Tunneling oxide based selective contacts for high efficiency solar cells

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Abstract: The conversion efficiency of crystalline silicon solar cells, is limited by recombination losses associated with the contacts. Namely, a contact structure that simultaneously passivates the c-Si surface while selectively extracting only one type of charge carrier (i.e., either electrons or holes) is desired. Such passivating contacts in c-Si solar cells have recently become an important research objective. In this work we studied different selective carrier stacks using tunnelling SiO_2 and TiO_2 layers with variable combinations, along two routes: high temperature route, in which the silicon oxide is obtained by thermal oxidation and a low temperature route where the silicon oxide is obtained by chemical oxidation or by e-beam evaporation. Symmetrical silicon samples with TiO2/SiO2 stacks on each side were prepared and minority carrier lifetimes were measured, to assess the passivation properties of the contacts. SiO2 thickness measured by ellipsometry.

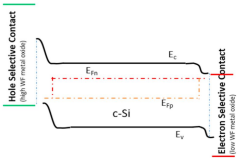
MOTIVATION

Standard contacts have high recombination and limit conversion efficiency

Point metal contacts can reduce this recombination. However this is more complicated to manufacture

Selective contacts allow to achieve both good passivation and carrier selectivity and can be applied on the whole surface

The ultimate goal is to manufacture doping free solar cells



RESULTS

SiO_2 Tunnel layer

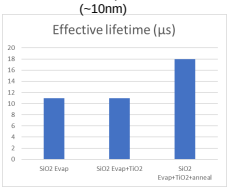
High Temperature

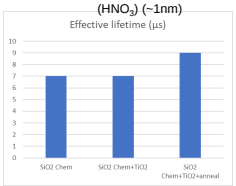
Low Temperature

E-beam evaporation (~10nm)

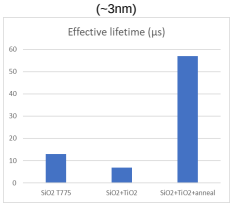
Chemical oxidation (HNO_3) (~1nm)

For the low temperature route, it was observed a progressive increase in life time, along the process, toping with the final annealing.

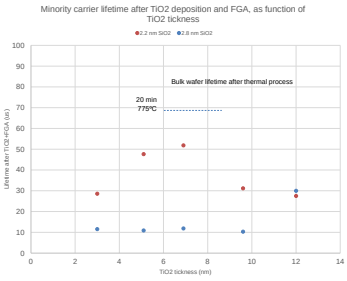




Thermal Oxidation 90' 775ºC (~3nm)



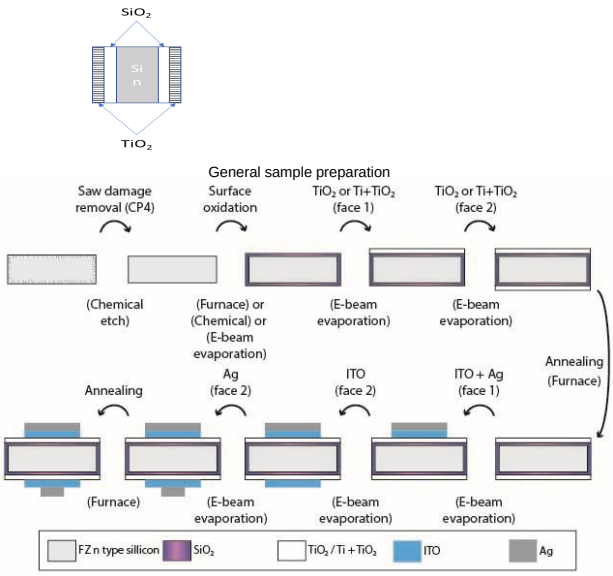
Oxidation at 900ºC showed better passivation, suffering a drop when stacked with TiO_2 , even though still at higher level than any of the low temperature stacks.



Oxidation at 775ºC resulted in the higher increase in lifetime along the process reaching higher lifetimes than the higher temperature approach.

PROCEDEURE

SiO_2 / TiO_2 layer samples



Silicon FZ n-type: 1-5 Ohm.cm, 280 µm thick, double sided polished
Annealing at 350 ºC for 5 min in forming gas

CONCLUSIONS

- The annealing step is critical for the effective selective contact formation.
- The high temperature route can induce lifetime degradation in the bulk of the wafer.
- An optimum TiO2 thickness, to minimize contact recombination, was obtained for the chosen SiO2 layer thickness.

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