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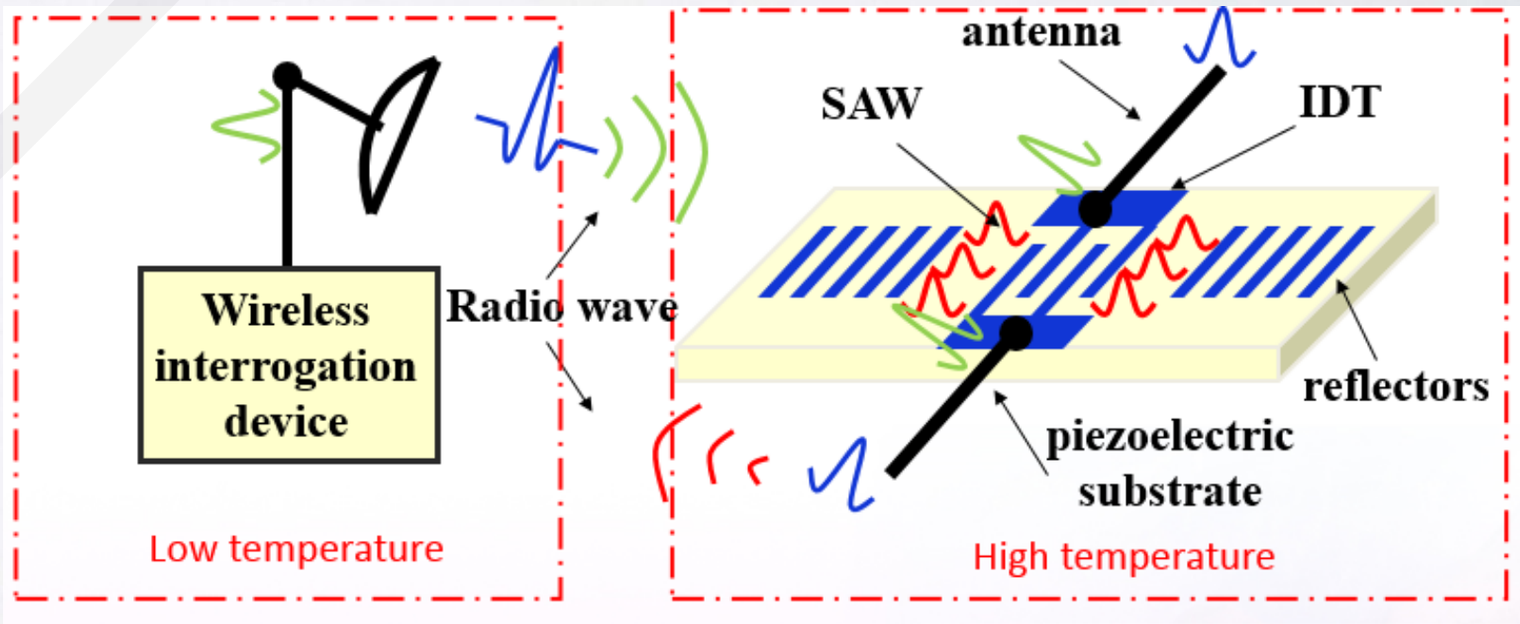
Design and fabrication of an surface acoustic wave resonator based on AlN/4H-SiC material for harsh environments

Key words:

