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Improving Thin Silicon Solar Cells Utilizing Nanopillars By Silica Nanosphere Lithography and Metal-Assisted Chemical Etching

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Background

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- Thin wafers (< 100 µm thick) use less silicon than thick wafers (200-300 µm) but show less absorption of the longer wavelengths of light, thus decreasing cell efficiency.
- Nanopillars have been shown to increase the effective optical path length and therefore allow for greater light trapping.
- Current methods of fabricating nanopillars are costly and time consuming.

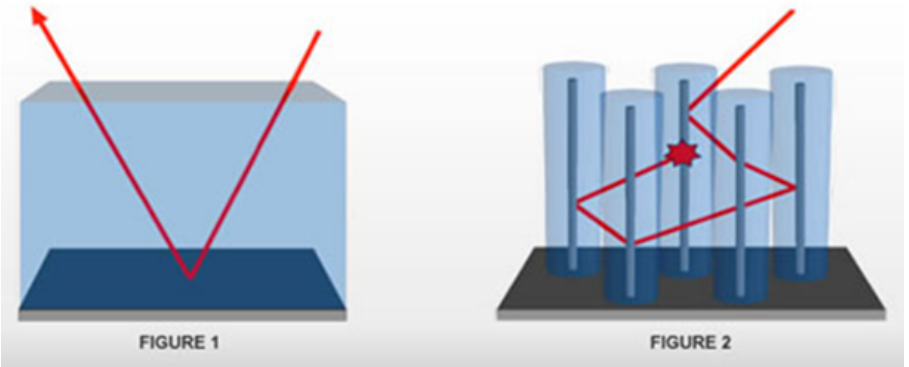
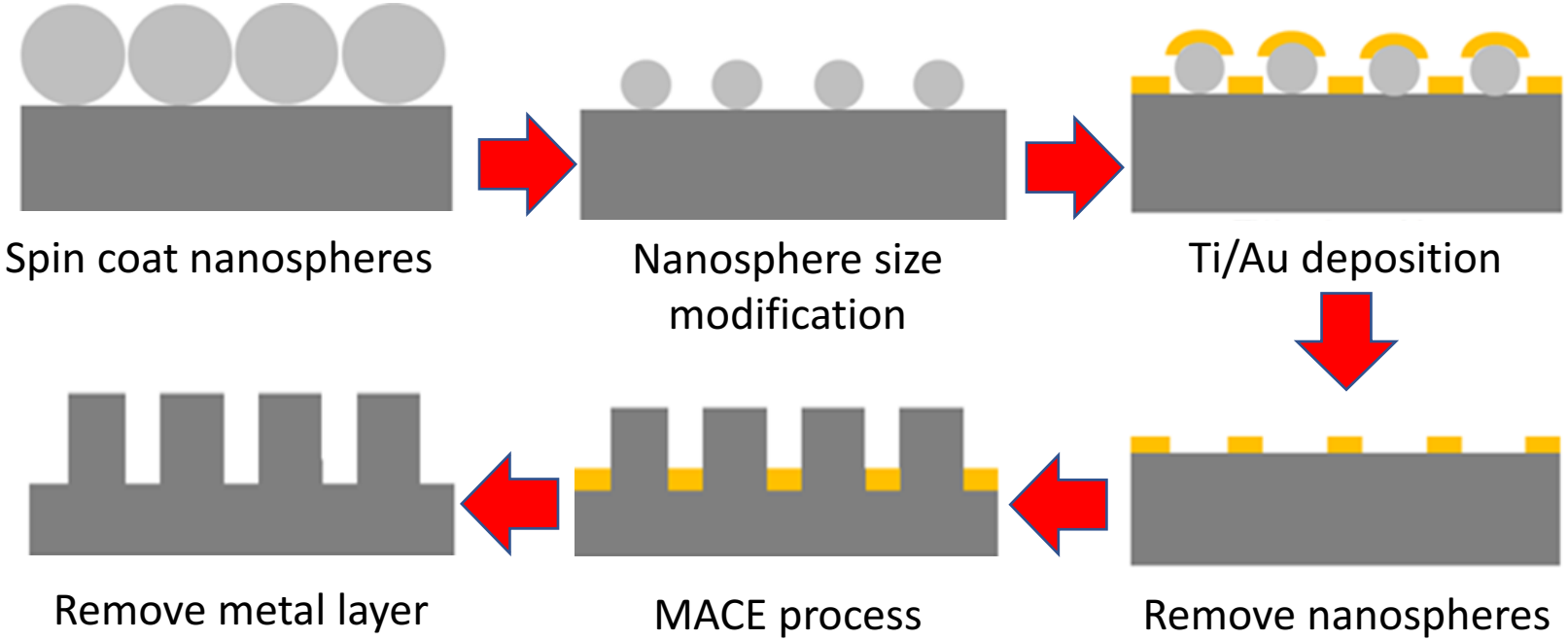


