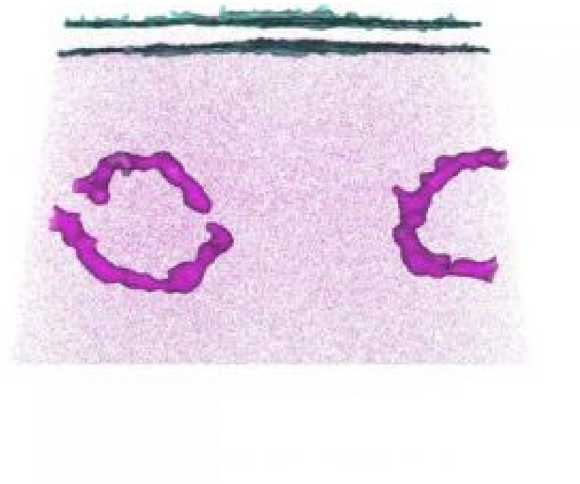
Researchers find a crucial difficulty in semiconductor device scaling

September 6 2007



Distribution of dopants revealed by atom probe. Credit: © Imago Scientific Instruments

In 1959, Nobel Prize winner Richard Feynman presented a talk entitled "There's Plenty of Room at the Bottom." Feynman concluded that there was no physical reason why humans couldn't manipulate atoms. However, if atomic manipulation is achieved the question of observing the new atom positions remains. How do you know what you have done?

As reported in the Sept. 7, 2007 issue of *Science*, IBM and Imago have taken a seminal step along the path to achieving Dr. Feynman's vision by observing, for the first time, distributions of individual dopant atoms in semiconductor devices.

Atom probe tomography was used to quantify the location and elemental identity of the atoms proximate to defects in silicon. The dopants were implanted into the silicon uniformly and it was always hoped that the distribution of dopant atoms would be uniform.

However, the IBM and Imago researchers found that clusters (more properly Cottrell atmospheres) of dopant atoms form around defects after ion implantation and annealing. Furthermore, these atmospheres persist in surrounding dislocation loops even after considerable thermal treatment creating dopant fluctuations that may ultimately limit the scalability of semiconductor devices.

“This is the first time that unambiguous quantitative 3D information regarding the precise location of individual dopant atoms relative to defects has been available” said study co-author and Imago CEO Tom Kelly. “The ability of the Imago LEAP 3000X Si laser assisted atom probe to make this measurement is the fruition of many years of instrumentation and applications development. We now have a powerful new way to probe the atomic positions of dopants in a semiconductor device. This is a critical tool for scientists seeking to answer Professor Feynman’s challenge to manipulate matter at the atomic level and hence enable nanotechnology.”

Previously, researchers have used secondary ion mass spectrometry (SIMS) and transmission electron microscopy (TEM) to correlate indirectly the presence of dopant atoms with the evolution of defects, and detailed models have been proposed to account for these experimental correlations. However, the atom probe study published in Science reports, for the first time, the location of individual dopant atoms. Said Imago Senior Director of Applications and co-author David Larson, “The Sept. 7 *Science* article is the most recent in a series of significant scientific advances reported by Imago’s customers.” Added Dr. Larson, “In addition to producing breakthrough published scientific results, the Imago atom probe is also being applied to various industrial problems. These proprietary results are advancing scientific knowledge, enabling the development of new products, and improving time to market for our customers."

Source: Imago Scientific Instruments

Citation: Researchers find a crucial difficulty in semiconductor device scaling (2007, September 6) retrieved 20 April 2024 from
https://phys.org/news/2007-09-crucial-difficulty-semiconductor-device-scaling.html