

Deposition of phosphorus-incorporated layered carbon nitride films for electrical materials

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Introduction

Layered carbon nitride (g-C₃N₄) has received much attention as a non-toxic functional material that can be considered as a novel semiconductor material. However, only a several reports of g-C₃N₄ semiconductor applications exist. In this report, the incorporation of phosphorus (P) atoms into g-C₃N₄ films is demonstrated to enhance the functionality as an electronic material.

Methods

The films were deposited on epi-polished c-plane sapphire substrates using a homemade hot-wall chemical vapor deposition system. Melamine (C₃H₆N₆) and red P powders were used as the source molecule, which was heated and supplied in the gas phase.

Results

At the optimal deposition temperature of 600 °C, no incorporation of the P atom into g-C₃N₄ was achieved. Then, P composition increased with the rise in growth temperature up to 675 °C. Therefore, intentional introduction of structural defects enhances P addition. In addition, X-ray photoelectron spectroscopy (XPS) analysis suggested that P atoms were incorporated into g-C₃N₄ films by the substitution for C sites.

The current density - voltage characteristics of the g-C₃N₄ film under different applied bias direction were investigated (see the attached figure file). No current was obtained when the bias voltage was applied along the in-plane direction, which is consistent with our previous study. By contrast, current density was obtained by applying a bias voltage along the out-of-plane direction. Relatively low resistivity was achieved in g-C₃N₄ film, indicating that the P incorporation contributed to its control.

Conclusion

The P incorporation into g-C₃N₄ film and the improvement in electrical conductivity were achieved.