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Improved n-type behaviour of Cu_2O by successive electrodeposition of Cu and Cu_2O

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Cuprous oxide (Cu_2O) is a non-toxic, low cost and potentially attractive material as an active semiconductor for solar cell applications. Further, it has an added advantage of direct band gap of 2 eV. Cu_2O typically shows p-type conductivity due to copper vacancies created in the lattice. In 1986, it was reported that electrodeposition of Cu_2O in slightly acidic solutions shows n-type conductivity due to the excess of Cu or oxygen vacancies in the Cu_2O lattice. However, n-type conductive Cu_2O reported so far has both n-type and p-type photoactivity showing n-type behavior predominantly. This effect of n-Cu_2O is a major problem in the fabrication of solar cells, as it affects the overall performance of the device.

In the present study, to avoid the formation of p-type photoconductivity in n-Cu_2O, environment was made Cu rich by depositing a very thin Cu film before the growth of Cu_2O. Electrodeposition of n-Cu_2O was carried out in an acetate bath by growth of very thin Cu film followed by Cu_2O deposition. A very thin Cu film was potentiostaticaly electrodeposited on the Ti substrate at -700 mV Vs $Ag/AgCl_2$ for a few minutes in a three electrode electrochemical cell containing aqueous solution of 0.1 M sodium acetate and 0.01M cupric acetate at a temperature of 55 ^{o} C and the deposition potential was switched to – 200 mV Vs $Ag/AgCl_2$ for 60 min in order to grow n-Cu_2O with sufficient thickness. Thickness of the Cu layer was adjusted by varying the Cu deposition time. Photoactivity of n-Cu_2O films were characterized by dark and light current-voltage measurements and spectral response measurements in a PEC cell containing 0.1 M sodium acetate.

Results revealed that, in general, electrodeposited n-Cu_2O thin films produced p-type photoconductivity in addition to the n-type photoconductivity. Growth of very thin Cu film prior to the Cu_2O improves the n-type photosignal and shifts the flat band potential significantly towards negative direction by removing the p-type conductivity of electrodeposited films. In conclusion, our study revealed, for the first time, that the n-type behaviour of Cu_2O thin films can be improved with consecutive growth of very thin Cu film prior to the Cu_2O deposition.