I-7

Structural Variation of Tantalates with Layered Perovskite and the Photocatalytic Activity

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Hydrogen energy is one of the clean energy that is possible to develop new generation energy. Ideal method producing hydrogen can be chemical decomposition methods of water using photocatalyst. Recently, tantalum oxides have been introduced for the new photocatalysts. Especially, tantalum oxides with the layered perovskite structure have an advantage to occur photocatalytic reaction without supporting co-catalyst because layered structure acts as active sites. This research initiated with assumption that a change of electron structure enhances the mobility of electron-hole pair and suppresses recombination of electron-hole pair exited by light in photocatalyst. A change of electron structure will be achieved by the distortion of crystal structure. In the concrete, $Sr_2Ta_2O_7$ with layered perovskite structure, known as promising photocatalyst, was used as a main material. Barium was doped on strontium site of $Sr_2Ta_2O_7$ in order to give structural variation. Photocatalytic activity of $Sr_2Ta_2O_7$ was successfully enhanced about three ~ four times higher than that of undoped $Sr_2Ta_2O_7$. Using X-ray diffraction, SEM, UV-visible absorption spectra, and BET method, the characterization of each sample was performed to investigate the reason to improve the photocatalytic activity in terms of specific surface area and crystal size. Based on the results, the photocatalytic activity was improved with increasing Ba content on $Sr_2Ta_2O_7$. In 20 mol% of Ba dope, the photocatalytic activity of $Sr_2Ta_2O_7$ (~6374 mmol/hour) increased three time higher than that of undoped $Sr_2Ta_2O_7$ (~2800 mmol/hour). Raman spectroscopy and Rietveld analysis were performed to investigate the improvement of photocatalytic activity of Sr2Ta2O7 due to Ba dope in terms of structural distortion. The unit cell volume of $Sr_2Ta_2O_7$ increased up to 30mol% of Ba-dope and became almost constant after 30mol%. On the other hand, mass fraction of $Sr_2Ta_2O_7$ was almost constant up to 30mol% of Ba dope and started to decrease after 30mol%. This relationship was explained with the lever rule. Moreover, all lattice parameters in a, b, c axes of $Sr_2Ta_2O_7$ were increased anisotropically with Ba dope up to 30mol%. Based on these, it was confirmed that the distortion occurred in the structure of $Sr_2Ta_2O_7$ due to Ba dope. According to these results, distortion of structure of $Sr_2Ta_2O_7$ was one of the reasons to improve the photocatalytic activity.

Keywords: Photocatalyst, Phase, Ba doped Sr2Ta2O7, Crystal distortion

I-8

MOCVD를 이용한 InGaN/GaN 기반 발광다이오드 구조 제작과 발광다이오드에의 응용

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Firstly, the effects of well protection layer (WPL) on the optical and crystal properties of InGaN/GaN multiple quantum well (MQW) will be addressed. The five-pair MQW, consisting of InGaN well grown at 750 ℃ and GaN barrier grown at 850 ℃, was simply embedded between GaN cladding layer on sapphire(0001) substrate. While this dual-temperature MQW growth scheme seemed better suited to the GaN barrier quality, it exposed the volatile InGaN well to a higher temperature ambient upon ramping-up process to grow the barrier. In order to prevent the fragile well, a thin GaN WPL was coated subsequently on each well layer at the same temperature before the temperature ramping-up. Consequently, it was found that the WPL directly influenced indium composition and optical properties of the MQW. Indium composition was in fact increased, as was evident from x-ray diffraction experiments. In addition, photoluminescence measurements showed emission peak wavelength was increased from 464 nm to 520 nm. These results provide the proof evidence that the WPL effectively suppresses indium re-evaporation during the ramping-up time. Present study proposes that the WPL paves a new pathway to increase the wavelength of InGaN/GaN MQW.

Secondly, multiwavelength emitting InGaN/GaN QWs formed on V-shaped GaN(1-101) microfacet will be reported. After a MOCVD of 2 μm thick GaN, SiO2 mask stripes were formed along GaN<11-20> direction by a conventional photolithography. The period and opening of the stripes were 11 and 4 μm wide, respectively. Subsequent regrowth of GaN generated the V-shaped (1-101) microfacets along <11-20> direction. Finally, five-period InGaN/GaN multiple QWs were fabricated on these microfacets. The cross sectional observation in the<11-20>direction by SEM revealed the well-developed microfacets. Interestingly, cathodoluminescence (CL) spectra measured on the microfacets showed a continuous change in the luminescence peak positions. The CL peaks were shifted to a longer wavelength from 420 nm to 440 nm as the probing points went up. We believe that by controlling growth parameters and mask geometries, not only the overall difference between the peak positions can be further increased but also a desired wavelength can be produced. Present works thus propose the fabrication of a monolithic white light emitting diode without phosphors.

Keywords: GaN, MOCVD, MQW, LED