Morphology of Spin-coated PEDOT:PSS on Neutral Beam etched Silicon nanopillar surface for Hybrid Solar Cells

IFS, Tohoku Univ.[1], AIMR, Tohoku Univ.[2]
°Aditya Saha[1], Daisuke Ohori[1], Susumu Toko[1], Sou Takeuchi[1], Seiji Samukawa[1,2]
E-mail: saha.aditya.q6@dc.tohoku.ac.jp, samukawa@ifs.tohoku.ac.jp

Introduction: Module cost accounts for around 30% of the price of current cells at around 40,000 yen/kWh. The high vacuum and high temperature production techniques employed in commercial Si-based solar cells set a limit to lowering prices. Organic-silicon hybrid solar cells can take advantage of low-cost processing techniques of conjugated polymers and the optoelectrical properties of Si to reduce the module cost while maintaining high performance. Achieving parity in efficiency with current inorganic solar cells has the potential to significantly drop the price of solar cells. Poly(3,4-ehylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) has been widely used due to its high conductivity and thermal stability. Previous attempts at making micro or nanostructured surfaces have faced challenges in penetration of PEDOT:PSS[1,2] and formation recombination sites due to defects[2]. We hope to improve effective contact area, charge separation and photon management of PEDOT:PSS/Si hybrid solar cells through the formation of an even thin film of PEDOT:PSS around silicon nanopillars (SiNP) etched by a damage-free neutral beam etching (NBE) process[3]. The NBE process will be able to reduce the number of surface recombination sites that tend to affect the V_{oc} of plasma etched nanostructures while improving the J_{sc}. The following report describes the first set of trials in our project.

Experimental: Silicon nanopillars were created by using a chlorine neutral beam to etch over a PEGylated Ferritin bio-template on 10mm x 10mm substrates. The resulting nanopillars were 100 nm in height with a pitch of 52 nm. PEDOT:PSS (FHC Solar) solution mixed with Polyoxyethylene(10)octylphenyl ether (1 wt %) and Dimethyl sulphoxide (DMSO) (5 wt %) at 500 rpm for 15 sec then at 2000, 3000 and 4000 rpm (for different samples) for 20 sec. The samples were subsequently annealed at 150°C for 15 mins in an atmosphere of Argon and allowed to cool to room temperature. A scanning electron microscope (SEM) was used to observe the surface morphology.

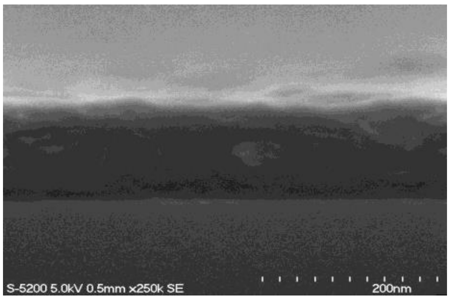

Fig 1. PEDOT:PSS on flat Si surface

Results and Discussion: A repeatable and highly controllable process is essential for ensuring a good design. Different combinations of dopants and speeds were tested on flat silicon surfaces to determine their effect on film thickness and uniformity. A very uniform coating of 100nm thick layer PEDOT:PSS has so far been achieved [Fig 1]. PEDOT:PSS was only able to penetrate through 10nm of 100nm long SiNPs. This is likely due to the high surface tension of the PEDOT:PSS dispersion along with its large molecular chain. Future efforts will focus on improving the penetration of PEDOT:PSS into the SiNP surface texture. This may include changing nanopillar height and pitch as well as exploring different coating methodologies. More information will be shared during the presentation.

[1] S. Samukawa , *Applied Surface Science 253 (2007) 6681–6689*
[2] Wang et al., *Nanoscale Research Letters (2015) 10:191*
[3] Kwang-Tae Park et al., *Scientific Reports (2015) 5:12093*