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PROCESS OPTIMIZATION AND CHARACTERIZATION OF NANOSTRUCTURED ZINC OXIDE THIN FILMS FOR SOLAR CELL APPLICATIONS

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

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ABSTRACT

Recently, nanotechnology is employed in chemical synthesis of zinc oxide (ZnO) to produce novel nanostructured ZnO thin films. This new material synthesis technique could enhance the electrical and optical properties which can be applied for window layer application in solar cells. Although there are many chemically synthesis methods available, thermal chemical vapor deposition (CVD) method offers ZnO purity up to 99% and high quality films. However, to produce uniform and repeatable nanostructured ZnO thin film using double furnaces thermal CVD is very challenging and almost impossible. Therefore, a novel method using a gas blocker to synthesize ZnO nanowires was introduced in this thesis. As a result, uniform and repeatable nanostructured ZnO thin films were successfully deposited on ITO coated glass assisted with gold catalyst. The resulting crystallite size is around 32 nm and nanowire length around 5 μm. Since the electrical and optical properties of nanostructured ZnO are strongly dependent on the thin film's quality, the crystallinity of the thin films was enhanced by post annealing. Annealing the films at 550°C for 1 hour has produced optimum crytallinity in (0 0 2) crystal orientation. Another parameter which affects the structural and growth intensity is the carrier gas flow rate. It was found that using 0.75 L/min of gas flow rate had produced smoother nanostructured ZnO surface morphology and more growth on (0 0 2) plane. However, the transmittance in the visible region is only 65% with film thickness approximately 630 nm. This low transmittance is resulted from the gold catalyst which absorbs light at visible region. Therefore, ZnO seed layer was deposited and optimized to enhance the (0 0 2) crystal orientation and substitute the gold catalyst. As a result, catalyst-free nanostructured ZnO thin film was fabricated and the transmittance improved to more than 80%. However, the conductivity decreased to 1.82×10^{-3} $S.cm^{-1}$. The fabrication of nanostructured ZnO-based heterojunction thin film solar cell was realized by depositing new p-type material (In_xSn_yS thin film) on nanostructured ZnO thin film using electrochemical deposition (ECD) method. A solar simulator was used to measure the current-voltage (I-V) characteristics of the solar cell using indium metal as the electrodes. It was obtained that the solar cell has energy conversion efficiency (η) of 0.041% with short circuit current density of 181 $\mu A.cm^{-2}$ and open circuit voltage of 0.47 V. The field factor (F.F) of the solar cell is approximately 0.476, with maximum current density of 150 $A.cm^{-2}$ and maximum voltage of 0.27 V. This finding proves that nanostructured ZnO thin film successfully functioned as a window layer. It also proved that nanostructured ZnO can be synthesized without using metal catalyst which degrades the optical properties of the thin films. However, further research should be undertaken especially to synthesize p-type materials which are more suitable with ZnO.

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