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Band-gap tunable $(Ga_xIn_{1-x})_2O_3$ layer grown by magnetron sputtering

Key words: $(Ga_xIn_{1-x})_2O_3$ films; Band-gap tunable; Magnetron sputtering

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Motivation

1. Indium oxide has been used in various optoelectronic devices. However, the band-gap of In_2O_3 needs to be enlarged to allow the design of devices.

2. Band-gap of In_2O_3 can be enlarged by alloying with Ga_2O_3, which has a larger band-gap value than In_2O_3.

3. The grown $(Ga_xIn_{1-x})_2O_3$ films reported are all of amorphous structure and the Ga content range is limited.

4. Band-gap modulation creates higher potential for the application of $(Ga_xIn_{1-x})_2O_3$ in ultraviolet (UV) optoelectronics.

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Main idea

1. Grow crystalline $(Ga_xIn_{1-x})_2O_3$ films are prepared on a sapphire substrate.

2. Ga content *x* varies over a large range of 0.1–0.9.

3. The structural, band-gap, and optical properties of the obtained films are investigated and analyzed in detail.

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Method

1. $(Ga_xIn_{1-x})_2O_3$ layers were deposited on a sapphire substrate by a magnetron sputtering system at room temperature.

2. $(Ga_xIn_{1-x})_2O_3$ films were obtained using the layered deposition method; the In_2O_3 and Ga_2O_3 films were deposited layer by layer, followed by high temperature alloying.

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Major results

Prepared films

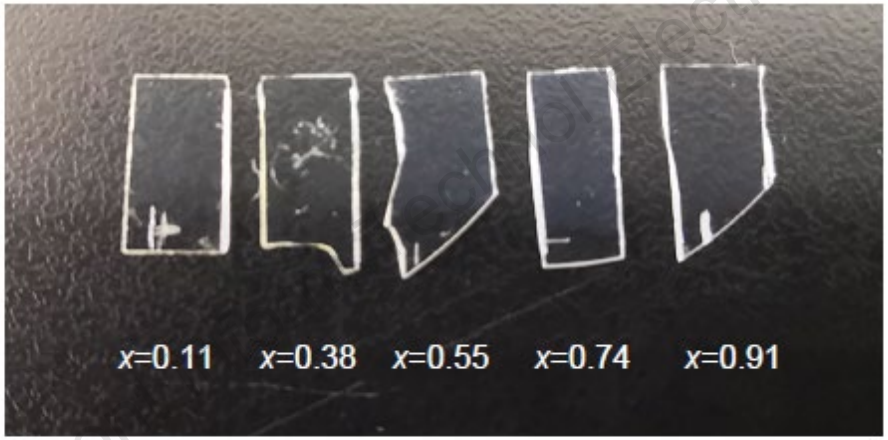

Fig. 2 Physical pictures of the prepared films

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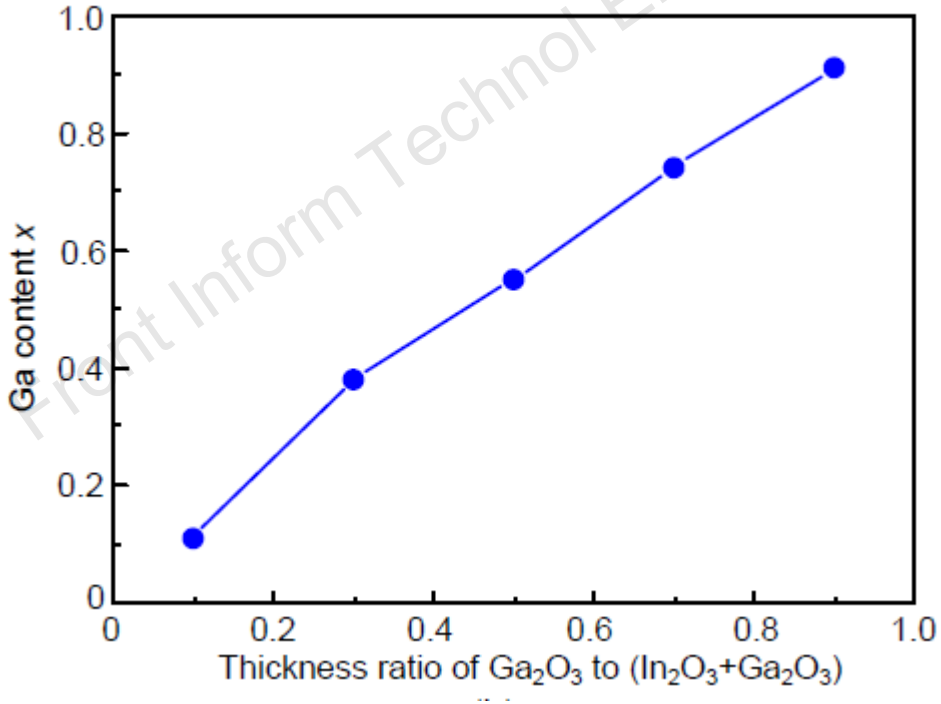
Major results (Cont'd)

