



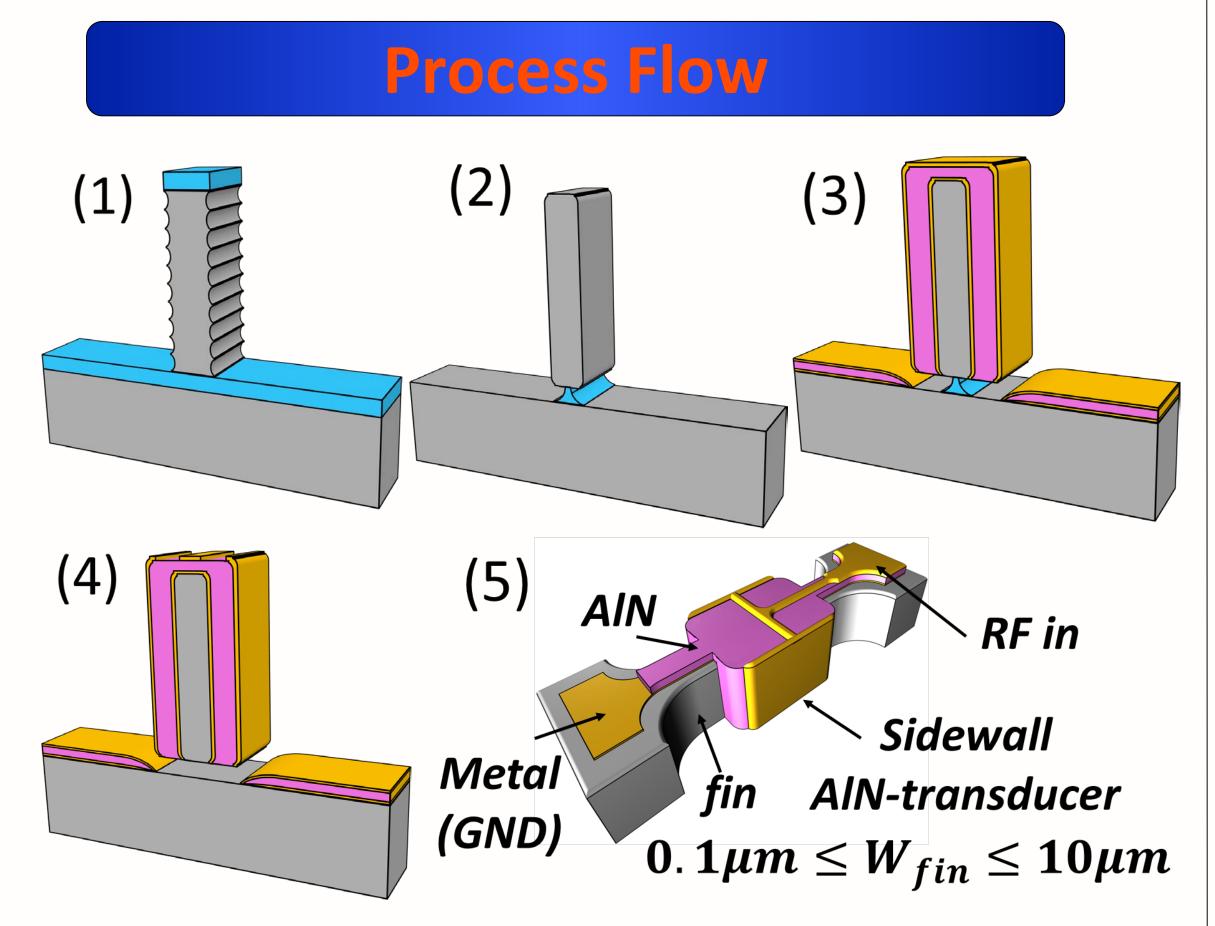
**Research Service Centers** 

## The Fin Bulk Acoustic Resonators (FinBAR): Enabling Integrated Signal Processing for 5G

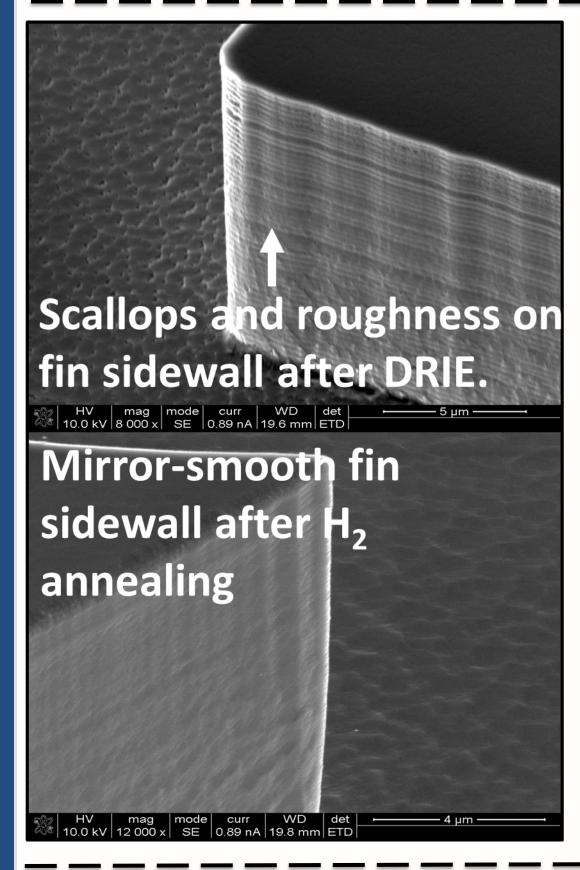
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## **Abstract**

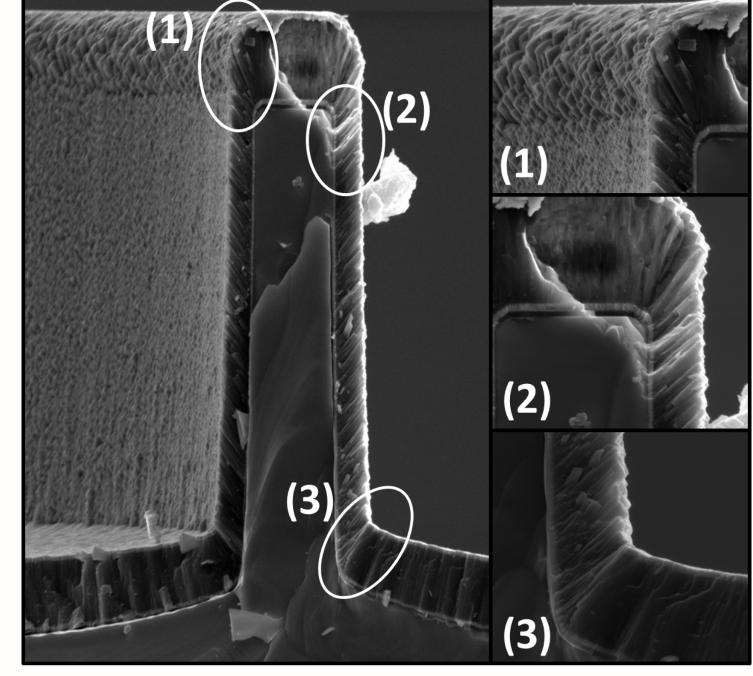
- This work presents the fabrication process for implementation of the <u>Fin</u> <u>Bulk</u> <u>A</u>coustic <u>R</u>esonator (**FinBAR**) with high aspect ratio of >30:1 & minimum lateral dimension of <1  $\mu$ m.
- The **FinBAR** technology surpasses the long-standing frequency scaling challenge of chip-scale filters through integration of piezo-film on sidewalls of semiconductor fin to enable high-Q mechanical resonance over SHF regime.



