Forecasting Failure

Determining Chip Quality at the Nanoscopic Level, DMEA may Avert Disaster

Wouldn't it be great if a microchip could be analyzed for reliability without all the messy, lengthy field testing? Maybe, thanks to research being done at DMEA, it can.

Problem

Computer manufacturers are designing components as throwaways that are more dependent on size and price than durability. That tactic works fine for a cell phone, but not for essential rocket components.

The Physics of Failure (PoF) problem becomes more important as more power gets put on smaller wafers and increased heat causes electro-migration of metal ions from transistor to transistor. Before long, the materials fuse together and wear out. "It's a huge problem," says Dr. Gary Gaugler, Defense Microelectronics Activity (DMEA) Technical Advisor.

The Department of Defense needs a way to determine which individual chips will last longer under the stressful conditions of military activity, something that has been impossible to predict – until now.

Solution

Just as Galileo turned the telescope to the heavens to find patterns that impact human life on earth, Gaugler is using electron backscatter diffraction (EBSD) technology to look at the grains of metal of transistors and predict lifespan based on consistency of the grain. This commercial quality control process collects crystallographic information using a scanning electron microscope to shoot a stationary electron beam at a tilted crystalline sample, sending diffracted electrons onto a fluorescent screen. The resulting pattern is considered characteristic of the crystal structure can be used to determine characteristics of the material being tests.

Gaugler had used all the traditional methods -- X-ray defraction, cross section microanalysis -- in an attempt to predict the PoF. None pointed to visible signs that a particular chip when used to navigate a jet or control a rocket might last longer than another chip. Then he came up with the idea of looking at the grain of the metal at the very smallest of levels.

Case Study

Gaugler simulated the life of the chip by subjecting it to environmental stresses by heating it to 150 degrees centigrade for a day. Then he turned the EBSD scope on the panel and looked at the distribution of grain size at a resolution of 90nm (to put this into perspective a nanometer is 10 to the -9th meter, or one billionth of a meter). His hypothesis is that the slope of change and degree of return is a measure of reliability. The more the result resembles a bell curve, the smaller the deviation in size and the less likely that the chip will wear out sooner than expected.

Benefits

- Eliminates time-consuming field testing
- Illustrates fiber texture
- Removes ambiguity about grain orientation and boundaries at the nanoscopic level
- Indicates patterns of consistency
- Predicts reliability

Once again, the Department of Defense had a need for a customized electronic service that the market wasn't meeting so DMEA adapted commercial quality control technology to determine the characteristics of materials that will meet essential, demanding military applications. Problem solved.

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