Image from “Solar Cells Getting a Makeover with Nanotechnology” Published June 28th, 2017. Available: http://www.21stcentech.com/solar-cells-makeover-nanotechnology/

Our Solution:

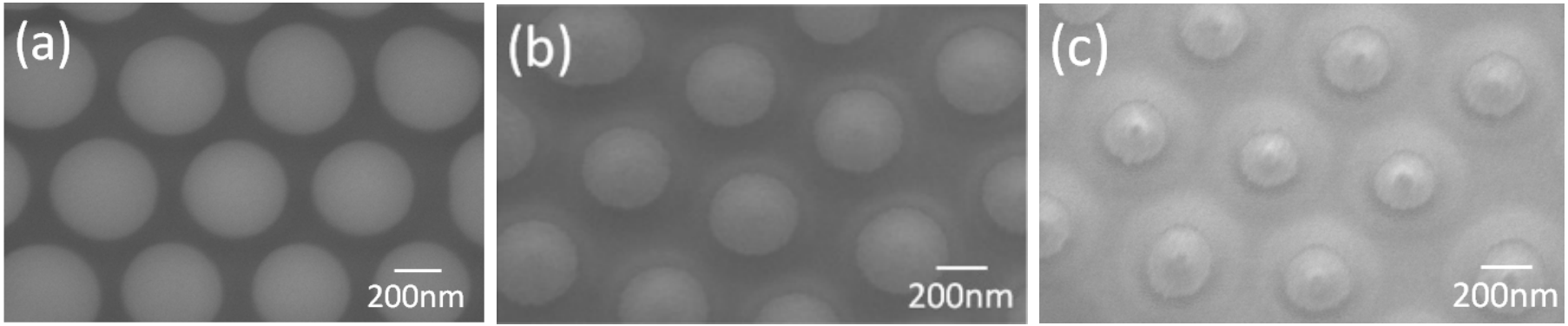
We can make nanopillars less expensive by using nanolithography and metal assisted chemical etching on thin wafer solar cells to increase long wavelength absorbency.

Process for Building Nanopillars



Source: Sanpyeong Kim (private communication)

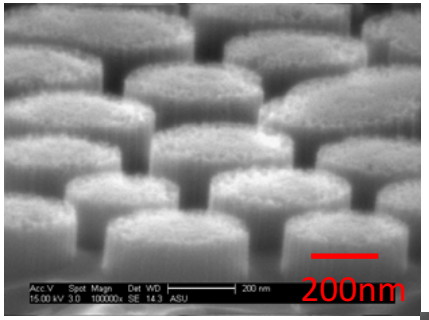
Process for Building Nanopillars



Nanosphere etching for different time durations: (a) 2min, (b) 3min 30sec, and (c) 4min 40sec. Nanospheres are etched by Fluorine RIE process after spin-coating.

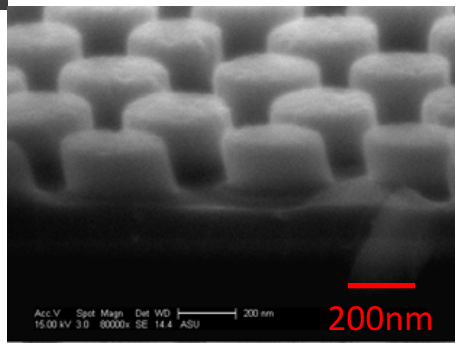
Smoothing, Annealing, and Measuring

1. Surface smoothing using KOH.
2. Cleaning process using HF, RCA-B, piranha.
3. Passivate with Al_2O_3 using ALD.
4. Anneal.
5. Measure lifetime, implied V_{OC}, and reflectance.



