Physics of Electronic Materials Prof. **Takafumi Yao** (Concurreutly)

【Staff Members】

Prof. Takafumi Yao, Assoc. Prof. Meoung-Whan Cho, Res. Assoc. Takashi Hanada, Res. Assoc. Hisao Makino

【Research Activities】

The purpose of the research for the fiscal year of 2004 is to develop materials processing technology for widegap ZnO-based oxide semiconductors and GaN-based nitride semiconductors aiming at contribution to fabrication novel optical and electronic devices. Followings are the main achievements of our research activities in 2004:

(1) We have developed the technology for controlling the crystal polarity of ZnO epitaxial layers on nonpolar substrates by engineering the hetero-interface. This achievement enables to grow high-quality ZnO layers suitable for device fabrications, which was confirmed through extensive defect characterization using TEM. Furthermore, we have clarified the local structures of ZnMgO layers, which should act as barrier layers in ZnO/ZnMgO heterostructure devices. This insight will contribute to the growth of high-quality ZnMgO which is a crucial issue for fabricating ZnO-based devices.

(2) Both the electronic structures and local structures of novel diluted magnetic semiconductor GaCrN films and GaMnN have been extensively studied using synchrotron facilities at SPRING 8 and PF. With a help of a theoretical group, the correlation between magnetism and those electronic and local structures have been elucidated.

(3) A chemical lift-off technique for high-brightness white LEDs has been developed. Based on this chemical lift-off technique, blue LEDs are successfully fabricated with excellent device performances, which demonstrates the feasibility of the chemical lift-off technology for high-brightness white LEDs.

(4) We have developed a new preparation technique for luminescence center-embedded nanoparticles: Eu-doped yttrium silicate nanoparticles were grown inside porous silicon oxide matrix by chemical impregnation of porous silicon layers. The nanoparticles show bright luminescence which can be applied to various optical devices including CL devices, EL devices, and so on.

(5) We have solved the problem that it is hard to form good Schottky contact to ZnO by inserting a high-resistive N-doped ZnO thin layer in between ZnO and Au electrode. This technique will enable the study on deep levels in ZnO, which is quite important for developing optical and electronic devices. In fact, some of the deep levels in MBE-grown ZnO layers have been studied using this technique.

1. DC Oh, JJ Kim, H Makino, T Hanada, MW Cho, T. Yao, and HJ Ko:
"Characteristics of Schottky contacts to ZnO : N layers grown by molecular-beam epitaxy"
Appl. Phys. Lett. 86 (4): Art. No. 042110 JAN 24 2005

2. DC Oh, T. Suzuki, JJ Kim, H Makino, T Hanada, MW Cho, and T Yao
Electron-trap centers in ZnO layers grown by molecular-beam epitaxy
Appl. Phys. Lett. 86 (3): Art. No. 032909 JAN 17 20

3. N Taghavania, G Lerondel, H Makino, and T Yao:
Europium-doped yttrium silicate nanoparticles embedded in a porous SiO2 matrix
Nanotech. 15 (11): 1549-1553 NOV 2004

4. JJ Kim, H Makino, K Kobayashi, T Yamamoto, T Hanada, MW Cho, E Ikenaga, M Yabashi, D. Miwa, Y Nishino, K Tamasaku, T Ishikawa, S Shin, and T Yao:
"Hybridization of Cr 3d-N 2p-Ga 4s in the wide band-gap diluted magnetic semiconductor $Ga_{1-x}Cr_xN$"
Phys. Rev. B70 (16): Art. No. 161315 OCT 2004

5. A. Setiawan, Z Vashaei, MW Cho, T Yao, H Kato, M Sano, K Miyamoto, I Yonenaga, and HJ Ko:
" Characteristics of dislocations in ZnO layers grown by plasma-assisted molecular beam epitaxy under different Zn/O flux ratios"
J. Appl. Phys. 96 (7): 3763-3768 OCT 1 2004

【Plan】

The purpose of the research is to develop materials processing technology for widegap semiconductors including ZnO-based oxide semiconductors, GaN-based nitride semiconductors, and other opto-electronic semicondcutors aiming at contribution to fabrication novel optical and electronic devices.

<Research projects for fiscal year 2005>

(1) Growth of high-quality p-ZnO layers through development of surfactant MBE of ZnO based materials.
(2) Demonstration of the feasibility of the novel device process technology based on the metal buffer for fabrication of high-brightness white LEDs.
(3) Elucidation of the InN bandgap mystery from microscopic view points.
(4) Fabrication of well-controlled nano-structures widegap semiconductors in terms of size, shape, and location.
(5) Fabrication of polarity-inverted superlattice-structures of ZnO-based semiconductors and exploration of nonlinear optical properties.