SAW resonator, AlN/4H-SiC, harsh environment, MEMS technology, gas turbine



application requirement



300~600℃

terrestrial heat exploitation



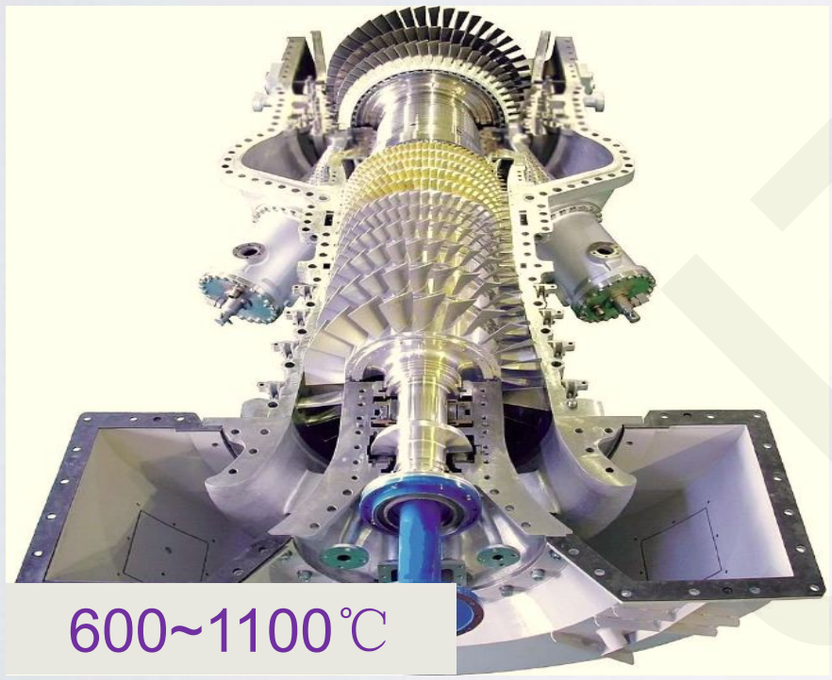
300~600℃

automotive engines



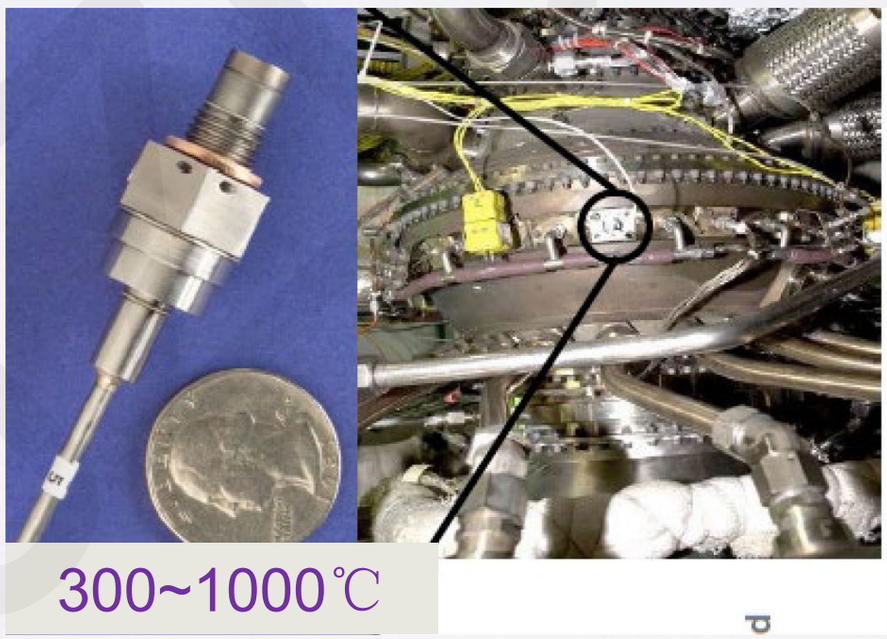
