Polarization Control

of AlScN piezoelectric films in high-volume production

In a significant leap forward for piezoelectric thin film technology, Evatec has successfully developed a process for polarization control of AlScN (Aluminum Scandium Nitride) layers – marking a groundbreaking achievement for high-volume manufacturing of RF devices. Evatec's Wireless Product Marketing Manager, **Dr. Oguz Yildirim**, and Process Engineer, **Demian Henzen**, tell us more.

A new era in Wireless Communication

The next generation of wireless communication (6G) is expected to be introduced at the end of the decade. As the race to meet the technological standards for 6G intensifies, the RF frontend module is emerging as a critical component in enabling end users to access the ultra-high speeds and bandwidths that 6G promises.

While many elements of the RF frontend can be adapted for high-frequency operation, the RF filter remains the most challenging and essential part of the puzzle.

In this context, the demonstration of periodically poled piezoelectric layers marks a significant step forward. These engineered structures offer the potential to dramatically increase resonance frequencies, paving the way for high-performance filters that meet the demands of next-generation wireless systems.

Periodically poled piezo AlScN (P3F) layers represent a transformative advancement in RF filter technology. By alternating the polarization direction across the piezoelectric film, these engineered structures enable the excitation of higher-order acoustic modes, most notably the 4th thickness extensional mode (TE4). This allows resonators to operate at frequencies up to four times higher than conventional AlScN devices, reaching 17–18 GHz without reducing the film thickness and thus providing the possibility to keep quality factors and coupling coefficients [1].

"In-situ polarization control during deposition without vacuum break is now possible"

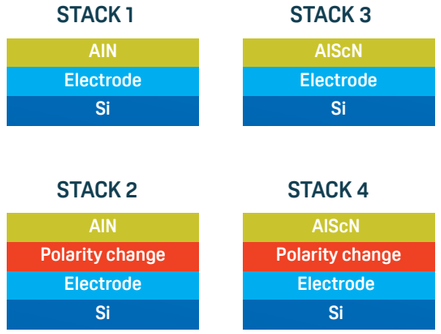


Figure 1: Stack designs for AlN and AlScN layers.

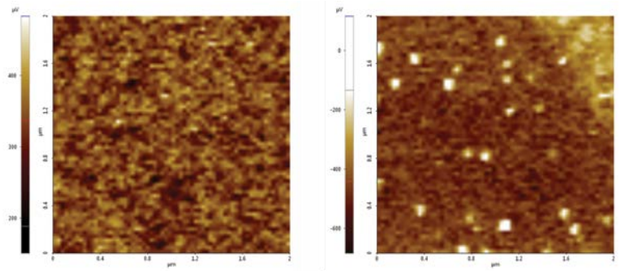


Figure 2: PFM quad images.

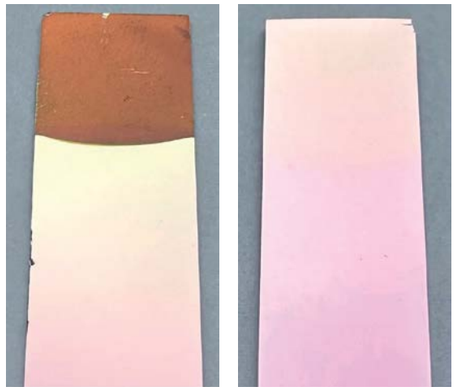


Figure 3: KOH etching results.

Polarization Control on CLUSTERLINE® 200

Using Evatec's CLUSTERLINE® 200 cluster tool platform, our process engineering team demonstrated precise control over the polarity of AlN and AlScN films through a combination of both new hardware and process developments. Particulary significant is the fact that such a breakthrough could be achieved without breaking vacuum and keeping the wafer in the same tool throughout the AlScN production process, significantly reducing the costs as compared to integration-based alternatives. This development also sits alongside our new solutions for epitaxial seed layers, hot electrodes (see LAYERS 8, 2024).

