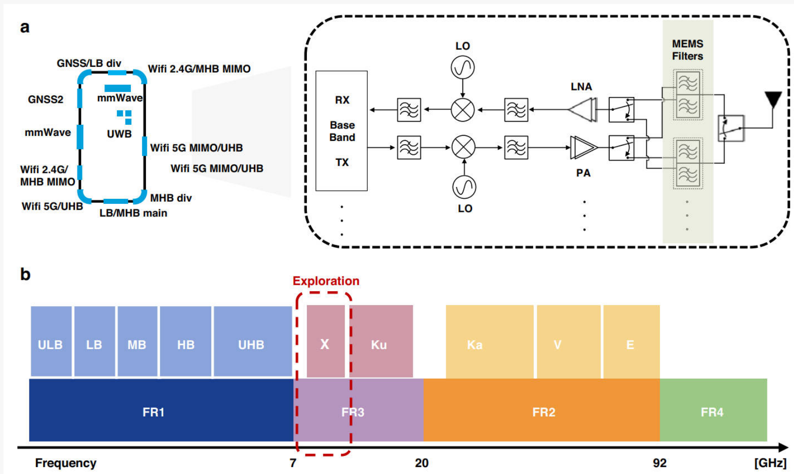
High-frequency and low-cost: the future of 6G filters on silicon

GA, UNITED STATES, June 23, 2025 /EINPresswire.com/ -- The race toward 6G wireless connectivity is intensifying, driving demand for faster, smaller, and more efficient components. A research team has now unveiled a breakthrough: a new class of radio frequency (RF) filters based on shear vertical surface acoustic waves (SV-SAW) fabricated on a cost-effective silicon-based platform. These filters operate in the centimeter-wave (cmWave) spectrum above 6 GHz—an essential frequency range for 6G—and deliver ultra-low insertion loss, high signal fidelity, and wide bandwidth. The innovation represents a pivotal step in making high-performance filters both manufacturable and scalable for next-generation mobile devices.



Wireless communication. a Radio frequency front-end module. b Spectrum resources

To support the explosive growth of AI-powered applications, immersive extended reality (XR), and a hyper-connected Internet of Things (IoT), wireless systems must migrate to higher frequencies. The cmWave band (7–15 GHz), which strikes a balance between speed and coverage, is at the forefront of 6G planning. Yet, filtering technology has lagged behind: traditional waveguide filters are too bulky for mobile use, and existing acoustic filters suffer at higher frequencies. Being fragile, suspended thin-film devices complicate mass production. Due to these limitations, there is a pressing need to develop compact, durable, and cost-effective RF filters that can perform reliably at cmWave frequencies.

In a study (DOI: 10.1038/s41378-025-00949-9) published in Microsystems & Nanoengineering on May 8, 2025, researchers from the University of Science and Technology of China and the Hong Kong University of Science and Technology presented a scalable solution to this challenge. They introduced shear vertical surface acoustic wave (SV-SAW) radio frequency (RF) filters based on a layered 128°Y $LiNbO_3/SiO_2$/poly-Si/Si substrate, designed specifically for 6G cmWave applications. These filters not only meet the demanding performance criteria of high-frequency communication but also promise low manufacturing cost and compatibility with silicon-based semiconductor processing.

The team’s design leverages the unique piezoelectric properties of 128°Y-cut lithium niobate, enabling excitation of shear vertical acoustic waves with strong energy confinement. By embedding additional SiO_2 and polycrystalline silicon layers between the piezoelectric layer and the supporting silicon substrate, the device achieves low insertion loss and excellent temperature stability. Experimental results reached center frequencies as high as 8.63 GHz, with insertion loss as low as 1.47 dB and 3-dB bandwidths up to 373 MHz. The resonators demonstrated high quality factors ($Bode\_Q_{max}$ up to 727) and high electromechanical coupling (k^2 ~ 8.9%). Moreover, the filters maintained performance across a wide thermal range with a temperature coefficient of −46 ppm/°C. Importantly, these were achieved using industry-compatible materials and techniques—laying a clear path toward scalable production.

“This work proves that high-frequency miniature-size RF filters can be both high-performing and manufacturable,” said Prof. Chengjie Zuo, corresponding author of the study. “Our SV-SAW design combines low cost with exceptional signal fidelity and thermal robustness. It’s the first time we've seen filters at this high frequency built on a solid silicon substrate, making it not only a scientific milestone but also a commercially viable innovation.”

The implications are wide-reaching. These SV-SAW filters could be integrated into 6G smartphones, routers, and base stations, dramatically improving data transmission while keeping production costs low. Their compatibility with standard semiconductor fabrication means they can be mass-produced using existing infrastructure. Beyond telecommunications, these filters have potential in aerospace, autonomous systems, and sensing applications—any field that demands compact and energy-efficient components operating at high frequencies. As the world edges closer to 6G deployment, this silicon-acoustic fusion offers a timely and transformative solution.

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