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Effect of Oxygen-Doping in Ferroelectric Wurtzite-type Al0.73Sc0.27N

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Background and aim

Al1-xScxN is a group III-N based wide-bandgap wurtzite (w)-type ferroelectric. The material has been proven to be highly temperature stable as well as thickness scalable towards ultra-thin range.[1], [2] Most importantly, it is also compatible to both CMOS and GaN technologies. Therefore, ferroelectricity in Al1-xScxN is highly promising for applications such as non-volatile memory devices, neuromorphic computing, high-electron mobility transistors and even harsh environment electronics.[3], [4] However, ferroelectricity in w-Al1-xScxN is affected by high-leakage current which can become a limiting factor for its successful integration into devices.[5] In the past, standard approaches such as doping or strain was used in semiconductors to alter their properties, especially conductivitiy. Therefore, in this work we address this issue via elemental doping with Oxygen (O). During sputtering of 200 nm thin Al0.73Sc0.27N on Pt/Si templates, we introduced O via gas source into. This allowed us to tune the overall O-content in the bulk thin-film and study its underlying effect on the material structure and the ferroelectric properties of Al0.73Sc0.27N.

Methods

The structure of the doped samples was examined using X-ray diffraction, scanning transmission electron microscopy (STEM). The surface imaging and topography was performed via scanning electron microscopy and atomic force microscopy.

Results

Our results show that all the O-doped Al0.73Sc0.27N films have an overall lower leakage current density compared to the undoped films. This applies to the films even with significantly high O-concentrations $\geq$ 8 at.%. STEM analysis showed that the columnar Al0.73Sc0.27N crystalline grains remained unhampered with no local phase or O segregation in the bulk. In addition, as O-dopant increases, the overall polarity of the film gradually changes from entirely nitrogen to metal polarity. This modification has no significant impact on the overall (0002) crystalline texture of the film, hence allowing for better control of the as-deposited polarization state of the material.

Conclusion

Our study shows that O-doping could be a viable remedy for the leakage current compensation in w-Al1-xScxN and possibly for all other wurtzite-type ferroelectrics as well.

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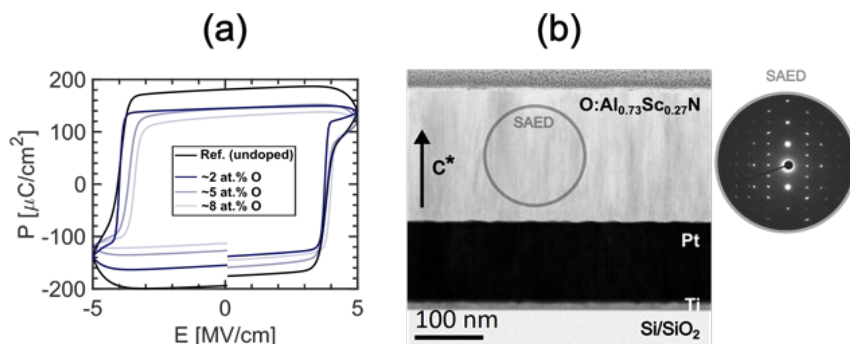
Graphic:



Keywords:

Wurtzite-type, Ferroelectric, doping, Oxygen

Reference:

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