200~1000℃

hypersonic aircraft



600~1100℃

gas turbine



300~1000℃

turbojet engine

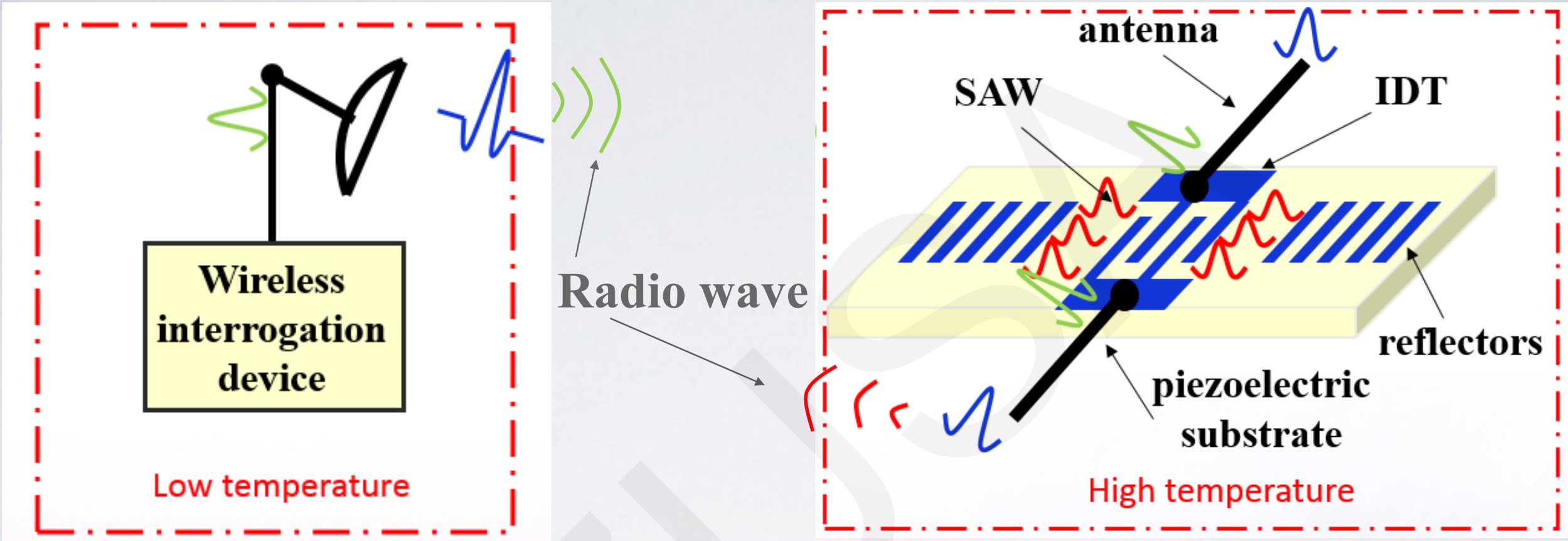


800℃~2600℃

near space aerocraft

photos source： google search

MEMS+SAW

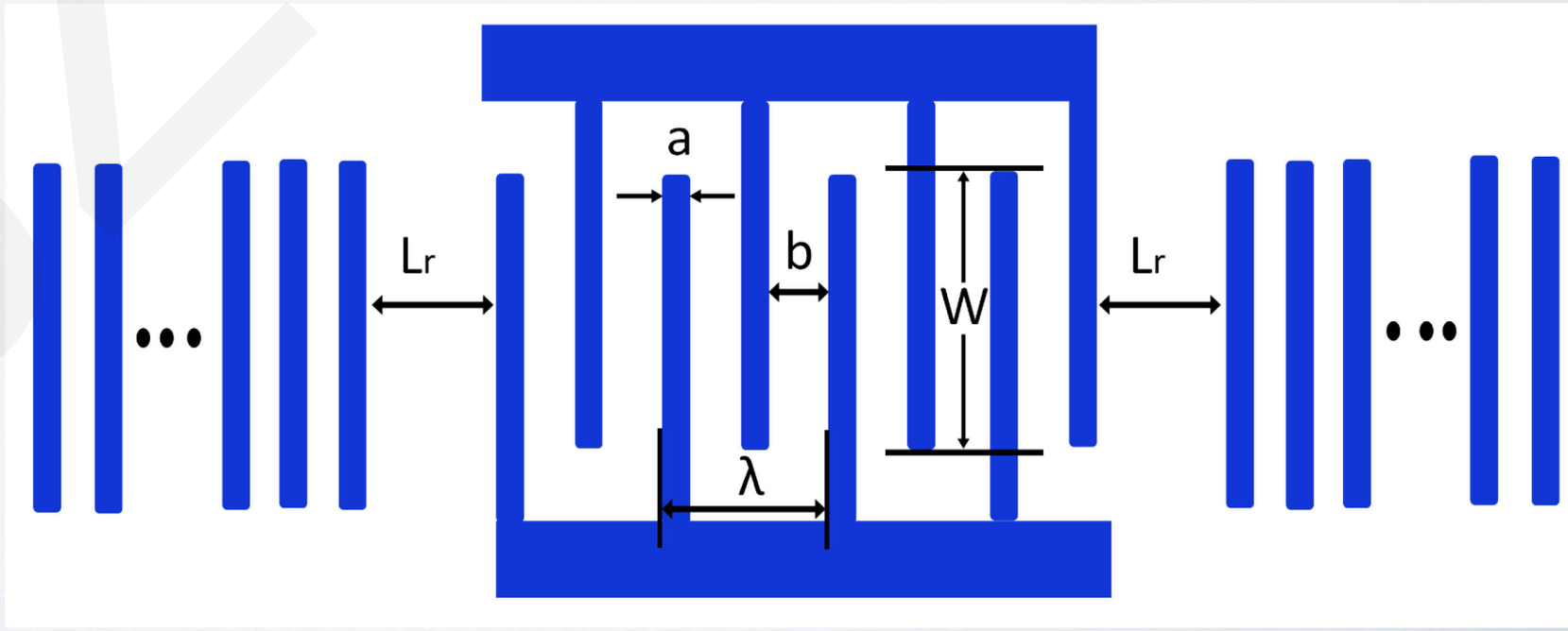


