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Ultralong Coherence of Phosphorus Donors in High-Purity ^{28}Si Silicon S.A. LYON, A.M. TYRYSHKIN, Princeton University, S. TOJO, K.M. ITOH, Keio University, J.J.L. MORTON, Oxford University, T. SCHENKEL, Lawrence Berkeley National Laboratory, M.L.W. THEWALT, Simon Fraser University, H. RIEMANN, N.V. ABROSIMOV, Institute for Crystal Growth, IKZ, P. BECKER, PTB Braunschweig, H.-J. POHL, VITCON Projectconsult GmbH — We report on electron spin coherence measurements for phosphorus donors in high purity, highly-enriched ^{28}Si, with residual ^{29}Si of less than 50 ppm. At this low ^{29}Si density, spectral diffusion processes by nuclear spin flip-flops are suppressed, and therefore other relaxation processes become prominent. By examining a series of ^{28}Si crystals with a donor concentration of 1×10^{14} to 3×10^{15}/cm^3, we identified three decoherence mechanisms, all related to dipole interactions between donors: (1) instantaneous diffusion, caused by flips of donor spins induced by the applied microwave pulses; (2) spectral diffusion caused by T_1-induced flips of neighboring donors; (3) spectral diffusion caused by donor spin flip-flops. We demonstrate how all three mechanisms can be suppressed, leading to measured coherence times extrapolating to T_2 $\sim$10 sec. The work was funded by DOE and LPS.

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