Controlling Ultrashallow Junction Formation through Surface Chemistry

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Forming extremely shallow pn junctions with very low electrical resistance is becoming an insurmountable stumbling block to the continued scaling of microelectronic device performance according to Moore's Law. We have developed a technology based on surface chemistry that holds great promise for simultaneously reducing junction depth and increasing activation for dopants implanted into silicon. The approach uses the surface as a large controllable “sink” that removes Si interstitials selectively over dopant interstitials. We have discovered a new way to employ adsorption at the surface for this task: adjusting the intrinsic loss rate of interstitials to the surface. We control the interstitial loss rate to the surface by saturating dangling bonds using adsorbed nitrogen (introduced as ammonia) before implantation or the subsequent annealing step. To demonstrate such effects, we have measured SIMS profiles of isotopically labeled Si (mass 30) implanted into a Si host lattice depleted in this isotope, The annealed profiles with an atomically clean surface change relatively little from the as-implanted profile, while the profiles with adsorbed N change much more. We have quantified the loss rate of interstitials at the surface by measuring the annihilation probability, which varies from about 0.05 on atomically clean Si(100) to about 0.0008 with only 1% of a monolayer of adsorbed N.