High-temperature Wireless MEMS Temperature Sensing System

Parameter design

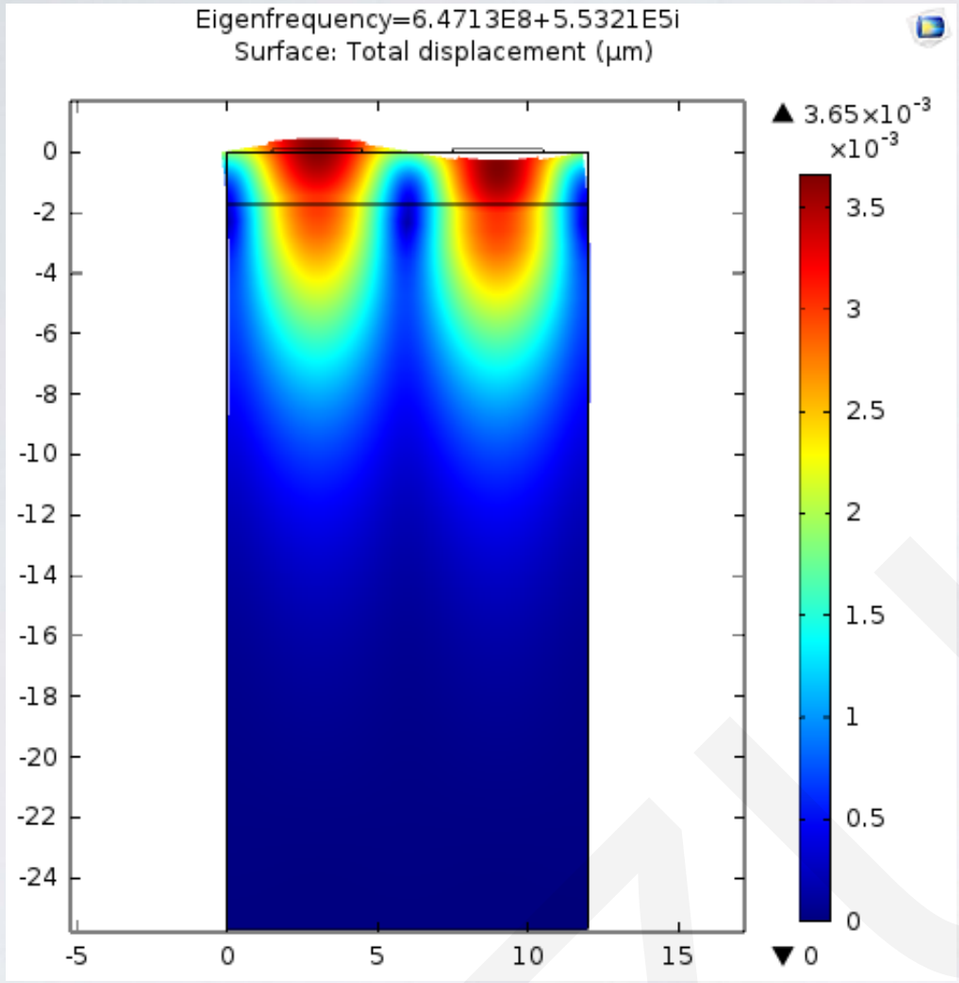
$$f = \frac{V_s}{\lambda_0} \qquad a + b = N\frac{\lambda_0}{2}$$

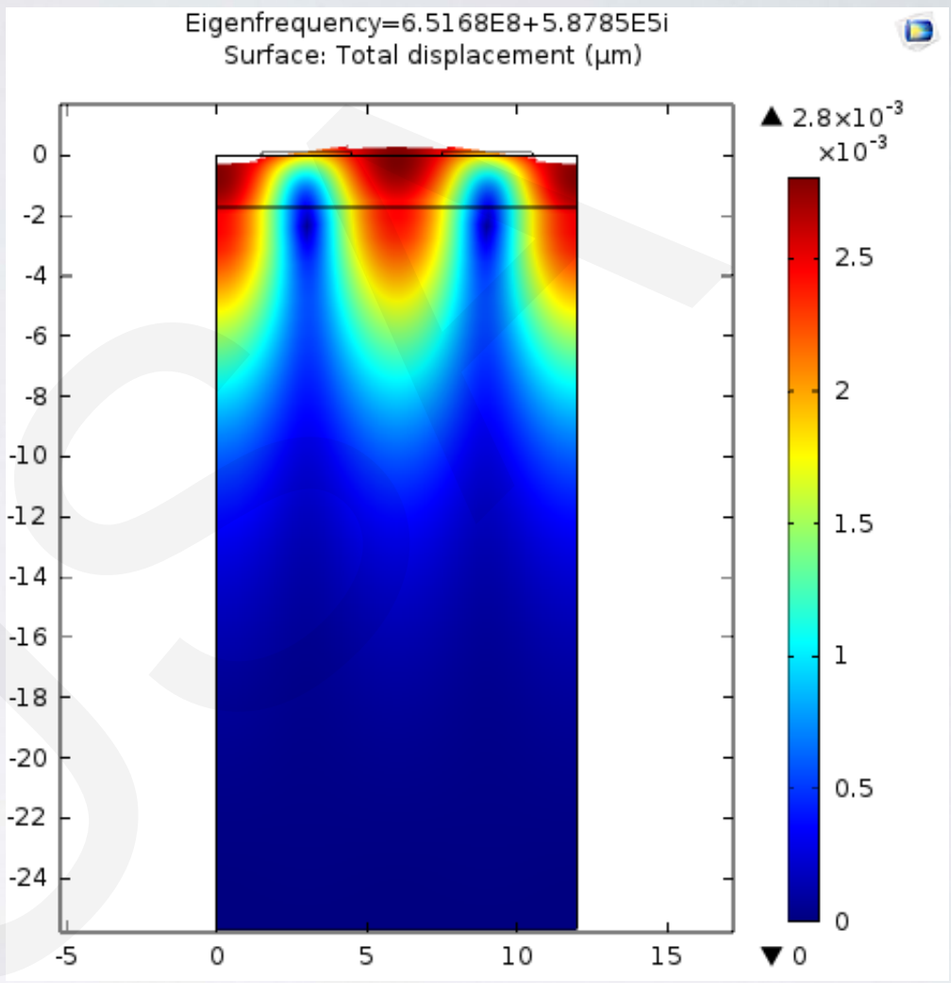
$$L_r = (N - \frac{1}{2})\frac{\lambda_0}{2}$$