Before smoothing process

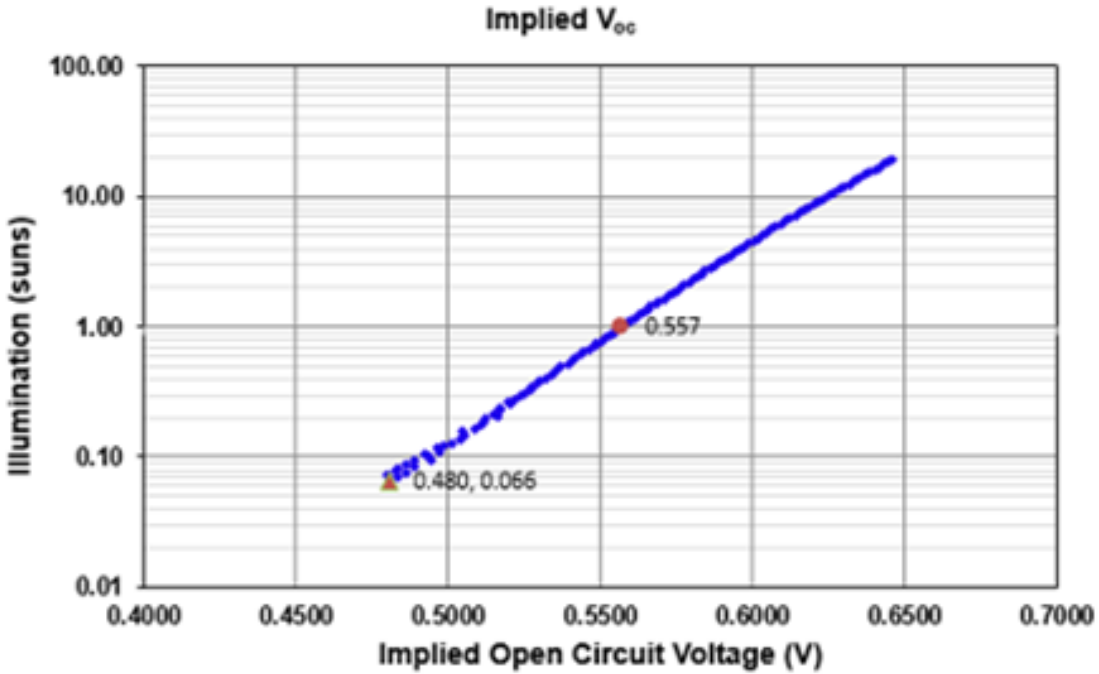
After smoothing process



Reflectance Data Results

- Reflectance higher than expected due to lack of uniform spread of nanopillars, and implied V_{OC} lower than expected due to wafer handling issues during production.
- Surface roughness made it difficult to get an even spread of nanospheres on the surface of the wafer, and caused the nanopillars to only form in certain areas during the MACE process.

Results and Future Research



- Implied V_{OC} lower than expected due to wafer handling issues during production.
- Adapting the process to thin wafers (gentler means of nanosphere removal, smoothing process using KOH and not HNA, etc).

