# ENHANCING PHOTOVOLTAIC PERFORMANCE OF SILICON BASED HYBRID SOLAR CELLS WITH VANADIUM OXIDE AS TRANSPARENT CARRIER-SELECTIVE CONTACT

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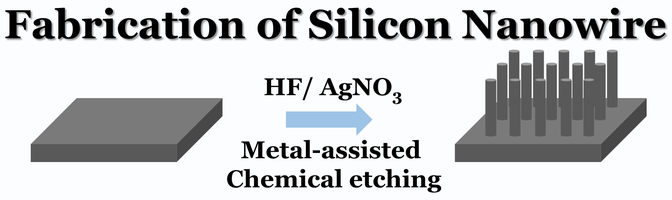
## Abstract

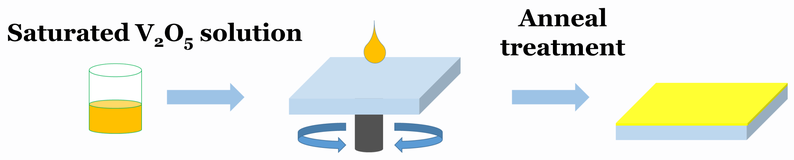
Silicon nanowire arrays with ultra-low reflectance approaching 3% was employed for the construction of hybrid solar cells. However, the photovoltaics devices still existed the inevitable phenomenon from possible recombination of carriers at contact electrode which significantly degraded the excited photocurrents. In this study, the strategy was undertaken for diminishing the charge recombination by taking advantage of the vanadium oxide ($VO_x$) as promising carrier-selective contact in the photovoltaic devices possessing the improved capability for electron blocking and hole extraction. Through detailed characterizations of crystallinity, chemical states, compositions and topography of formed structures, we found that the existence of mixed $V_2O_3$ and $V_2O_5$ phases based on a simplified solution processing method could benefit the improvement of both short-circuit current density and fill factor of cell devices. The resulting cell efficiency of such designed solar cells achieved 14.4%, which was around 1.6 times beyond the conventional $VO_x$-free hybrid solar cells.

## Experimental methods

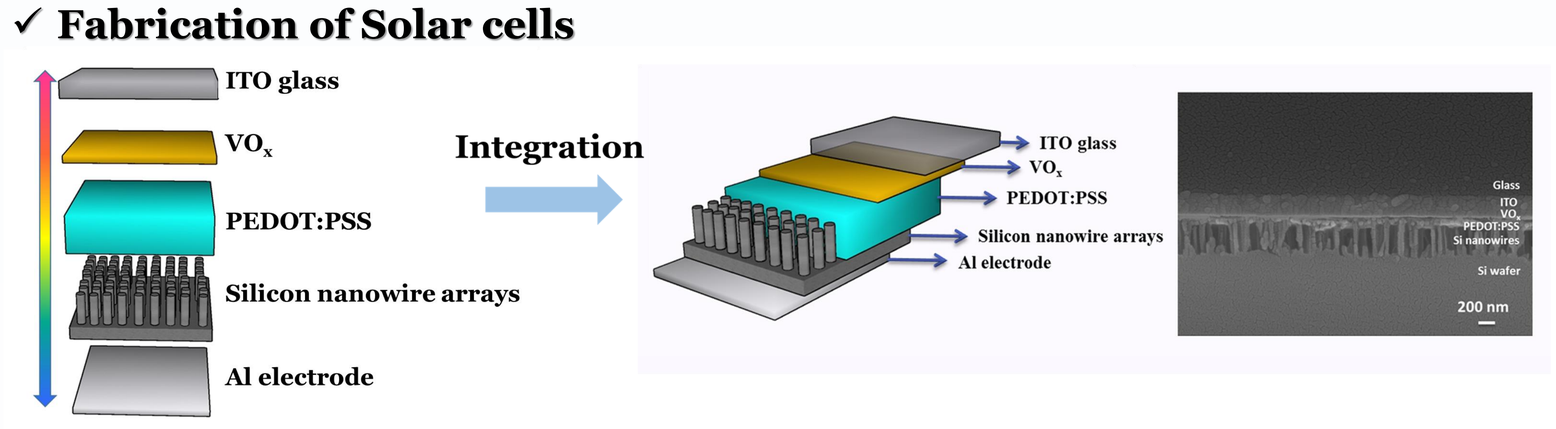
### ✓ Fabrication of Silicon Nanowire Arrays




