Full epitaxial ScAlN, ZnO and MgZnO SMR based on epitaxial metal acoustic Bragg reflector
Satoshi Tokai,1,2 and Takahiko Yanagitani1,2,3,4
1 Waseda University, 2 ZAIKEN, 3 JST-CREST, 4 JST-FOREST

1. Background

- High sharpness (Q factors) is required for BAW filters to prevent interference between neighboring frequency bands.
- Lower dielectric and mechanical losses in the single crystalline piezoelectric thin films should contribute the increase of Q factors.
- Fabrication methods for single crystalline piezoelectric thin films
  - (i) Bulk crystal slicing technique
  - (ii) Epitaxial growth technique
- Epitaxial growth technique might be better in order to obtain thin single crystalline layer in large areas of over 8 inches.

SMR [1] consists of a piezoelectric thin film on Bragg reflector based on high and low impedance layers.

To fabricate SMR with epitaxial piezoelectric layer, usual bottom-up process is difficult to be employed due to the amorphous SiO2 in a low acoustic impedance layer.

In this study

We report SMR with epitaxial ScAlIN, ZnO or MgZnO piezoelectric layer based on epitaxial Bragg reflector.

2. Method

All epitaxial thin films were grown by RF magnetron sputtering.

(i) The acoustic Bragg reflector based on epitaxial (0001) Ti / (111) Pt or epitaxial (0001) ZnO / (111) Pt was grown on (0001) sapphire substrate.

(ii) (0001) ScAlIN, (0001) ZnO or (0001) MgZnO piezoelectric layer was epitaxially grown on epitaxial acoustic Bragg reflector, respectively.

3. Result (full-epitaxial SMR based on 5 pairs of Ti/Pt)

3.1 Cross sectional SEM image

Epitaxial Sc0.43Al0.57N or Sc0.43Al0.57N piezoelectric layer was fabricated on epitaxial acoustic Bragg reflector based on 5 pairs of Ti/Pt.

3.2 Crystal orientation determined by XRD

ScAlIN layer exhibits clear six-fold symmetry.

Epitaxial piezoelectric layers were fabricated on SMR.

3.3 Local crystal orientation determined by TEM

Spot electron diffraction patterns from ScAlIN and 5th pair of Ti/Pt were observed.

All layers of SMR are epitaxially grown.

3.4 Impedance characteristic measured by network analyzer

- Resonance-antiresonance peaks were observed around 1.8 GHz.
- k'eff was determined by resonance-antiresonance method.

4. Result (full-epitaxial SMR based on 6 pairs of ZnO/Pt)

4.1 Cross sectional SEM image

Epitaxial Sc0.43Al0.57N or Mg0.30Zn0.70O piezoelectric layer was fabricated on epitaxial acoustic Bragg reflector based on 6 pairs of ZnO/Pt.

4.2 Crystal orientation determined by XRD

ScAlIN or MgZnO layer exhibits six-fold symmetry.

Epitaxial piezoelectric layers were fabricated on SMR.

4.3 Impedance characteristic measured by network analyzer

- Resonance-antiresonance peaks were observed around 2.1 GHz.
- k'eff was determined by resonance-antiresonance method [2].

Epitaxial Sc0.43Al0.57N SMR:

\[ k'_{eff} = 3.1% \]

5. Conclusion

SMR with epitaxial ScAlIN or MgZnO piezoelectric layer based on epitaxial Ti/Pt or ZnO/Pt acoustic Bragg reflector was characterized.

- Epitaxial ScAlIN and MgZnO layers showed clear six-fold symmetry.
- k'eff was determined by resonance-antiresonance method.
  - Epitaxial Sc0.43Al0.57N SMR (Ti/Pt 5 pairs):
    - k'eff = 5.1%
  - Epitaxial Sc0.43Al0.57N SMR (Ti/Pt 6 pairs):
    - k'eff = 3.1%
  - Epitaxial Sc0.43Al0.57N SMR (ZnO/Pt 6 pairs):
    - k'eff = 13.5%

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