FEM simulation

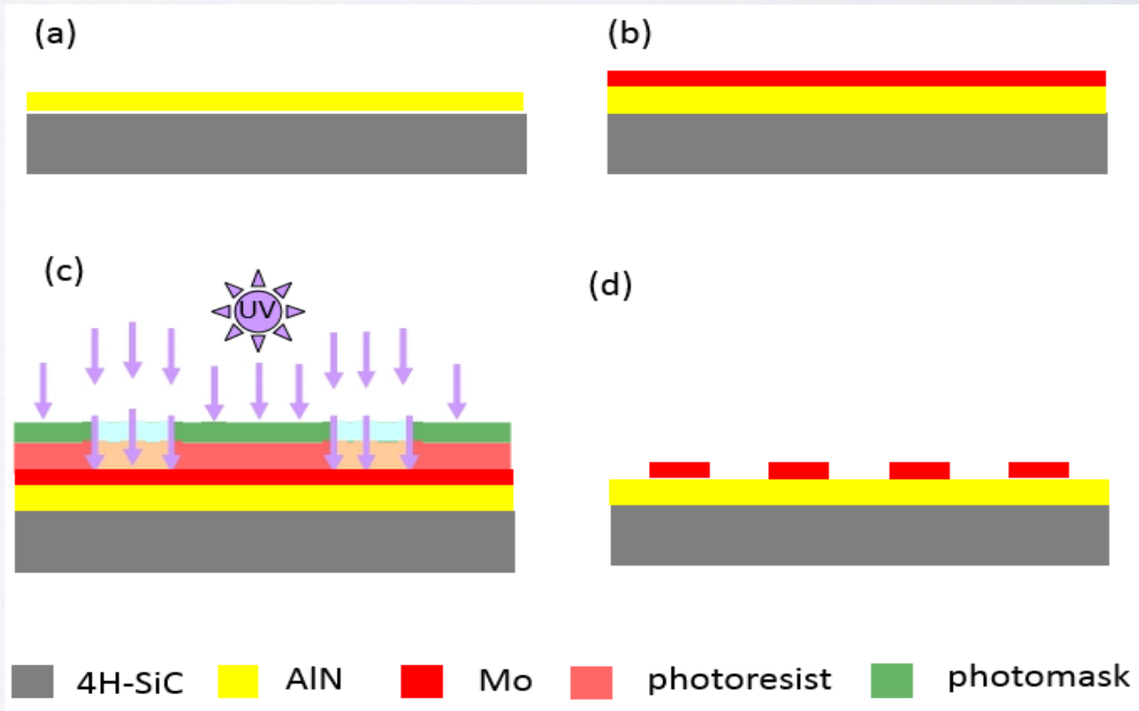
Finite element simulation software COMSOL Multiphysics is used to simulate the device performance