Checking the Results

Polarity control for the AlN and AlScN layers was checked by two different methods; i) KOH etching of AlN. Depending on the polarization, AlN etching rate in KOH changes significantly [2]. ii) Piezoelectric force microscopy (PFM). This technique probes the piezoelectric domains on the material and measures changes in response depending on the polarization direction (Figures 2, 3 & 4).

While these results show sucessful polarity control on the single piezo layer stack, double layer stacks with alternating polarity were also grown successfully and the device tests are currently ongoing.

[1] M. Izhar ,et al., Microsystems & Nanoengineering (2025) 11:19
[2] E. Milyutin et al, J. Vac. Sci. Technol. B 28 (6), Nov/Dec 2010

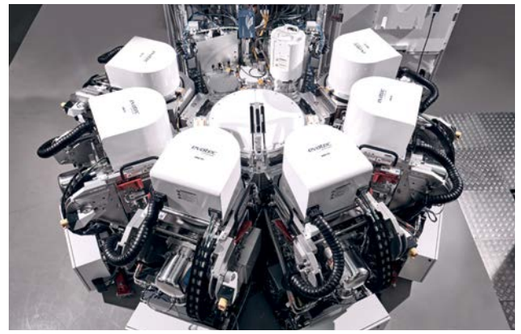
Evatec – Your long-term partner in wireless RF device technology

With over 25 years of experience in AlN-based piezoelectric layer development, and an installed base spanning North America, Europe, China, Southeast Asia, Korea, and Japan, Evatec has established itself as a global leader in RF filter technology. We are committed to pushing the boundaries of thin film technology and delivering solutions that empower our customers to innovate.

We would love to help you solve your own wireless thin film technology challenges too, so contact us today.

	AlN	AlN flipped	AlScN	AlScN flipped
STACK	AlN Electrode Si	AlN Polarity change Electrode Si	AlScN Electrode Si	AlScN Polarity change Electrode Si
RC (°)	1.29	1.44	1.63	1.49
$PFM/PFM_{(AlN)}$	1.0	-0.8	1.3	-1.1
$PFM/PFM_{(AlN)}$ Expected	1	~-1	~1.5	-1.5
Etched in KOh	Yes	No	-	-

Figure 4: Summary of the results.



CLUSTERLINE® 200.

SPOTLIGHT

About C-axis polarity control

C-axis polarity control enables RF filters working at frequencies where the frequency is defined by the thickness of the same polarity layer and not the whole thickness. For example, Figure 5a shows a conventional RF filter where the thickness defines the frequency. In Figure 5b the thickness is divided to 4 equal thicknesses which also quadruples the frequencies.

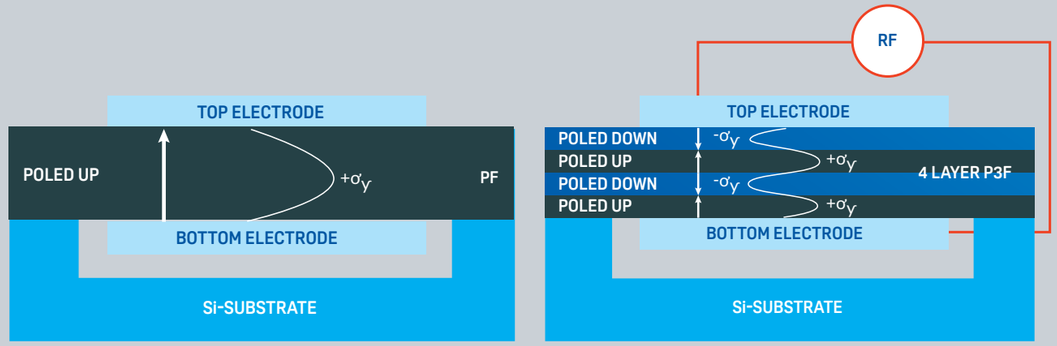


Figure 5: All about C-axis polarity control