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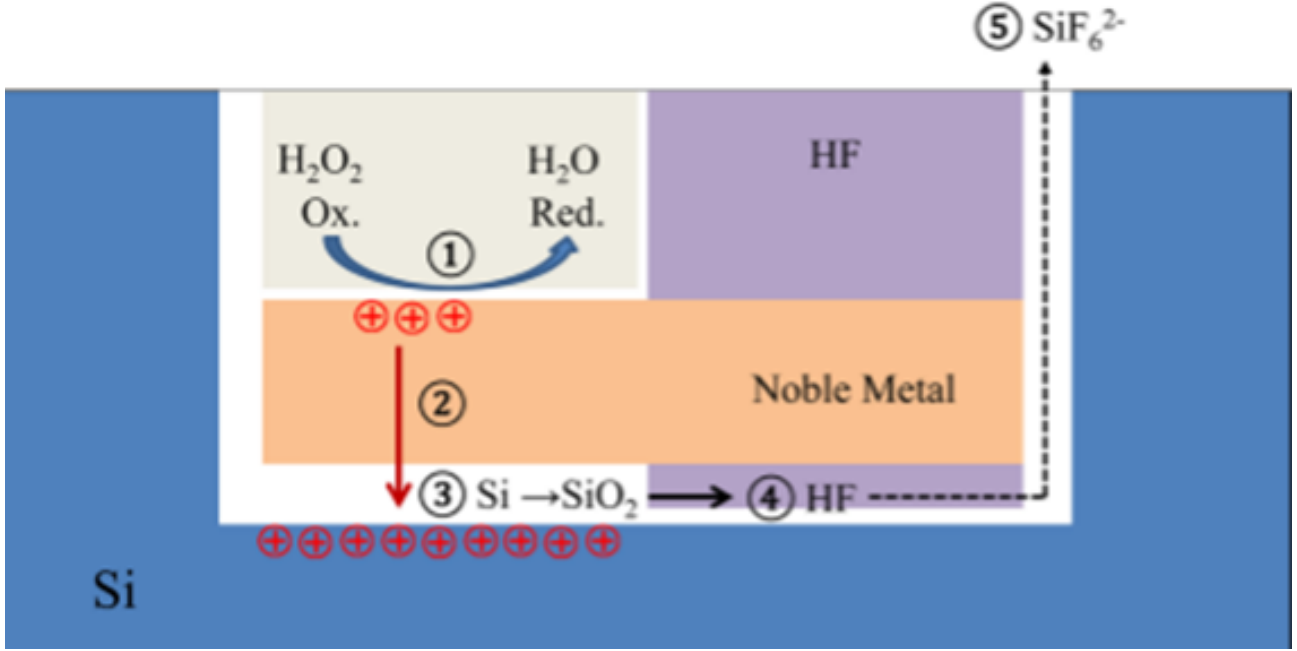
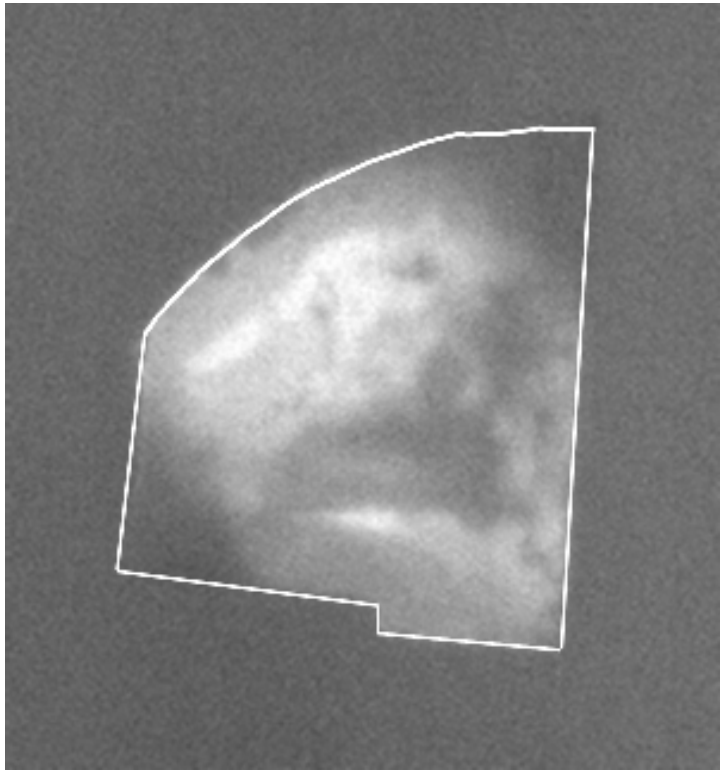
Questions?



The MACE (Metal-Assisted Chemical Etching) Process.
Choi et al Languir, 2015, 31(13), pp 4018-4023



Photoluminescence imaging results (quarter piece of a 2” wafer)