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Ion beam induced a-axis in-plane oriented (0001) ScAlN thin film

イオンビームアシストスパッタ法による a 軸方向の揃った c 軸配向 ScAlN 薄膜の成長

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1. Introduction

The frequency bands are becoming heavily used because of the increase of wireless standards. Therefore, the demands for high Q filters are increasing. Wurzite materials such as ZnO and AlN are tends to grow along the (0001) direction because the surface density energy of the (0001) plane is the lowest. On the other hand, a-axis in-plane direction of standard AlN is random as shown in **Fig. 1**. In previous study, it was found that the direction of crystal growth of ZnO can be controlled by ion beam irradiation during deposition [1, 2]. We considered that the mechanical Q_m factor is improved by aligning the direction of crystal growth of AlN and ScAlN for in-plane direction as shown in **Fig. 2** [3].

In this study, we demonstrated the growth of c-axis oriented (0001) AlN film and ScAlN film whose crystalline a-axis direction $(11\bar{2}0)$ is aligned by ion beam irradiation.

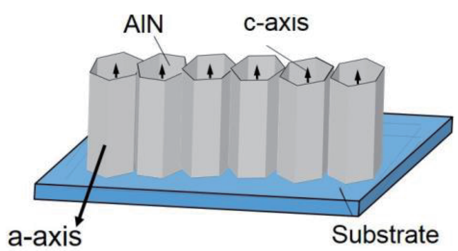

Fig. 1 AlN thin film whose a-axis in-plane direction is random

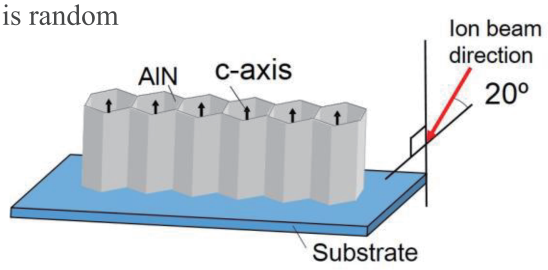

Fig. 2 AlN thin film whose a-axis in-plane direction is aligned

2. Experiment

AlN and ScAlN thin films were grown on Ti bottom electrodes/ silica glass substrates by RF magnetron sputtering system. One was grown without ion beam irradiation and the others were grown with ion beam irradiation during deposition. The ion beam accelerating voltage of each thin film is shown in **Table I**. N_2 ion beam from ECR ion source (ARIOS, EMIS-111Q) was accelerated to the substrate. Ion beam incident angle is 20º with respect to the substrate surface. The in-plane and out-of-plane orientations of the thin films were measured by the X-ray diffraction (XRD).

Table I Ion beam accelerating voltage of the films

	AlN film A	AlN film B	ScAlN film C
Ion beam accelerating voltage	None	0.5 kV	0.3 kV

3. In-plane orientation of the films

The crystalline orientations of the films were examined by X–ray diffraction (XRD). **Table II** shows the rocking curve FWHM (0002) peak and the thickness of the films. All films have sufficient crystalline orientation. **Fig. 3, 4, 5** show the $(10\bar{1}1)$ pole figure of the AlN thin films and ScAlN thin film. The sixth symmetry was not observed in the pole figure of the film without ion beam irradiation, as shown in **Fig. 3**. This indicates that a-axis in-plane direction of standard AlN is random. On the other hand, the sixth symmetry was observed in the pole figure of the AlN film and ScAlN film with ion beam irradiation shown in **Fig. 4, 5**, respectively. It shows that the a-axis orientation is aligned in-plane direction. Therefore, the a-axis direction of c-axis oriented AlN film and ScAlN film can be aligned in-plane by using ion beam irradiation.

