

# ナノ結晶シリコン自立膜セルの光電変換特性に対する表面修飾の効果 Effects of surface modification on the photovoltaic performance of nanocrystalline silicon membrane cells

<sup>1</sup>農工大, <sup>2</sup>名大工 <sup>○</sup>メンテック ロマン<sup>1</sup>, ジェロース ベルナール<sup>2</sup>, 筆宝大平<sup>1</sup>, 越田信義<sup>1</sup>  
<sup>1</sup>Tokyo Univ. of Agri. & Tech., <sup>2</sup>Nagoya Univ. <sup>○</sup>R. Mentek<sup>1</sup>, B. Gelloz<sup>2</sup>, D. Hippo<sup>1</sup>, and N. Koshida<sup>1</sup>  
E-mail: mentek@cc.tuat.ac.jp

Nanocrystalline porous silicon (nc-PSi) prepared by electrochemical etching has been previously reported to exhibit definite photovoltaic properties with a high open circuit voltage [1], indicating a possible wide gap absorber behavior of the material. The high resistivity and unstable hydrogen surface passivation currently limits the photovoltaic performance of the material. Here we present our current efforts on stabilizing the material through modification of its surface.

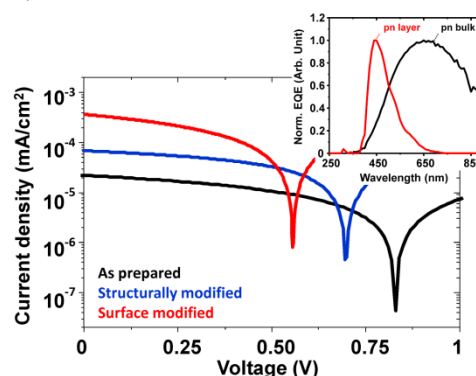
Nc-PSi material was produced through a top-down approach where bulk silicon material is nano-structured by wet electrochemical etching and subsequently separated from the bulk substrate resulting in free-standing membranes. The material surface was then processed through a low temperature thermal hydrosilylation with organic molecules [2] belonging to alkene and aldehyde groups to replace the original Si-H<sub>x</sub> terminations with more stable Si-C (alkene) or Si-O bonds (aldehyde).

The typical PV characteristics of a pn layers before surface chemical modification is shown in **Fig. 1**. The devices are characterized by a large  $V_{oc}$  up to 0.875V, never reported in such devices so far [3-5] and a spectral response peaking at 450 nm, shifted compare to the original bulk material. After surface modification by organic molecules, the photocurrent degradation due to uncontrolled reaction of the surface with ambient air was slowed down by the presence of the organic molecules at the surface as seen in **Fig. 2(a)**. In terms of performance, the photovoltage showed a slight decrease compared to as-prepared material while a notable increase in the photocurrent was observed for aldehyde modified material as shown in **Fig. 2(b)**. A similar tendency was observed on the same functional group of molecules with different length, showing that the observed differences between alkene and aldehyde modification may originate from the surface bonding type. Further alternative methods

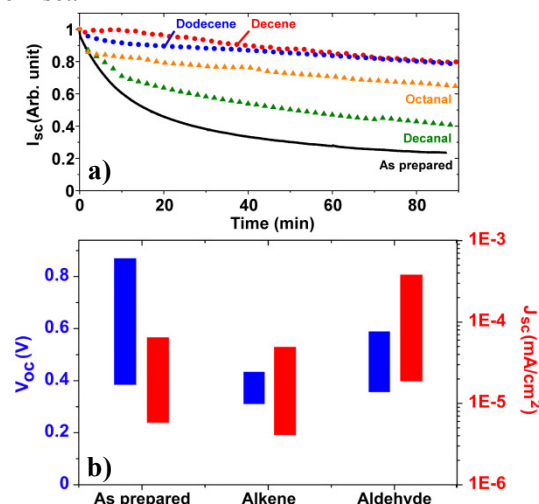
including the surface deposition with polymer such as polypyrrole are also under investigation.

*This work was partially supported by NEDO.*

- [1] R. Mentek, B. Gelloz, and N. Koshida, Jpn. J. Appl. Phys. **51** (2012) 02BP05.
- [2] J. M. Buriak, Chem. Rev. **102** (5) (2002) 1271.
- [3] G. Smestad, M. Kunst, C. Vial, Solar Energy Mater. and Solar Cells 26 (1992) 277.
- [4] L. Kore, G. Bosman, Solar Energy Mater. and Solar Cells 57 (1999) 31.
- [5] M. Rajabi, R. S. Dariani, J. Porous Mater 16 (2009) 513.



**Fig. 1** Typical PV characteristics of pn type nc-PSi layers with the corresponding spectral response shown in the inset.



**Fig. 2:** (a) Temporal variation of the photocurrent before and after surface modification, (b) corresponding range of PV parameters observed on as prepared and organically modified devices.