Silicon based heterojunction photovoltaics: first results on MoO_3/Si solar cells

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The silicon heterojunction solar cells display high performance with rather low-cost fabrication and low wafer thickness (<100µm). Their principle lies in a low surface recombination velocity through the separation of the crystalline silicon absorber from the highly recombination active metal contacts by a passivating, wide-bandgap emitter "buffer" layer as "transparent" as possible to allow the majority carriers flow while reflecting the minority carriers one. It is usually made of a hydrogenated amorphous a-Si:H layer which displays a 1.7 eV quasi-bandgap despite several limitations: low conductivity material, high electron-hole recombination rate, optical losses due to a large absorption coefficient. Therefore, to overcome these limitations, a wider bandgap semiconductor such as Molybdenum trioxide (MoO_3) could be a promising material to replace the a-Si:H in solar cells[1–3] since it displays high bandgap of about 2.9eV and a large work function[4], suitable for an appropriate electronic band line-up between this emitter layer and the silicon absorber.

To this end, different solar cell configurations based on ITO/MoO_3/p-type Si(001) heterostructures were fabricated and characterized. 3 samples were studied: 3 n+/p diodes, with 3 different treatments for the 15 nm-thin MoO_3 (prior to the 80 nm-thick ITO deposition): one sample was not annealed, one was annealed under N_2 atmosphere, and one was annealed under O_2 atmosphere. Indeed, MoO_3 doping level is linked to annealing conditions: a n-type doping of MoO_3 is observed which is known to depend on oxygen vacancies concentration[5]. External quantum efficiency measurements are presented on figure 1. Annealing under O_2 strongly enhances the EQE on the n+/p samples while N_2 annealing almost deteriorates EQE for both types of samples. A second step of ITO annealing, necessary to obtain efficient electric contacts, slightly deteriorates EQE in all cases.

Al front contact with busbar and fingers deposited on ITO on all samples, obtaining 1cm² square solar cells. I-V under solar simulator and EQE measurements were performed on each structure. n+/p structures present solar cell characteristics with high series resistances. The better results are obtained with O_2 annealing, with $V_{OC} = 0.55\ V$ under AM1.5G solar simulator, $J_{SC} = 23.21\ mA/cm^2$, a fill factor of 37.6%, giving an efficiency of 5.5 % (figure 2).

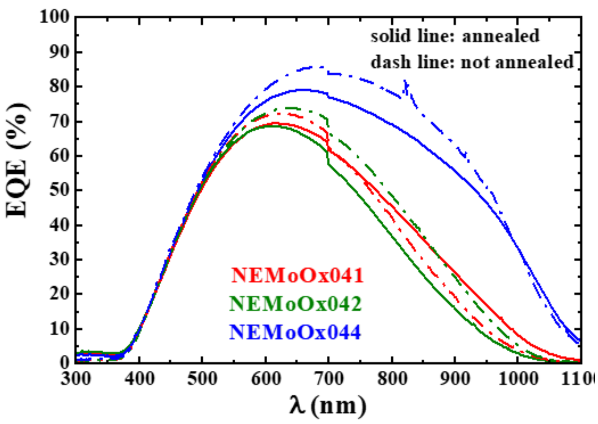

Figure 1 : EQE results on n+/p samples red curve : no MoO_3 annealing / green: MoO_3 annealing under N_2 / blue curve : MoO_3 annealing under O_2

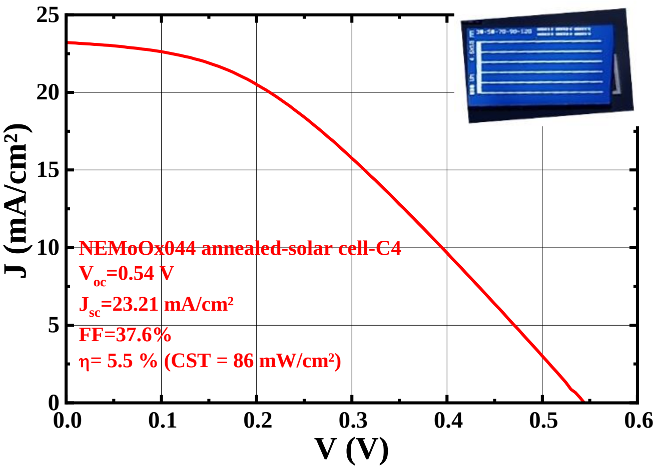

Figure 2: Best results diode picture (n+/p with O_2 annealing) and I-V characteristics

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