1. Ga content *x* as a function of the thickness ratio of Ga_2O_3 to (In_2O_3+Ga_2O_3)



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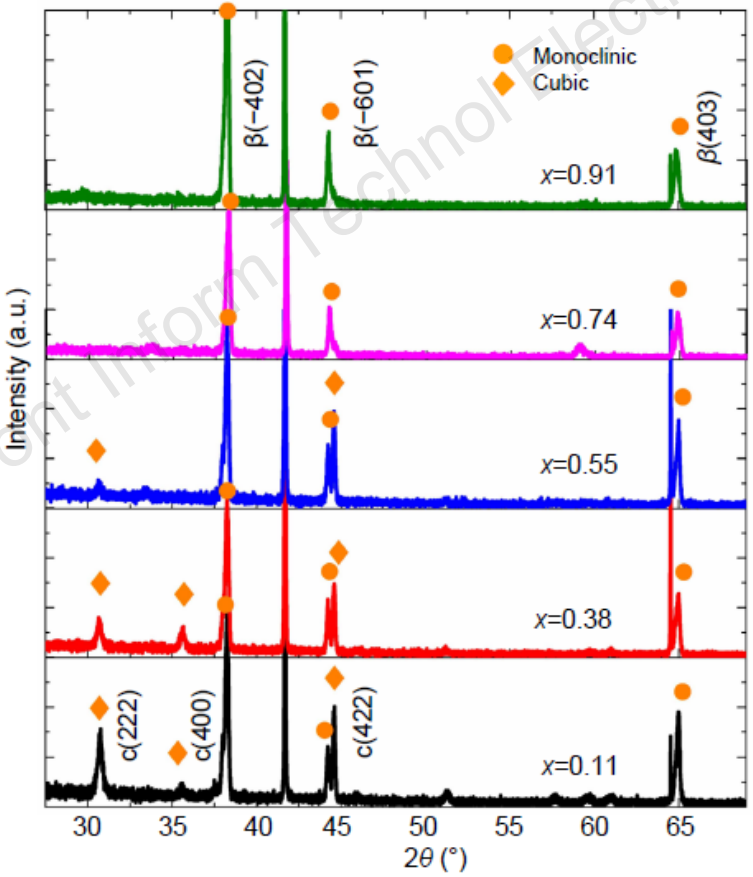
Major results (Cont'd)

2. X-ray diffraction (XRD) spectra of $(Ga_xIn_{1-x})_2O_3$ films at different Ga content values



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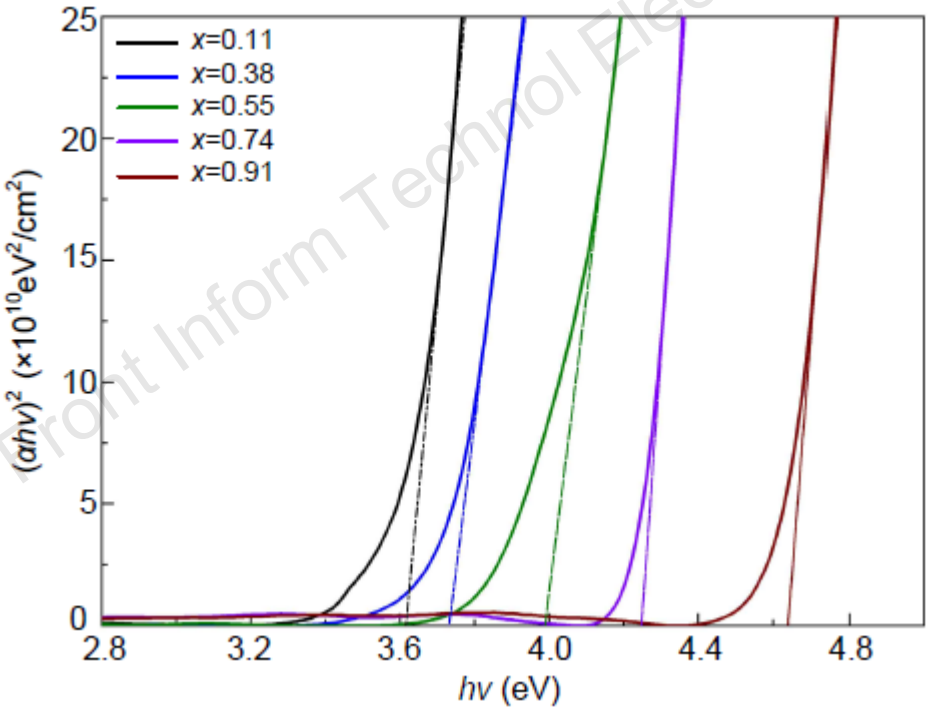
Major results (Cont'd)

3. Band-gap of $(Ga_xIn_{1-x})_2O_3$ films with Ga content values of 0.11–0.91



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Conclusions

1. For films with Ga content *x* from 0.11 to 0.55, both cubic and monoclinic structures existed, and for films with Ga content *x* higher than 0.74, only monoclinic structure appeared.

2. The surfaces of films were dense and had uniform grains, with a good surface quality.

3. All the films showed high transmittance in the visible range with sharp absorption edges.

4. Band-gap energy increased from 3.61 to 4.64 eV with increasing Ga content *x* from 0.11 to 0.91.

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Fabi ZHANG is a professor at Guilin University of Electronic Technology, China. He received his BS degree in 2001 and MS degree in 2003, both from Harbin Institute of Technology, and PhD degree in 2016, from Saga University. He has been supported by the projects “Guangxi Province Introduced Overseas Talent Plan” and “Key Teachers Training Program in Guangxi Province.” His research interest is wide band-gap semiconductor films.

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