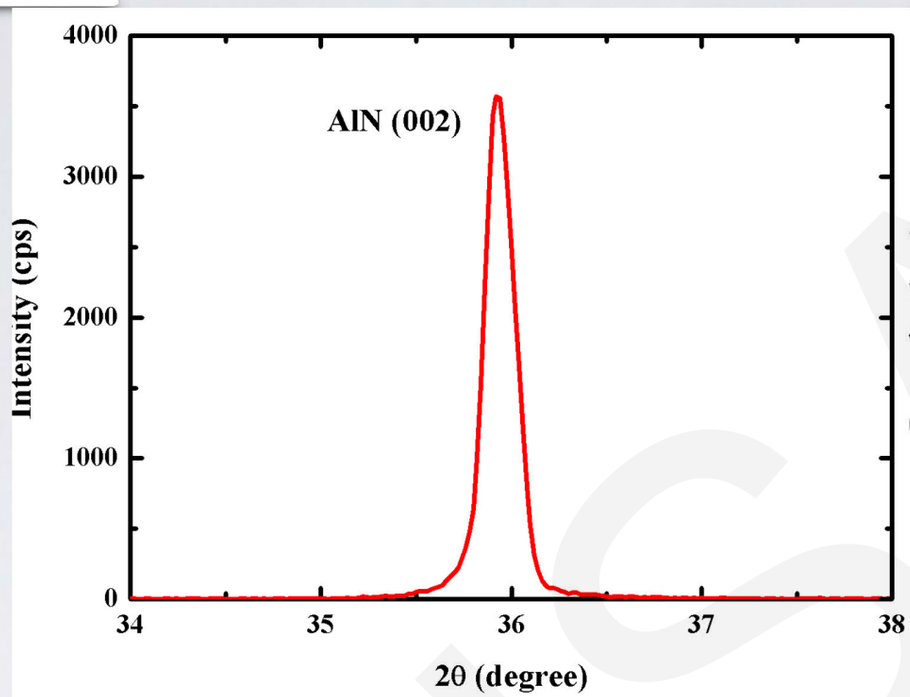
MEMS fabrication

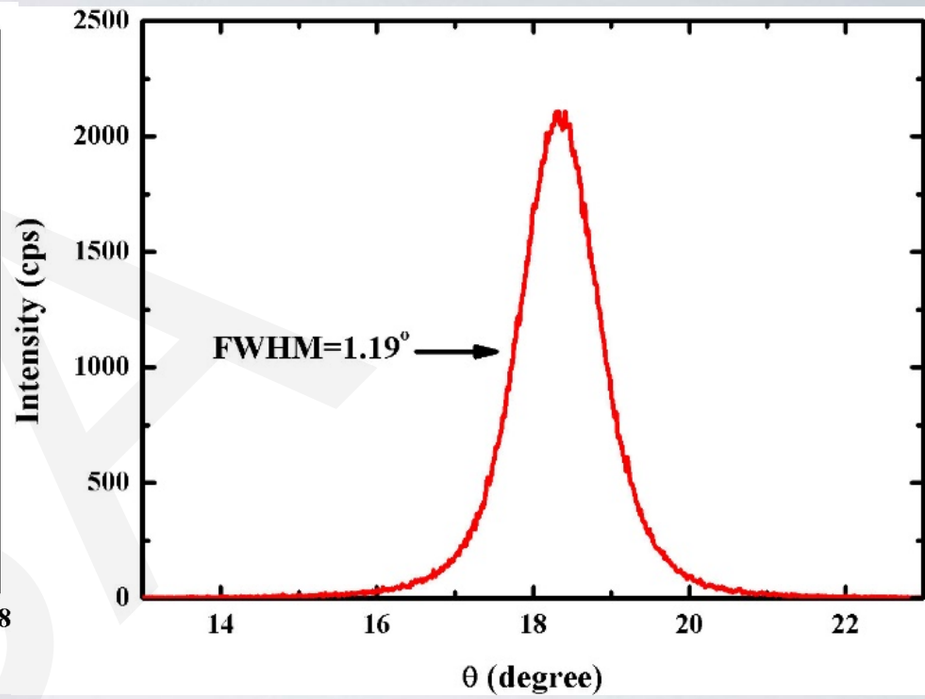
(a) AlN is deposited as piezoelectric layer on 4H-SiC.
(b) Mo is deposited on AlN.
(c) Mo is patterned through photoetching.
(d) IDT and reflecting grating electrode were fabricated by wet etching.



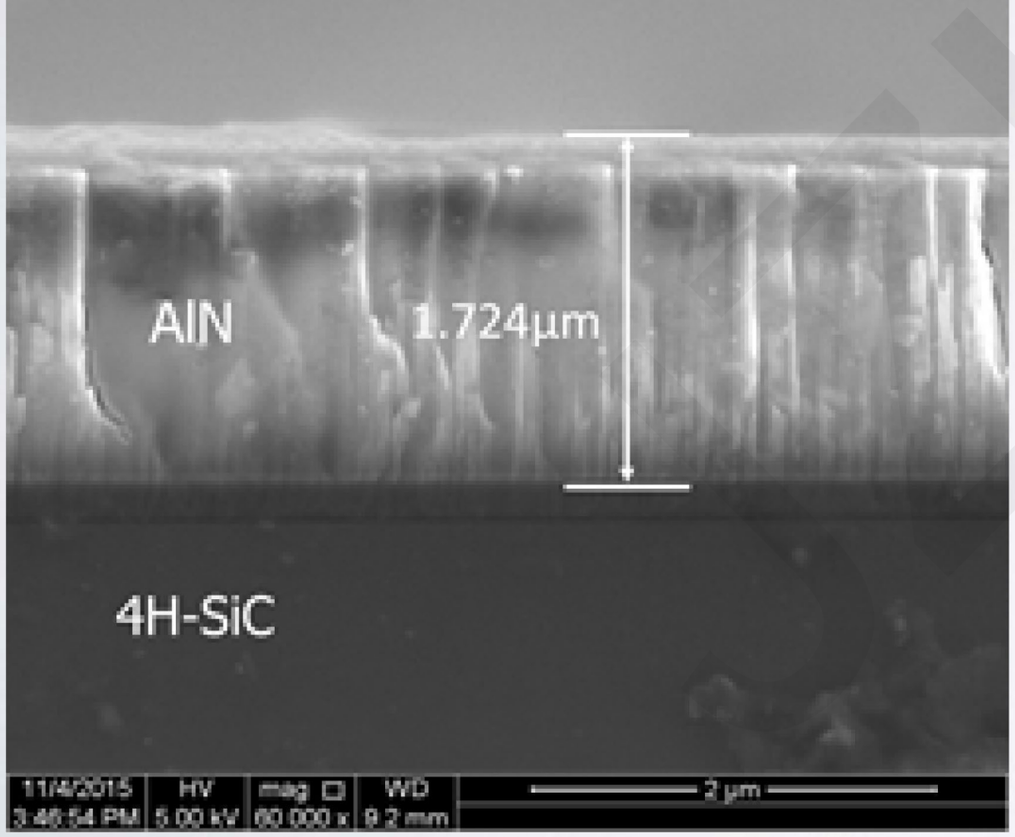
c-axis-oriented AlN thin films

- AlN thin film exhibits columnar grains perpendicular to the surface of the 4H–SiC layer
- High quality c-axis-oriented AlN thin film was grown on the 4H–SiC layer