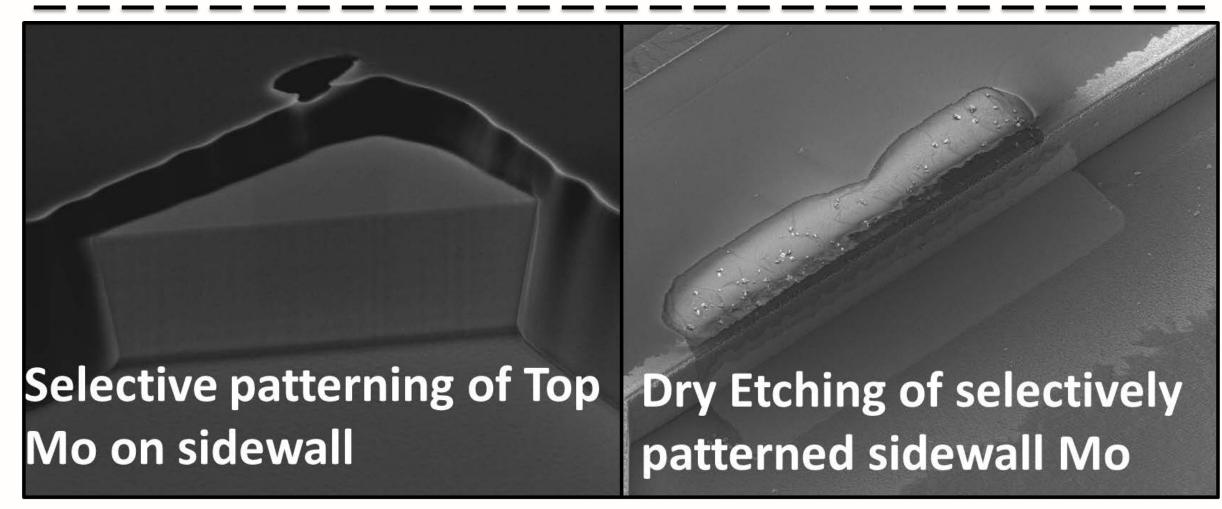
1) DRIE to pattern nano-fins on semiconductor substrate, resulting in rough sidewall surfaces. 2) <u>H<sub>2</sub> annealing (700°C)</u> to smoothen rough surface and sharp corners of fins. 3) <u>Sputtering</u> AlN transduction layer, sandwiched between Mo layers. 4) <u>Patterning</u> of top Mo & AlN on anchor-pad surfaces to facilitate RF / GND access. 5) One-port FinBAR.



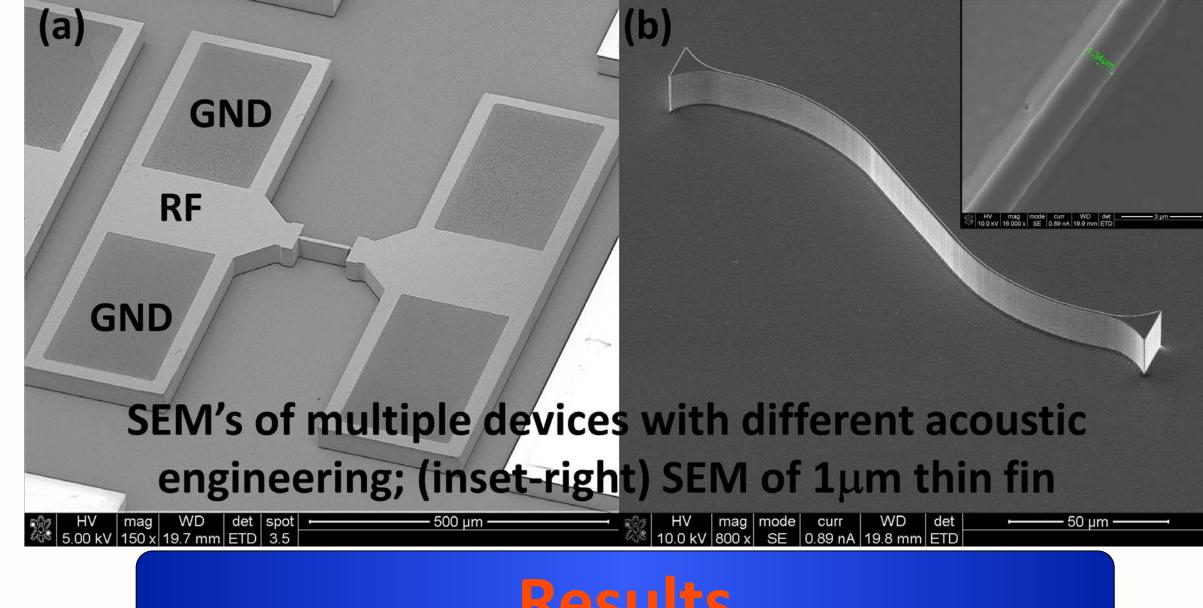
(top) Fin sidewall after 2-step Bosch Process (DRIE) with scallops (~200nm) and roughness non-conducive to C-axis-oriented and textured AIN growth; (bottom) mirror smooth fin sidewall after annealing at 700°C in N<sub>2</sub> /H<sub>2</sub> gas  $(10\% H_2 / 90\% N_2)$ . Several pre-anneal cleaning processes are conducted to remove polymer, organic and oxide residues.

