2011 中技社科技研究獎學金

CTCI Science and Technology Research Scholarship

有機金屬化學氣相沉積法成長極性(0001)與非極性(10$\bar{1}$0)氧化鋅與氧化鋅鎂磊晶薄膜之研究

A Study on Polar (0001) and Nonpolar (10$\bar{1}$0) ZnO/$Zn_{1-x}Mg_xO$ Epitaxial Films Grown by MOCVD Method

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研究重點

- **Growth, Characterization, and Polarity Identification of (0001)$Zn_{1-x}Mg_xO$ Epitaxial Films on Lattice-Matched β-$LiGaO_2$(001) Substrates**
- **Growth and Characterization of Nonpolar (10$\bar{1}$0) $Zn_{1-x}Mg_xO$ ($0 \le x \le 0.113$) Epitaxial Films: A Comparison of γ-$LiAlO_2$(100) and Sapphire (10$\bar{1}$0) Substrates**

研究成果

Crystal Characterization

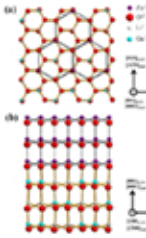

Figure 1. Atomic arrangement of the interfaces between (0001) ZnO and (001) LGO. (a) top-view (b) side-view.

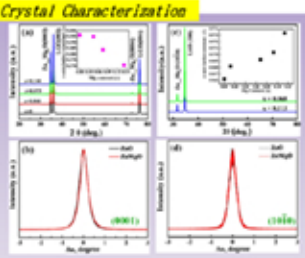

Figure 2. Normalized XRD patterns of the (a) (0001) and (c) (10$\bar{1}$0) $Zn_{1-x}Mg_xO$ films grown on LGO and LAO substrates, respectively. The inset figures in (a)(c) are the correlation between c-, a-axis lattice constants and the Mg contents, individually. Rocking curves of ZnO and $Zn_{1-x}Mg_xO$ films (b) (0001) and (d) (10$\bar{1}$0).

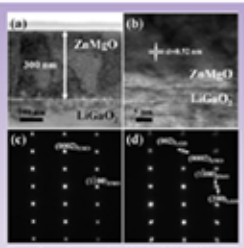

Figure 3. (a) Cross-sectional bright-field TEM image and (b) HRTEM image of the (0001) $Zn_{1-x}Mg_xO$ (ZMO) film grown on the (001) LGO substrate. SAED patterns taken from (c) the $Zn_{1-x}Mg_xO$ films far from the interface and (d) the interfacial region of the $Zn_{1-x}Mg_xO$ film on the (001) LGO substrate. The zone axis is $[11\bar{2}0]_{ZMO}$.

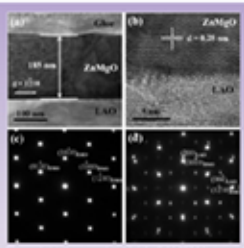

Figure 4. (a) Cross-sectional bright field TEM image and (b) HRTEM image of the (10$\bar{1}$0) $Zn_{1-x}Mg_xO$ (ZMO) film grown on the LAO substrate. SAED patterns taken from (c) the $Zn_{1-x}Mg_xO$ films far from the interface and (d) the interfacial region of the $Zn_{1-x}Mg_xO$ film and the LAO substrates. The zone axis is $[0001]_{ZMO}$.

Surface Morphology

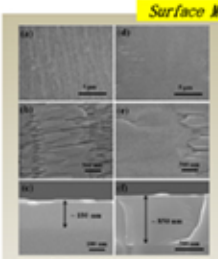

Figure 5. Typical SEM morphologies of the (10$\bar{1}$0) $Zn_{1-x}Mg_xO$ films grown on the LAO substrates for 1 h and 6 h, respectively. (a), (d) Low-magnification of plane-view images. (b), (e) high-magnification of plane-view images. (c), (f) cross-sectional images.

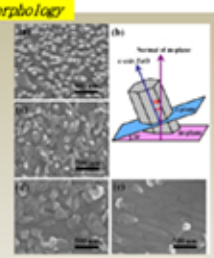

Figure 6. SEM images of the $Zn_{1-x}Mg_xO$ nanorods/films grown on the m-plane Al_2O_3 substrates. (a) $x = 0$, (c) $x = 0.012$, (d) $x = 0.068$, (e) $x = 0.113$. (b) A perspective view of a sketch demonstrating the directional growth of c-plane ZnO on the m-plane Al_2O_3 substrates.

Optical Properties

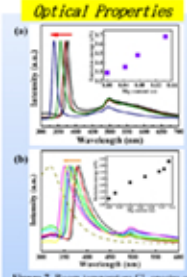

Figure 7. Room temperature CL spectra of the (a) (0001) and (b) (10$\bar{1}$0) $Zn_{1-x}Mg_xO$ films with different Mg contents and the dependence of the CL emission energy as a function of the Mg content (inset).

Polarity Determination

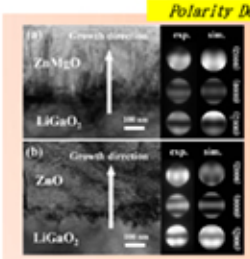

Figure 8. Experimental (exp.) and simulated (sim.) CBED patterns taken along [$\bar{1}$$\bar{1}$00] zone axis of (0001) (a) $Zn_{0.887}Mg_{0.113}O$ and (b) ZnO films. The thicknesses of TEM specimens used for simulation are 42 nm and 50 nm, respectively.

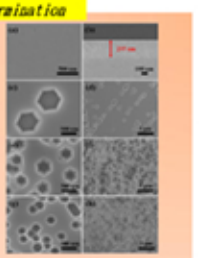

Figure 9. Typical SEM morphologies of the (0001) $Zn_{1-x}Mg_xO$ films (a) top-view, (b) cross-section, etched by 0.01 M $HCl_{(aq)}$ for 30 s [(a), (d)] pure ZnO; [(c), (f)] $x = 0.075$, [(g), (h)] $x = 0.144$.

研究生活及心得

回首過去幾年的博士研究生涯，明顯有別於碩士兩年的研究訓練，最大的差異除了所需的修業時間較長之外，更在於獨立研究的能力與創新思維的培養。抗壓性與意志力的訓練，張張獲奘李珍教授在研究方面的悉心栽培與全力協助，以及在生活方面的關心與愛護，亦師亦友，讓學生的博士生涯一路走來順利跌跌撞撞，但也充滿快樂回憶，感激之情實在無以言表，同時也十分感謝五年研究生活中親夕相處的實驗室伙伴們，包括學長們的諄諄教誨，讓學生能夠以他們為榜樣，期許自己朝著更有實力的目標邁進；學弟妹們的鼓勵與幫忙，讓學生有機會能培養團隊合作與領導的能力，並讓研與學生研究領域不同的太陽能電池，皆有世知名的企業家告訴學生：「博士之所以稱為博士，是因為知識與見識要比一般人更廣博，」一直以來學生將此看勉勵奉為主臬，期許自己能海納一個不斷地吸收新知，並爭取國科會提供的機會出國研究，如今，歷年研究成果能獲得此殊榮肯定，學生深感榮幸，更成為激勵學生向上的動力，讓學生有信心在未來踏入社會後能繼續貢獻所學，不斷地發光發熱。

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