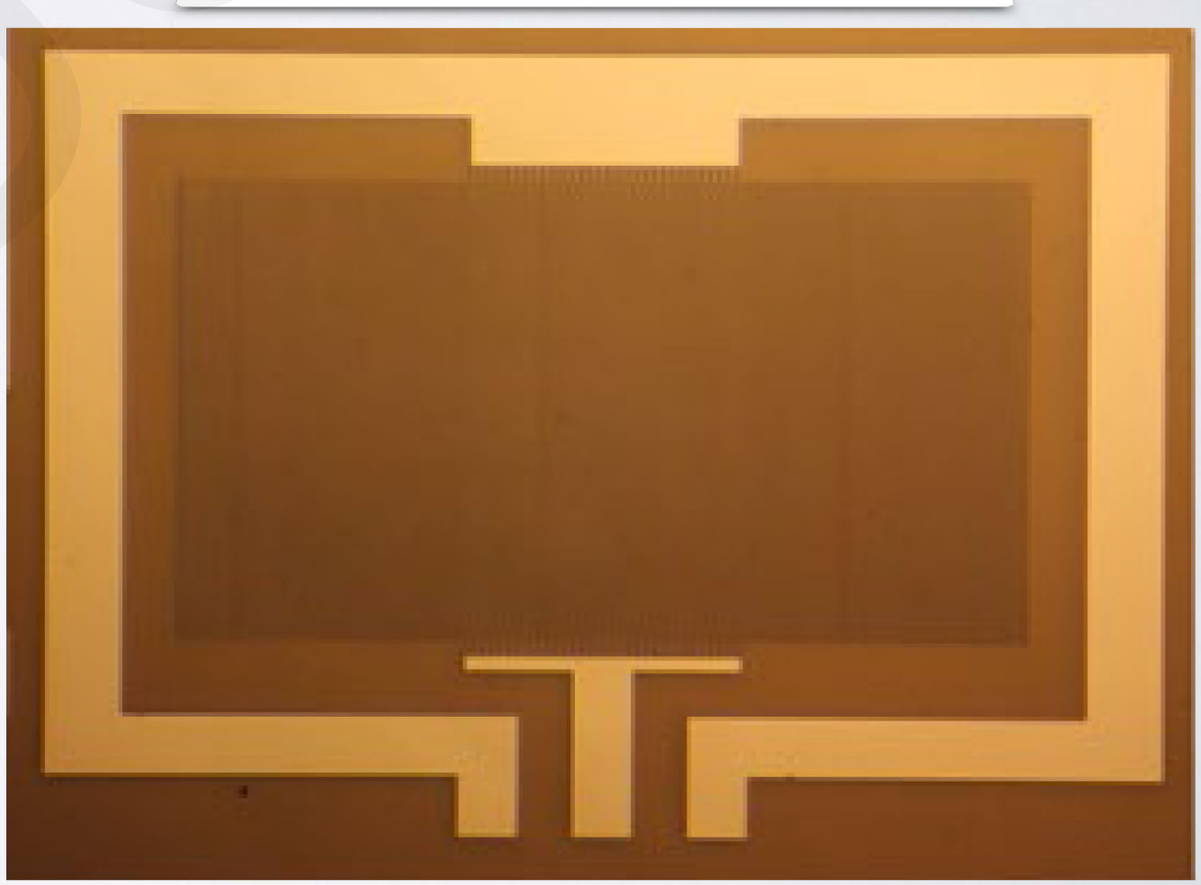


XRD（**35.92°**）



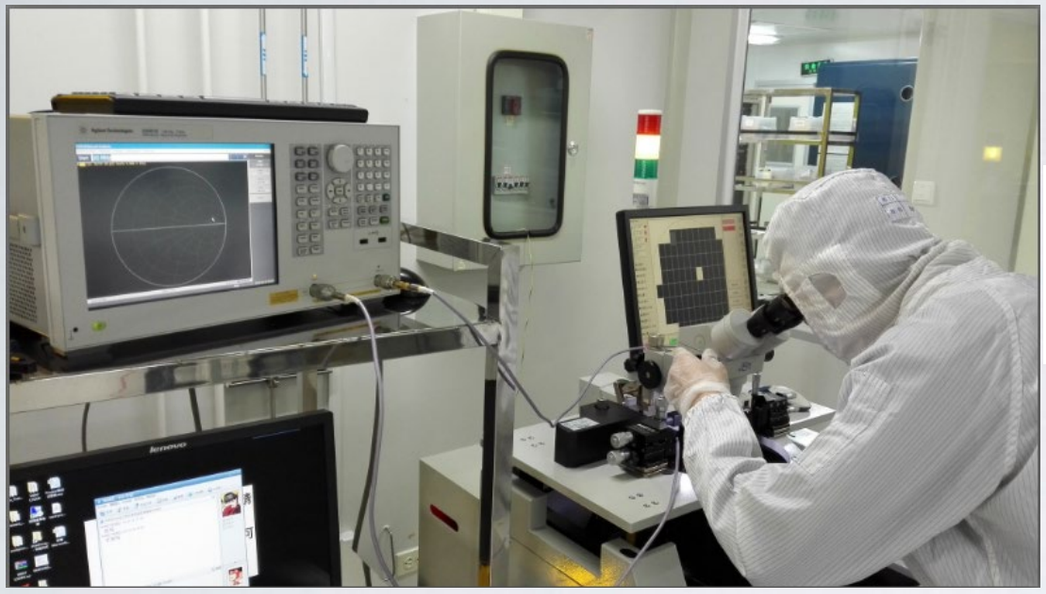
Cross-sectional SEM micrographs of the 4H-SiC and AlN films

