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Field effect of fixed negative charges on oxidized silicon induced by AlF_3 layers with fluorine deficiency

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Abstract

We recently discovered that in an $AlF_3/SiO_2/Si$ structure extrinsic electrons are trapped at fluorine (F) vacancies in AlF_3 at the interface with SiO_2, generating a high sheet density of fixed negative charges.

p- and n-Type Si substrates were oxidized using rapid thermal oxidation (RTO) or furnace oxidation (th); some samples were passivated in hydrogen (H_2). AlF_3 was deposited onto oxidized Si wafers by a modified PVD process, leading to a F deficiency (AlF_x). Samples were characterized by mercury probe (Hg) CV and microwave photo conduction decay (μW-PCD), determining charge and trap densities and effective carrier lifetime τ_{eff}, respectively. An effective charge density of up to $|Q_{eff} = -6.9 \times 10^{12}$ cm^{-2} is reached due to electrons tunneling from Si into AlF_3, occupying F vacancies. Lifetime scans of p-type float zone (FZ) Si samples with 1.5 nm RTO and 20 nm AlF_3 show an increase in effective minority carrier lifetime by a factor of 8.4 compared to samples with 1.5 nm RTO only. The fixed negative charge density increases with exposure time to sunlight or at simulated ageing by a 24 h anneal at 200 °C in air.

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