Case Study

# Miniaturizing RF Components Using Advanced Circuit Fabrication Methodologies

**Benchmark Lark Technology has transformed traditional radio frequency (RF) filters into small, surface mountable circuits with a significant reduction in size and weight. Achieving high performance in a much smaller package was made possible by the expertise of Lark engineers.**

## The Challenge: Designing High Performance Lightweight Filters for Microwave and Millimeter Wave (mmWave) Applications

Technologies, such as commercial 5G wireless and cutting-edge military communication systems, require ever-smaller electronic devices operating at higher frequencies with increasingly sophisticated electronics.

Passive and active RF components are the building blocks in the design of these applications; generating, blocking and receiving signals at specific frequencies to transmit data from point A to point B without interference. These components must be miniaturized to enable the next generation of innovation.

Conventional waveguide technology has high quality (Q) and low loss characteristics, but is also bulky and difficult to integrate with planar technology, such as surface mount technology or stacking with other components. RF filters, which select or block bands of frequencies received by RF or microwave devices, are often required in large quantities in communication systems.

Optimizing the size, weight and power, as well as cost, (SWaP-C) while maintaining or improving the performance has the potential to greatly improve the performance of the overall system.

For these reasons, the greatest potential lies in creating miniaturized components that can be easily stacked in a RF system.

## The Solution: Unique Circuit Design and Fabrication Technology

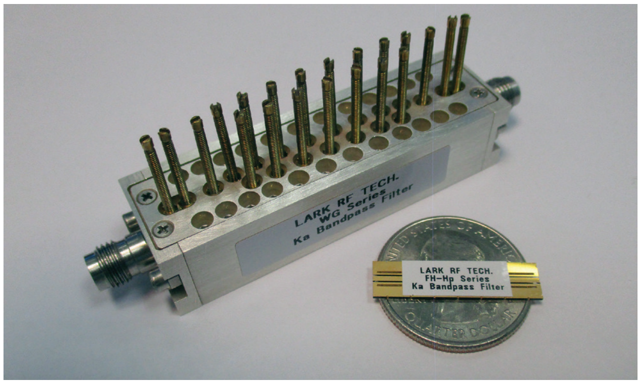
Benchmark Lark Technology has been providing the very best quality microwave and RF filters for telecommunications, medical, compute, aerospace, and defense applications since 1986.

Today, Lark offers high-performance RF components, to solve tough size, weight, power and cost (SWaP-C) challenges. This combination of skills was essential to the design of smaller, lighter filters.

To arrive at smaller, high-performance filters that address many of the disadvantages of conventional waveguide technology, engineers at Lark have created a new line of surface-mountable filers. Using a dielectrically filled waveguide, engineers developed a filter that offers high Q, small size, and easy integration with existing planar technology.

To solve the challenges of miniaturizing RF filters, the Lark RF filter designers and high performance circuit designers worked in tandem. The circuit designers are experienced working with Lark's unique semi-additive circuit fabrication process that allows for sub-25 micron lines and traces in boards 10+ layers thick with complex circuit topologies. This technology give the Benchmark teams multiple tools for solving the miniaturization problem while maximizing RF performance.

Choosing the correct material for the substrate was a major consideration for optimal performance at microwave and mmWave frequencies. The engineering



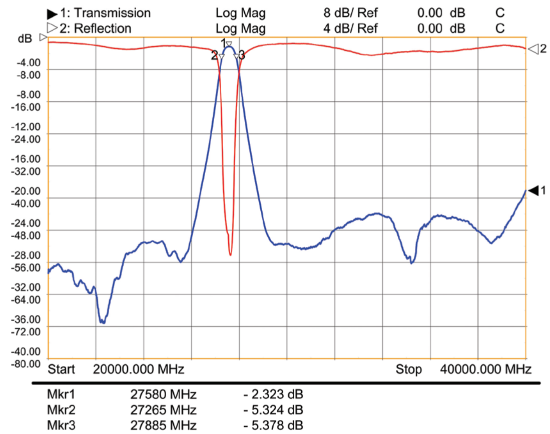




**Fig. 1 Fused Silica SMT BP filter:**
**(a) Size comparison versus a conventional WG filter (b) Measured results**

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team started by experimenting with many filter topologies and substrates at lower, easier to work with frequencies to identify and overcome initial design problems, as well as the best materials for further trials. After narrowing down the materials, fused silica and liquid crystal polymer (LCP) proved promising.

The team designed a higher frequency filter and produced a prototype in fused silica (Fig. 1), a low loss, ultra-stable over temperature material for narrowband filters. However, fused silica is limited to one-layer designs.

LCP has excellent characteristics for single and multilayered broadband filter designs. Additionally, LCP is a thermoplastic material with excellent electrical and mechanical characteristics, such as a stable dielectric constant (3.16 ±0.05) and low dielectric loss tangent (0.0045) up to 110 GHz, as well as low moisture absorption and low coefficient of thermal expansion å (17 ppm/°C).

