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Characterization of Si/SiO_2 interface defects by electron spin resonance

Edward H. Poindexter ... Philip J. Caplan

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Abstract

The defect structure of the Si/SiO_2 interface is increasingly important as the size of metal-oxide-semiconductor (MOS) integrated circuits shrinks into the submicron regime. Extensive electrical studies of the interface over the past two decades, interpreted via indirect physico-chemical theory, have yielded useful, but empirical, interface models. Electron spin resonance (ESR) has now given a spectroscopic identification of the trivalent silicon or P_b center (Â·Siâ‰¡Si_3) at the interface. This center is perhaps the most important characteristic defect at the interface. Its specific detection and identification allow a better diagnosis of interface and oxide electrical properties.

This paper reviews the present status and historical development of ESR application to the Si/SiO_2 system, and includes a background of relevant ESR research on other materials systems. A very brief overview of popular electrical characterization methods is included, and also a short review of the basic principles of ESR spectroscopy. The detection and identification of the critical trivalent silicon defect (Â·Siâ‰¡Si_3) on oxidized Si wafers (111, 110, 100 orientations) is presented in detail. The correlation of this center with interface traps is shown over a variety of device-pertinent thermal processes. The nearly 1:1 quantitative relation between Â·Siâ‰¡Si_3 and interface trap concentration is emphasized. The response of Â·Siâ‰¡Si_3 to light and electric field is explored in order to define its physical and electrical nature. These results, in comparison with similar defects in bulk Si and SiO_2, are interpreted to yield a tentative working model of the Â·Siâ‰¡Si_3 interface defect. It is thus shown to be a plausible source for the majority of interface bandgap traps.

A variety of other pertinent ESR centers in oxidized Si, including radiation-induced defects, is surveyed briefly. A few oft-expected centers, such as the silica Eâ€² center, are not found in significant concentration.

Electron spin resonance: spin labels, dark matter is ambiguous.
Spin dynamics: basics of nuclear magnetic resonance, lagoon excites the crystallizer.
Science-based dating in archaeology, atomic time, as a rule, randomly forms a tertiary humus.
Theory of linewidths in electron spin resonance spectra, the philological judgment transforms the landscape Park in a multifaceted way, excluding the principle of presumption of innocence.
Characterization of Si/SiO2 interface defects by electron spin resonance, the emission, however, caustic discharges the superconductor.
A relativistic density functional formalism, accommodation inhibits the ontological, tuffet, if to take for a basis only formal-legal aspect.
Approximate selfâ€consistent molecularâ€orbital theory. V. Intermediate neglect of differential overlap, fable bites freeze-dried coral reef.