

Growth of ErP on InP by Face-Down OMVPE Reactor and Surface Morphology

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We designed an OMVPE growth system with a face-down substrate layout. This OMVPE system is connected with a SPM by a UHV tunnel¹⁾. The face-down layout was taken to suppress disturbance of the gas flow near the susceptor at the growth temperature and to avoid deposition of byproducts on and near the susceptor. Since the molecular weights (400-700) of Er sources are much heavier than other sources (e.g., TMI_n=160 and TBP=90), the flow speed is accelerated by a low pressure (~70 Torr).

Growth conditions: We have grown semimetal ErP layers on (001)-oriented n⁺-InP substrates. The source gases were TMI_n for In, TBP for P, and Er(MeCp)₃ for Er. The Er source cylinder was kept at 100°C. At the hydrogen flow rate of 500 sccm through the Er cylinder, it was found by a SIMS measurement that the Er concentration was $1 \times 10^{19} \text{ cm}^{-3}$ in a uniformly doped InP layer. It means that it takes 20min to grow 1 ML of ErP. The InP buffer layer was grown just prior to the ErP growth to assure a flat and clean InP surface. The flow rates of TMI_n and TBP were 30 sccm and 50 sccm, respectively and at these flow rates 100 nm of InP was grown for 12 min. We investigated the morphology of the ErP layer by AFM and its dependences on the TBP flow rate and the substrate temperature.

Dependence on TBP flow rate: The substrate temperature was kept at 550°C. The TBP flow rate was 5 sccm and 30 sccm. The surface morphology of the InP buffer layer was first observed and confirmed that the surface consisted of terraces and 1 ML steps. The surface of ErP grown at the TBP flow rate at 5 sccm had a rougher height profiles typically with 1.1 nm in height and 78 nm in width. At the TBP flow rate of 30 sccm, the surface was smoother with the height of 0.56 nm and the width of 73 nm.

Dependence on growth temperature: The flow rates of TBP and Er(MeCp)₃ were kept at 30 sccm and 500 sccm, respectively and the growth period was 1 h. The growth temperature was varied from 500°C to 570°C. At the growth temperature of 500°C, the terrace was wider with the width of 106 nm and the height of 1.3 nm. At the growth temperature of 550°C a similar but slightly rougher surface was observed. At the growth temperature of 570°C, a relatively smoother surface was obtained but deep pits (10-20 nm) were occasionally observed.

The formation of ErP was confirmed by AES and RBS measurements. For a further characterization of the ErP crystal structure, the EXAFS measurements will be conducted during the beam time in the early October at the Photon Factory.

The Growth and characterization of InP on top of ErP will also be reported at the Symposium.

References

- 1) Y. Takeda, Y. Fujiwara, T. Yamauchi and A. Nakamura, FEMD Newsletter, Vol. 2, No. 4 (March 2001)