Preparation and Characterization of SrO–Bi₂O₃ Complex Oxide

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Introduction

Bi-based oxide semiconductors (Ca₅O₂₋₃Bi₂O₅₋₄) have attracted considerable attention because of their small bandgap energies. The preparation of high-purity Bi oxides powders with large surface area is indispensable to developing efficient photocatalysts. However, Bi-based oxide powders have been prepared by a solid-state reaction in general. Although solid-state reaction is most frequently used due to easiness and convenience, this method has several problems. As a result, the surface area of the powder decreases and the preparation of metal oxide powders with large surface area is indispensable to photocatalysts.

Problems in preparation

- crystal growth
- change of the stoichiometric ratio
- reducibility of the formation of secondary phase

Organic acid method

Stable Crystallographic data

<table>
<thead>
<tr>
<th>Space Group</th>
<th>Pnma (No. 62)</th>
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<tbody>
<tr>
<td>a = 14.368Å</td>
<td>b = 6.160Å</td>
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<tr>
<td>c = 7.642Å</td>
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Crystal system: Orthorhombic

Table: Kubelka-Munk function

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<tr>
<th>Wavelength / nm</th>
<th>Kubelka-Munk function f(Rₑ) = (1-Rₑ)²/2Rₑ = α/S</th>
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α = (hv - Eₐ)²/2hv

Effective mass, mᵣ

mᵣ = 0.22 m₀

UV-vis

SrBi₂O₃ phase of high purity was obtained from a malonic acid complex, but not from a solid-state reaction.

First-principles calculation

SrBi₂O₃, the VBM and the CBM are located at Γ-point, obviously indicating that SrBi₂O₃ is a direct band gap material. In addition, the energy bands near the VBM and the CBM have a wide dispersion, suggesting high mobilities of photo-generated holes and electrons.

Kubelka-Munk function

f(Rₑ) = (1-Rₑ)²/2Rₑ = α/S

Slope of ln (ab) vs ln (hv) plot

n = 1/2 (direct-gap material)

Eg = 3.1 eV

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Experimental

Characterization by XRD, UV-vis, BET and first-principles energy band calculation

Photocatalytic activity examination

The specific surface area (SSA) was calculated by applying a least-squares fit to a BET plot.

Photocatalytic activity

Among the three kinds of photocatalysts examined, the highest activity was obviously achieved for SrBi₂O₃ prepared from a malonic acid complex.

Conclusion

- SrBi₂O₃ phase of high purity is obtained from a malonic acid complex, but not from a solid-state reaction.
- The specific surface area is ca. 9 times larger in a malonic acid complex than in a solid-state reaction.
- SrBi₂O₃ is a direct-gap material.
- A high photocatalytic ability of SrBi₂O₃ is attributable to the wide band dispersion near the VBM and the CBM.
- The SrBi₂O₃ powder exhibits a distinct photocatalytic degradation of MB under visible light irradiation.