### ✓ Fabrication of Vanadium Oxide layer

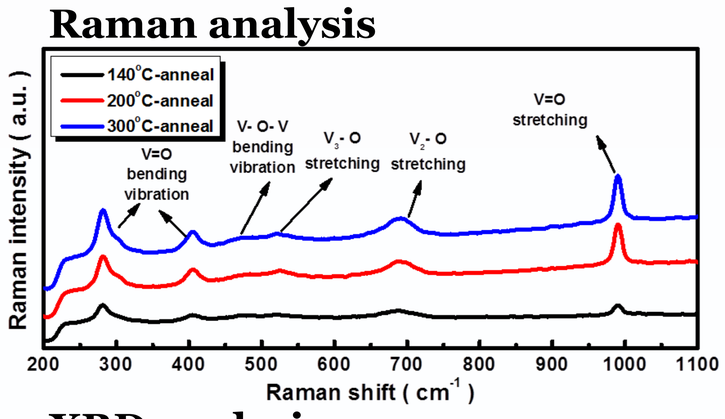



### ✓ Fabrication of Solar cells

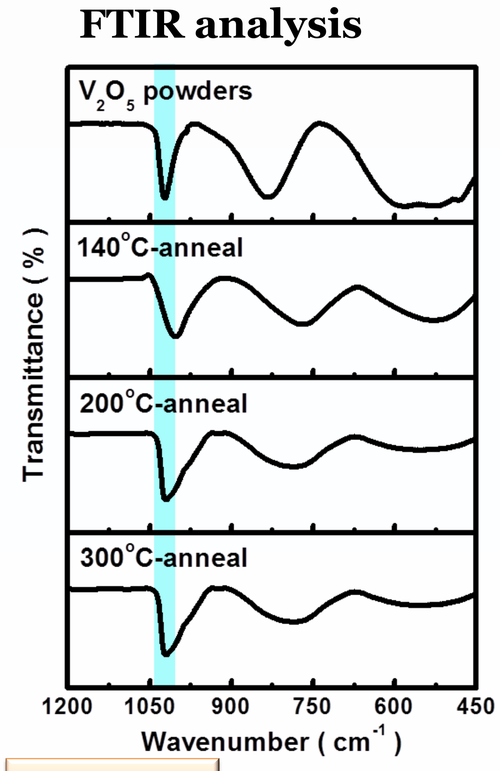



## Characterization

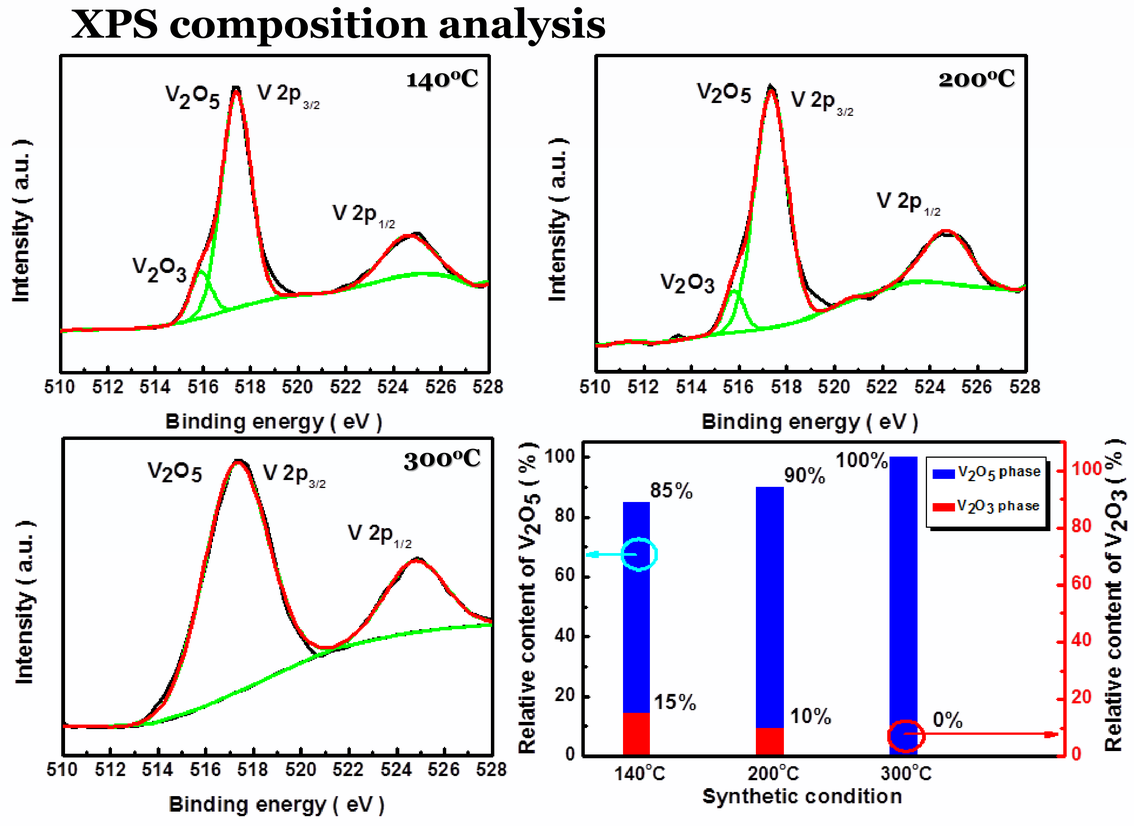
### Raman analysis



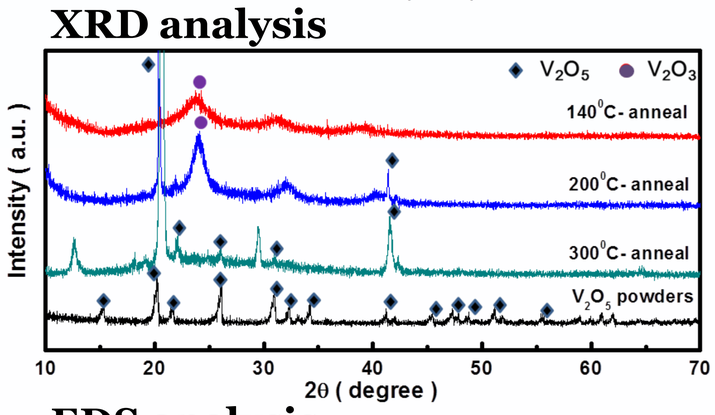

### FTIR analysis




### XPS composition analysis

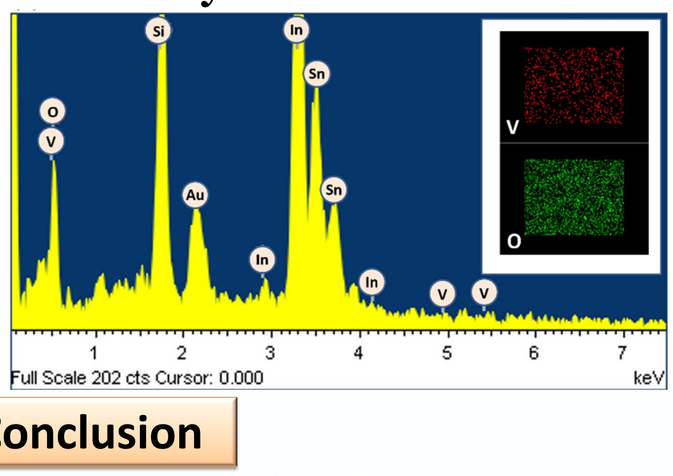



### XRD analysis

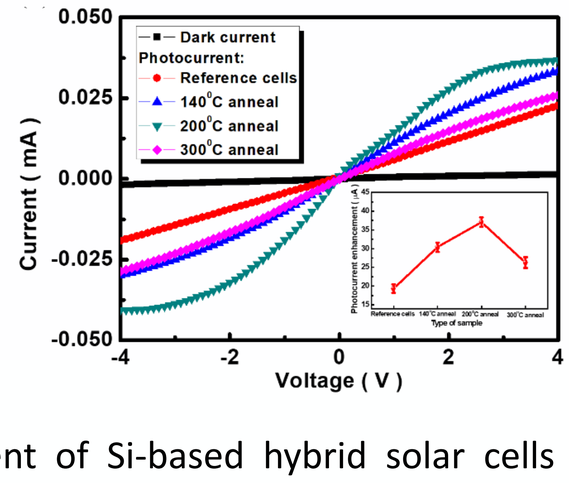



## Results

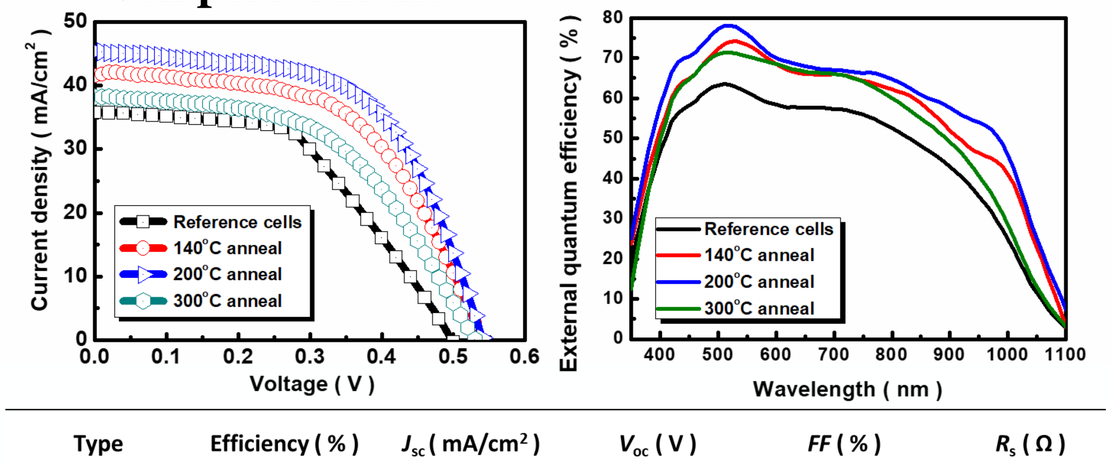
### EDS analysis




### Photocurrent measurement




### Cell performance




| Type | Efficiency ( % ) | $J_{sc}$ ( mA/cm² ) | $V_{oc}$ ( V ) | *FF* ( % ) | $R_s$ ( Ω ) |
|---|---|---|---|---|---|
| Reference cell | 9.1 | 35.6 | 0.499 | 50.91 | 6.31 |
| 140℃ anneal | 12.5 | 41.5 | 0.540 | 55.77 | 5.12 |
| 200℃ anneal | 14.4 | 45.4 | 0.541 | 58.31 | 4.86 |
| 300℃ anneal | 10.4 | 38.2 | 0.530 | 51.28 | 6.03 |

## Conclusion

In conclusion, the efficiency improvement of Si-based hybrid solar cells was achieved with the introduction the mixed $VO_x$ phases as an insertion layer that acted a decisive role on cell performances. We found that this introduced layer offered dual functionalities on both electron blocking and hole transport phenomena, resulting in the improved efficiency approaching 14.4% with around 1.6 times beyond the $VO_x$-free cells. This evidenced the incorporation pf $VO_x$ as transparent carrier-selective contact could be benefit the development of high-performance solar cells based on simple and reliable all solution-processing methods.

## Acknowledgements

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