

Comprehensive study of rapid, low-cost silicon surface passivation technologies

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Abstract:

A comprehensive and systematic investigation of low-cost surface passivation technologies is presented for achieving high-performance silicon devices such as solar cells. Most commercial solar cells today lack adequate surface passivation, while laboratory cells use conventional furnace oxides (CFO) for high-quality surface passivation involving an expensive and lengthy high-temperature step. This investigation tries to bridge the gap between commercial and laboratory cells by providing fast, low-cost methods for effective surface passivation. This paper demonstrates for the first time, the efficacy of TiO/sub 2/, thin (<10 nm) rapid thermal oxide (RTO), and PECVD SiN individually and in combination for (phosphorus diffused) emitter and (undiffused) back surface passivation. The effects of emitter sheet resistance, surface texture, and three different SiN depositions (two direct PECVD systems and one remote plasma system) were investigated. The effects of post-growth/deposition treatments such as forming gas anneal (FGA) and firing of screen printed contacts were also examined. This study reveals that the optimum passivation scheme consisting of a thin RTO with a SiN cap followed by a very short 730/spl deg/C anneal can 1) reduce the emitter saturation current density, J/sub 0e/, by a factor of >15 for a 90 /spl Omega/sq. emitter, 2) reduce J/sub 0e/ by a factor of >3 for a 40 /spl Omega/sq. emitter, and 3) reduce S/sub back/ below 20 cm/s on 1.3 /spl Omega/cm p-Si. Furthermore, this double-layer RTO+SiN passivation is relatively independent of the deposition conditions (direct or remote) of the SiN film and is more stable under heat treatment than SiN or RTO alone. Model calculations are also

performed to show that the RTO+SiN surface passivation scheme may lead to 17%-efficient thin screen-printed cells even with a low bulk lifetime of 20 /spl mu/s.

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