TiO₂/BiOI ヘテロ構造のアニール処理:光起電力特性への影響

Annealing Treatment of TiO₂/BiOI Heterostructure: Effect on its Photovoltaic Performance

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1. Introduction

BiOI is one of the promising bismuth materials which can be derived to other materials including Bi_7O_9I , Bi_5O_7I , and $Bi_4O_5I_2$ by modification on its synthesis route or applying the heating treatment. Almost of these materials could act as promising photocatalyst especially for environmental application^{[1],[2]} which also may be promising for photovoltaic application.

BiOI and TiO₂ for p-n heterojunction in photovoltaic system has been applied successfully and resulted in the 3.8 mA/cm² of Jsc value by CBD method.^[3] However, this value might be difficult to be increased in that structure since BiOI has the bigger size than TiO₂. This limitation has motivated us to make the composite materials consisted of TiO_2 and BiOI and studying the annealing effect of BiOI on its photovoltaic performance. Although we did not obtain the photovoltaic parameters as high as in the previous reports yet, we noticed that there is an enhancement in the efficiency value of annealed BiOI compared with the BiOI. Furthermore, this work may open the development of bismuth based material for eco-friendly solar cell.

2. Materials and Methods

Each equimolar of Bi(NO₃)₃.5H₂O and KI as precursors were ground together for several minutes and dissolved in the DO water to get BiOI powder. The stirring process was carried out for 5 hours at room temperature. Then, the precipitated as BiOI material was washed with DO water and ethanol. Finally, the BiOI powder was heated at 80 °C for 2 hours and dispersed together with TiO₂ P25 to obtain the TiO₂/BiOI composites. The composites were deposited into FTO substrates by doctor blading and annealed at different temperature. All samples were characterized by UV-Visible and Raman spectrophotometer, also solar simulator measurement.

3. Results and Discussion

Fig. 1 displays the Raman spectra of BiOI by the annealing treatment. The non-annealing and annealing treatment up to 300 °C showed the internal stretching mode (E_g) of Bi-I as the strongest peak around 149.6 cm⁻¹.^[4] Due to the annealing, there was a shift in Bi-I vibration peak which might indicate the chemical structure transformation from BiOI to other bismuth-based materials (Bi₅O₇I and Bi₂O₃).

We also measured the films performance in the photovoltaic system. I-V measurement showed that the non-annealing sample had the lowest photovoltaic parameters compared with other samples and the increasing of annealing temperature also improved the V_{oc} value. Annealing treatment might change the chemical and crystal structure which related to the Fermi level state and band gap energy value (Eg). However, this increment was not gained by annealing TiO₂/BiOI composite at 550 °C. Other characterizations also were carried out and the result will be discussed later.



Fig.1 The Raman spectra of BiOI with the annealing temperature variation.

4. Conclusions

The annealing treatment in the TiO₂/BiOI composite materials had the effect on its chemical structures. Different chemical structure may have the different crystal structure which affected on its band gap energy value. From the IV measurement, we concluded that the photovoltaic performances were changed by the annealing treatment.

5. References

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