High-resolution optical imaging of current and temperature in integrated circuits

Technology #cu12300

There is a growing need for diagnostic techniques to assess the performance and stability of integrated circuits (ICs), both for commercial and research purposes. Specifically, the distribution of current and temperature within the chip are important for IC diagnostics. Magnetic and thermal imaging techniques have been developed to measure current and temperature, respectively; however, existing techniques are typically limited to micron-scale spatial resolutions. This technology is an optical imaging technique to detect current and temperature distributions at extremely high spatial resolutions (~10 nm). This high resolution is achieved by depositing a current- and temperature-sensitive coating of diamond nanoparticles on the surface of any IC. Following optical excitation, the nanoparticles emit fluorescence signals that can be detected using a modified optical microscope, allowing for localization and quantification of current and temperature within the IC.

Engineered diamond nanoparticle coating can resolve variations in current and temperature at ~10 nm resolution

This technology offers vastly improved spatial resolution compared to current IC diagnostic techniques. Such high spatial resolution is obtained through the use of diamond coatings that contain point defects called nitrogen vacancies (NVs). NVs emit fluorescence upon laser excitation at an intensity that varies with current and temperature. These NVs are highly sensitive to changes in magnetic field and temperature and can detect fluctuations at distances of ~10 nm. The importance of high spatial resolution is likely to increase in time as ICs become smaller and more compact. Furthermore, the use of optical microscopy as an imaging method allows for a wide field-of-view camera to be employed, permitting high-resolution functional mapping of the entire chip at once. Assessment of both current and temperature can be performed using the same chip, eliminating the need for multiple tests.

This technique can also simultaneously resolve current in separate layers of stacked ICs. Thus, in addition to offering superior spatial resolution, this technology reduces the complexity and time required for IC diagnostic testing.
Lead Inventor:

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Applications:

- Current/temperature diagnostics of integrated circuits
- Quality control systems for ICs
- Verification of IC functionality
- Protection against malicious hardware
- Optical imaging of magnetic fields and temperature

Advantages:

- Nanoscale spatial resolution
- Simultaneous measurement of current and temperature
- Able to image current in multiple layers in stacked ICs
- Uses familiar optical microscopy imaging

Patent Information:

Patent Pending (WO/2013/188732)

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Related Publications:


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