Table II Properties of the thin films

	AlN film A	AlN film B	ScAlN film C
Thickness of film (μm)	4.4	4.3	3.9
Rocking curve FWHM	1.3°	2.0°	3.7°

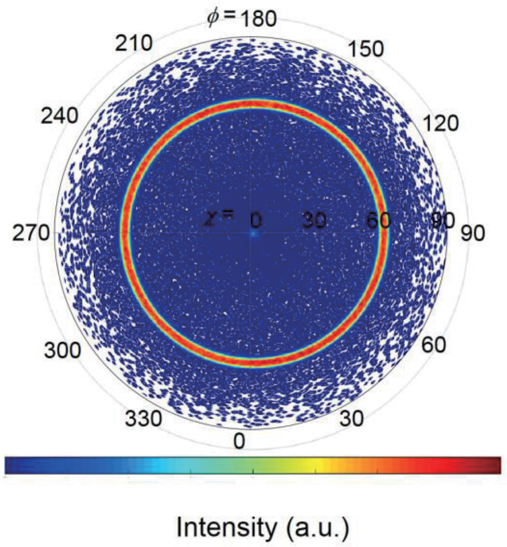

Fig. 3 $(10\bar{1}1)$ pole figure of the AlN thin film A without ion beam irradiation

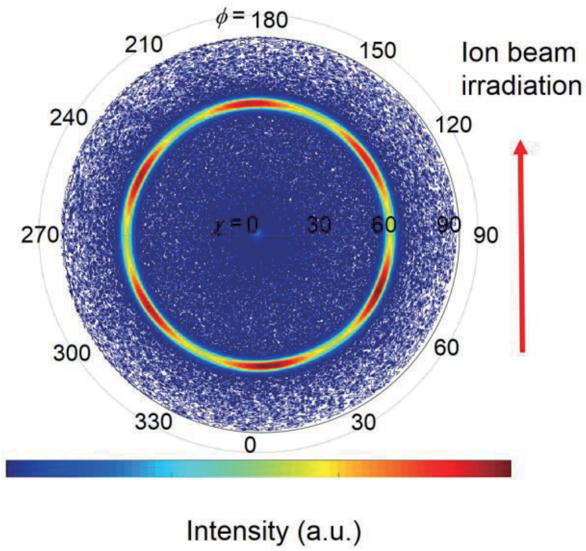

Fig. 4 $(10\bar{1}1)$ pole figure of the AlN thin film B with ion beam irradiation (0.5 kV)

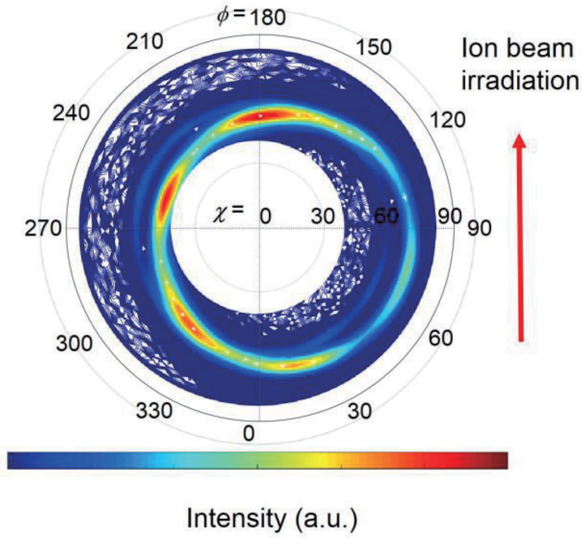

Fig. 5 $(10\bar{1}1)$ pole figure of the ScAlN thin film C with ion beam irradiation (0.3 kV)

4. Conclusion

We reported the growth of the c-axis oriented (0001) AlN film and ScAlN film whose crystalline a-axis direction is aligned by ion beam irradiation. Sixth symmetry were clearly observed in the $(10\bar{1}1)$ pole figures of the films with ion beam irradiation. This indicates that the a-axis direction of AlN film and ScAlN film can be aligned in-plane by using ion beam irradiation. This demonstration holds promise for increasing the Q_m factor of thin films.

Acknowledgment

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References

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