COPPER INDIUM DISELENIDE (CIS) BASED SOLAR CELLS: EFFECT OF CIS PREPARATION CONDITIONS AND THICKNESS ON PERFORMANCE

By

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A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy (Physics) of the University of Dar es Salaam.

University of Dar es Salaam

September 1999

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the University of Dar es Salaam a thesis entitled: *Copper Indium Diselenide ($CuInSe_2$) based Solar Cells: Effect of $CuInSe_2$ Films Preparation Conditions and Thickness on Performance*, in fulfillment of the requirements for the degree of Doctor of Philosophy (Physics).

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ABSTRACT

The effect of $CuInSe_2$ thin film preparation conditions and thickness on $CuInSe_2$ based solar cells has been investigated. Prior to $CuInSe_2$ thin films and device fabrication, metallic Cu and In resistivity changes with deposition conditions were studied. The $CuInSe_2$ thin films were fabricated by two stage process which involved DC sputtering of metallic CuIn bilayers followed by reaction of the bilayers in H_2Se gas in a chemical vapor deposition reactor.

Metallic Cu and In films resistivities depend on vacuum deposition conditions as well as their thicknesses. For deposition parameters studied in this work, Cu film resistivity changes are within the order of 10^1 while those for In film were up to order of 10^{11}.

A semi quantitative description on the formation of $CuInSe_2$ films with respect to reaction period, reaction temperature, and precursor thickness has been given. This has helped to explain the phases observed and their effects on device performance. Low reaction temperatures require long reaction periods for complete reaction of CuIn precursors which is consistent with low reaction rate constants for low reaction temperatures. At temperatures greater than 400 °C device performance deteriorates.

A kinetic model was used to predict the progressive number of moles of $CuInSe_2$ and InSe phases in the selenized CuIn bilayers and compared with experimental number of moles calculated from XRD counts. Generally, the experimental data were found to be in good qualitative agreement with those predicted. The best solar cell (efficiency was 10.6 %) in this work was obtained using an absorber layer with a trace of InSe phase. This means a good device with efficiency greater than 10 % can be obtained using an

absorber layer with a trace of InSe phase provided that the number of InSe moles approaches zero.

For each reaction period, there is a limiting $CuInSe_2$ thickness which gives the highest efficiency. Similarly, for each precursor thickness, there is a limiting efficiency which can be obtained. For commercial considerations, the most interesting result is the 7.41 % efficiency obtained for a 0.6 μm thick $CuInSe_2$ absorber layer prepared for 15 minutes at reaction temperature of 350 °C. The thinner $CuInSe_2$ saves the starting Cu and In materials while the short reaction period and the lower reaction temperature translates to low operating costs.