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Wave-Interrogated Near-Field Array System and Method for Detection of Subwavelength Scale Anomalies

Anomalies on semiconductor substrates, such as process contaminants, post-polishing substrate fragments, or voids, must be accurately located and identified in order to obtain the cleanliness required by the next generation of integrated microcircuits. While technological advances have reduced the critical anomaly size to less than 80 nm, existing conventional optical beam scattering approaches are incapable of detecting anomalies so minute in size; indeed, current optical scattering approaches can accurately detect objects no smaller than approximately 500 nm. The diffraction limit (approximately 1/3 of the wavelength) of the light dictates the maximum detection limit, which is consequently on the order of 150 to 200 nm for visible light.

While investigators have proposed schemes to defeat the diffraction limit by concentrating the radiated energy into subwavelength areas, these schemes generally suffer from very small transmission efficiencies (i.e. the ratio of incident power to power at the tip) because these schemes concentrate the wave energy by guiding the wave through closed waveguides that are so small compared to the wavelength that most of the incident energy reflects before reaching the tip. Moreover, the enormous scanning times required to physically scan entire wafer surfaces at such extreme focus further complicates these schemes. Still, because optical instruments and sources in the visible range are very mature and reliable, an optical system that circumvents the diffraction limit is a more attractive alternative to perform such detections than is a newly developed approach that would operate at frequencies beyond the visible range.

Researchers at Arizona State University have developed a detection approach that exploits the benefits of near-field energy concentration, while retaining the convenience and speed of far-field scattering data collection. This approach employs a near-field probe consisting of an open-circuited moderately-sized antenna to detect subwavelength sized defects on the surface below the probe.

Potential Applications

- Detection of Anomalies on Semiconductor Substrates

Benefits and Advantages

- Exploits the Increased Detection Range of Near-Field Energy Concentration ? detects subwavelength defects on a substrate surface; a probe illuminated at optical frequencies (670 nm) and suspended at 60 nm above the surface of the substrate has been shown to be able to detect anomalies 45 nm wide by 30 nm thick

- Permits Subwavelength-Scale Mechanical Scanning to Detect Sub-80 nm Defects over an Entire Surface ? the array need only scan over one period cell (of the order of 450 nm) to detect all defects in the area covered by the entire array
- Employs Existing Optical Instruments and Sources ? optical sources in the visible range are very mature and reliable; cost effective