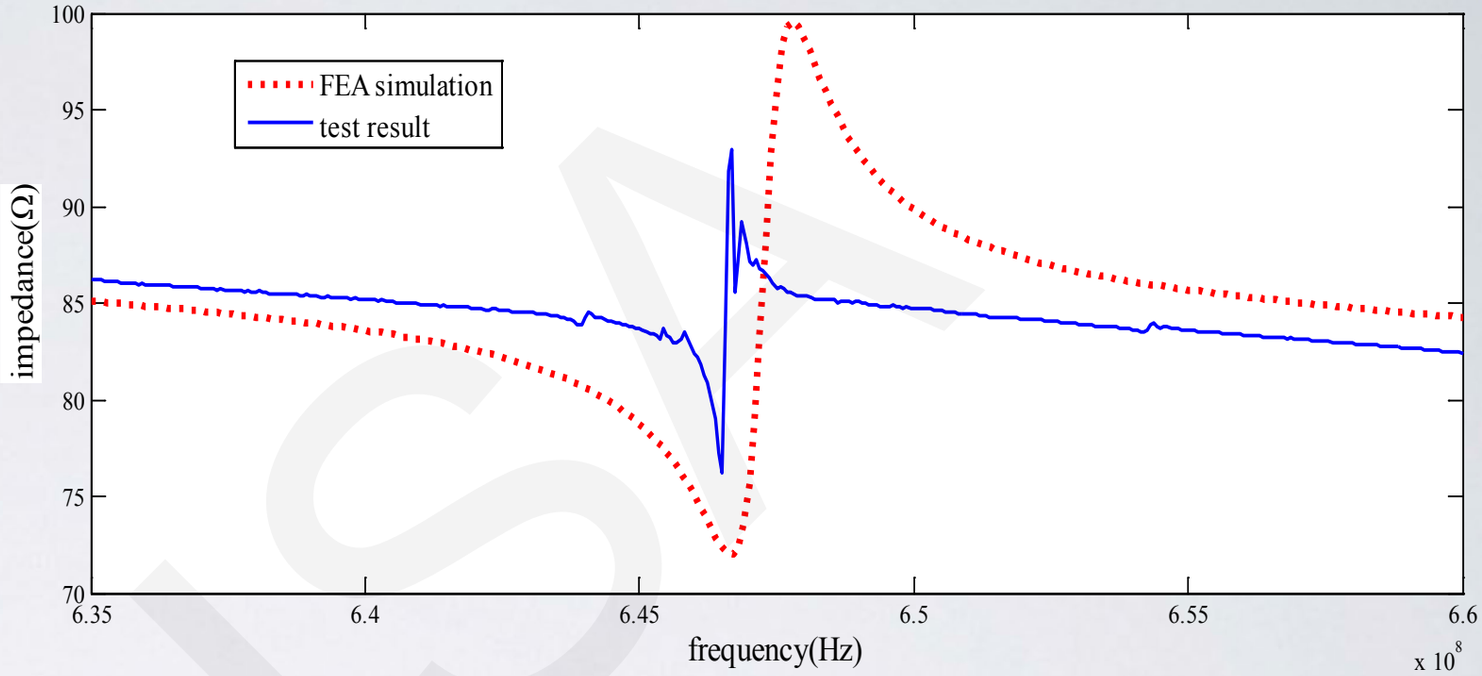
Fabrication result



Optical image of the fabricated resonator

resonance frequency test





frequency-impedance chart of the FEA simulation and test result.

conclusions

- For the first time, a SAW resonator (size: 1107μm×721μm) based on the AlN/4H-SiC multi-layer structure is designed and fabricated in this work.
- Highly c-axis-oriented AlN thin films were success-fully deposited on the 4H–SiC substrate by using RF reactive magnetron sputtering and the lowest FWHM value is only 1.19°.
- a MEMS-compatible fabrication process has been employed to fabricate the SAW resonator.
- In comparison with the simulation curve, the test results of the network analyzer are consistent with it.