There were still challenges to overcome; RF filters must be exactly the right dimension to perform well, which initially presented a challenge for the circuit design team.

By the second iteration the team found a solution to precisely control circuit thickness, and by the third iteration the team had created a multilayered miniaturized high-performance filter (Fig. 2).

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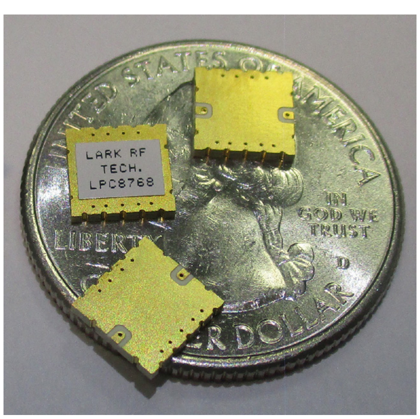


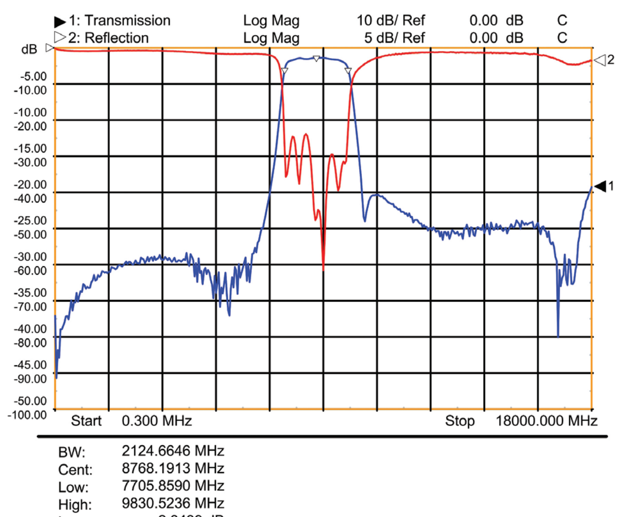




**Fig. 2 LCP SMT BP filter:**
**a) Actual size (b) Measured results**

## The Result: New RF Module Architectures that provide Better Performance in a Smaller Package

Benchmark Lark Technology has transformed microstrip (MS) BP filters into small, surface mountable LCP stripline filters, which enable a significant reduction in SWaP-C. The filter shown in Fig. 3, measures 0.25" x 0.25" x 0.032", and weighs only 0.0032 oz. (0.09g). This is five times lighter in weight than an interdigital microstrip BP filter fabricated on RO4003 substrate.

Lark is currently developing new microwave and mmWave filters at frequencies up to 40 GHz using LCP to deliver high performance and optimize for size, weight, and power. In RF systems with dozens of filters, this new technology will have a major impact on system capabilities.

Switch filter modules and other multi-component modules can be designed and fabricated using a stacked topology (Fig. 4). Moreover, passive and active components can be embedded between LCP layers, not only reducing the size of the module but also improving performance.

Bringing together its experts in RF components and manufacturing services, provides unparalleled value to the industry.  From wireless 5G to avionics systems, medical devices, and defense communications, Lark is bringing tomorrow's technology to reality today.

**Fig. 3 Comparison of microstrip BP filter and LCP stripline filter**

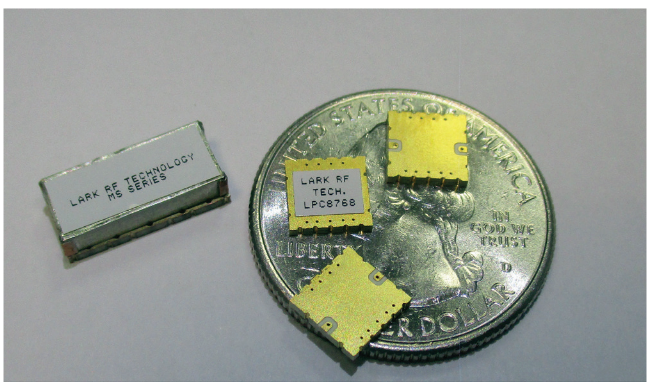
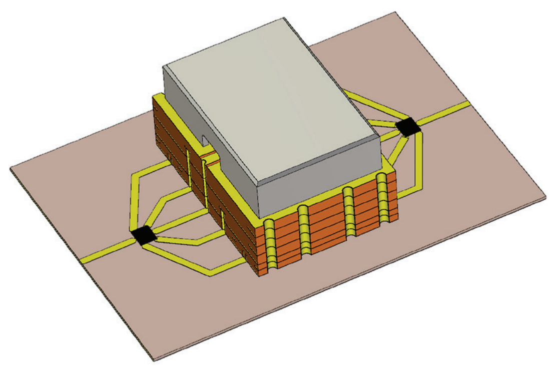



**Fig. 4 Switched filter bank showing stacking LCP BP filters**



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