Investigations found that there was gold in the silicon and that it was ruining the electrical properties. When you use gold in high-speed switching transistors, it provides a place for hole-electron pair recombination, speeding transistor switching. For linear transistors, however, the gold just ruins the properties with excessive leakage and poor low-current amplification. But the investigators thought that they had eliminated any and all potential sources of gold contamination.

After some extensive research on what had changed in the fab, they found that the fab had brought in a used diffusion oven from another division. The diffusion oven had come from a line that was making high-speed chips, and that other line had at one point used the oven for gold diffusion. Changing glassware was not permanently solving the problem. If gold could diffuse into the quartz tubes, it could also continue on and contaminate the heating coils. We got a new set of quartz tubes and also changed the heating coils.

Even after three months, the transistors coming out of that furnace were just fine. It turns out that, in the old factory, the gold had continued to diffuse into the quartz. When the gold atoms reached the outside of the quartz tube, they deposited themselves on the nichrome heating coils. It had taken three months for the gold to diffuse from the outside to the inside of the tubes; it then began to ruin the wafers inside the tubes. This fact amazed the production people, but anyone who has worked on semiconductor processes knows that you can never just look at the usual suspects. EDN

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