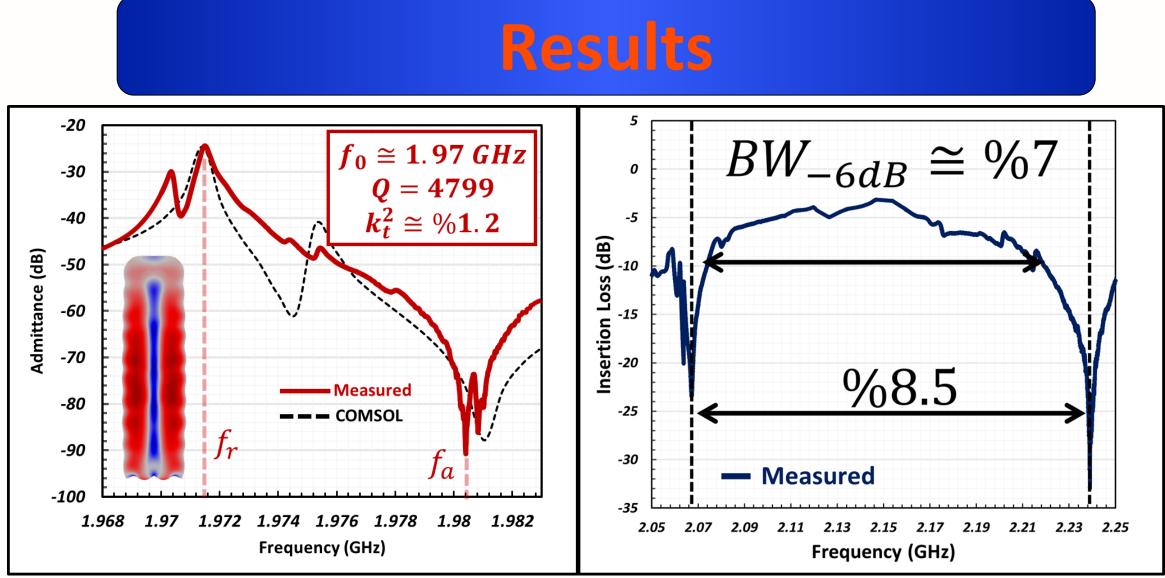


(left) Fin cross-section demonstrating piezo AlN layer sandwiched between Mo layers. (insets) Texture details of C-axisoriented piezo-AlN, enabled by annealed smooth sidewalls. AlN-on-top =~3um, AlN-on-sidewall=~1um.



(left) Selective PR patterning on the 3D nano-fins to pattern top Mo; (right) dry etching of Mo on the sidewalls & top.





(left) **Measured admittance** for the FinBAR operating in 3<sup>rd</sup> width-extensional mode, compared with COMSOL simulations; (right) **wideband UHF filter** implemented by electrical coupling of FinBARs with different fin widths [1].

[1] Ramezani, M, <u>Ghatge, M</u>, and Tabrizian, R. "High-Q Silicon Fin Bulk Acoustic Resonators for Signal Processing Beyond the UHF." *Electron Devices Meeting* (IEDM), 2017 IEEE International. IEEE, 2017.

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