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18% efficient silicon photovoltaic devices by rapid thermal diffusion and oxidation

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For the first time, cells formed by rapid thermal processing (RTP) have resulted in 18%-efficient 1 and 4 cm/sup 2/ single-crystal silicon solar cells. Front surface pass... **View more**

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Abstract:

For the first time, cells formed by rapid thermal processing (RTP) have resulted in 18%-efficient 1 and 4 cm/sup 2/ single-crystal silicon solar cells. Front surface passivation by rapid thermal oxidation (RTO) significantly enhanced the short wavelength response and decreased the effective front surface recombination velocity (including contact effects) from 7.5/spl times/10/sup 5/ to about 2/spl times/10/sup 4/ cm/s. This improvement resulted in an increase of about 1% (absolute) in energy conversion efficiency, up to 20 mV in V/sub ot/, and about 1 mA/cm/sup 2/ in J/sub sc/. These RTO-induced enhancements are shown to be consistent with model calculations. Since only 3 to 4 min are required to simultaneously form the phosphorus emitter and aluminum back-surface-field (BSF) and 5 to 6 min are required for growing the RTO, this RTP/RTO process represents the fastest technology for diffusing and oxidizing /spl ges/18%-efficient solar cells. Both cycles incorporate an in situ anneal lasting about 1.5 min to preserve the minority carrier lifetime of lower quality materials such as dendritic-web and multicrystalline silicon. These high-efficiency cells confirmed that RTP results in equivalent performance to cells fabricated by conventional furnace processing (CFP). Detailed characterization and modeling reveals that because of RTO passivation of the front surface (which reduced J/sub 0c/ by nearly a factor of ten), these RTP/RTO cells have become base dominated (J/sub 0b//spl Gt/J/sub 0c/), and further improvement in cell efficiency is possible by a reduction in back surface recombination velocity (BSRV). Based upon model calculations, decreasing the BSRV to 200 cm/s is expected to give 20%-efficient RTP/RTO cells.

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