Optical methods for defect detection and imaging of silicon integrated circuits (ICs) are crucial for microelectronics. Circuit analysis relies on either the monitoring of electrical signal variation under optical excitation or the imaging of photoemission and scattering from the microelectronic structures. A correlated reflection image is necessary for registering the analytical information to the circuit layout. Current IC technology includes a multitude of opaque metal layers, thus hindering frontside optical imaging of buried device layers.

Therefore, nearly all optical analysis and inspection techniques require backside imaging through the silicon substrate. In backside imaging, optical absorption in the substrate restricts the optical spectrum to energies below the silicon bandgap, thus limiting the lateral resolution in backside microscopy to about 1 μm in conventional systems.

Utilization of solid immersion imaging by the introduction of numerical aperture increasing lens (NAIL) revolutionized the way that IC inspection is conducted, allowing high-resolution backside imaging of silicon ICs. A silicon NAIL placed on the backside of the substrate increases the numerical aperture (NA) by a factor of the square of the refractive index, to a maximum of 3.5 in silicon. An immediate impact of this technique has been observed in the semiconductor industry.

Recently, we demonstrated high-resolution widefield subsurface microscopy of ICs by exploiting the intense induced current imaging, our approach allows for very tight focusing; thus, light emanating from other layers results in a nearly uniform backside image. By subtracting this background, we achieve distinguishable images of features in individual layers with relatively high contrast. Stacked polysilicon and metal layers can be imaged individually down to a longitudinal separation of 1.2 μm.

The fast and easy image acquisition capability of widefield microscopy combined with high-resolution NAIL microscopy offers a unique prospect for assisting failure analysis of ICs. Our experimental demonstration of record lateral and longitudinal resolution in widefield microscopy suggests that this imaging modality will have an impact on the analysis of modern ICs, allowing nanoscale imaging.

References