The success of smartphones with more and more functions and features is growing around the globe, and the miniaturization of electronic components remains one of the leading trends in mobile communications. RF360 is a driving force in this field with its innovative DSSP® (die-sized SAW packaging) and TFAP® (thin-film acoustic packaging) technologies.

By 2020 it is expected that up to 80 percent of all mobile phones will be smartphones. In order to offer worldwide coverage, smartphones must support more RF bands (up to 100 filters in premium phones) than ever and feature growing numbers of functionalities. Despite the fact that their RF circuits are becoming more complex, the phones must remain as compact and flat as ever.

As a global market leader in SAW products for mobile communications, RF360 will continue to play a leading role in the miniaturization of RF components and modules. Through the introduction and further development of the patented CSSP® (chip-sized SAW packaging) technology, the size of discrete RF filters and duplexers has been steadily reduced. Now, with DSSP and TFAP the components are up to 85 percent smaller than the first generation CSSP products (Figure 1).
Wafer-level packaging

DSSP and TFAP offer the highest degree of miniaturization currently available in the market. Filters and duplexers in such technologies are designed primarily for use in RF modules, as these require the maximum in miniaturization both in terms of surface area and insertion height. With their insertion heights of just 0.21 mm and 0.15 mm, respectively, DSSP and TFAP components are significantly flatter than products manufactured in other currently available packaging technologies. Figure 2 shows an ultra-slim BAW filter in TFAP technology.

Figure 1: Miniaturization of SAW filters, duplexers and multiplexers. With DSSP and TFAP technologies, a package size reduction of up to 65 percent has been achieved for RF components compared to first generation of CSSP (top).

Wafer-level packaging

DSSP and TFAP offer the highest degree of miniaturization currently available in the market. Filters and duplexers in such technologies are designed primarily for use in RF modules, as these require the maximum in miniaturization both in terms of surface area and insertion height. With their insertion heights of just 0.21 mm and 0.15 mm, respectively, DSSP and TFAP components are significantly flatter than products manufactured in other currently available packaging technologies. Figure 2 shows an ultra-slim BAW filter in TFAP technology.
With a fine pitch of only 180 µm the DSSP technology takes full advantage of the state of the art in module manufacturing. The latest equipment is typically able to assemble components with pitches this small. During the module production process, DSSP products based on lithium tantalate (LT) can withstand molding at pressures of up to 80 bar and are tested according to IPC/JEDEC J-STD-020B MSL2a.

With DSSP technology components sizes are achieved that are identical with the chip size. DSSP components consist of a filter wafer and a cap wafer made of the same material (LT or niobate). Both wafers are bonded at wafer level. CuNi traces, defined by 3D photolithography, have to be routed across the vertical side wall of the package for their electrical interconnection (Figure 3). Following a wafer bumping process, the wafer is diced into individual DSSP components. As a final step after automated testing, the filters are packaged into the tape and reel.

Figure 2: BAW filter in TFAP technology, which offers state-of-the-art wafer-level packaging integration and thickness.

Figure 3: Schematic layout of DSSP package. The mass production of first DSSP products has been running for over 4 years, and the product portfolio of RF duplexers and filters for GSM/WCDMA/LTE, and connectivity filters (GPS, WLAN) continues to grow.

DSSP and TFAP duplexers

DSSP and TFAP duplexers will be mainly used for integration in FEMiDs (front-end modules with integrated duplexers), diversity modules (diversity filters combined with switches and LNAs), and in PAMiDs (power amplifier modules with integrated duplexers). DSSP and TFAP duplexers offer not only best-in-class performance, but also a smaller footprint and significant savings in insertion height. The typical surface area of the DSSP and TFAP duplexers is 1.5 mm x 1.1 mm – with an insertion height of 0.21 mm for DSSP, and 0.13 mm for TFAP. Customer samples are already available for duplexers in multiple frequency bands.
DSSP and TFAP filters

The DSSP and TFAP filter portfolio may be divided into two categories. Cellular RF filters for GSM/WCDMA/LTE systems, and GPS/WLAN filters for connectivity systems. LTE filters are offered either as single filters and N+1 filters, for example, 4in1 filters. The latter are designed as a single chip with multiple filter functions for bands B1, B3, B40 and B7. The application for LTE filters in DSSP technology is very similar to that of duplexers, and they can be used to miniaturize any RF front-end module. The front-end module shown in Figure 4 integrates most of the common frequency bands for low band diversity LNA module applications.

Currently, a large and growing RF360 filter portfolio in DSSP and TFAP technologies is available; please consult with RF360’s Munich Portfolio Management team for more information: pcortese@qti.qualcomm.com.

![Figure 4: Integration of DSSP components in front-end modules. The main application for connectivity filters is in WLAN and GPS applications. DSSP filters for WLAN and GPS are generally integrated into more complex systems that also include chipsets such as connectivity SiPs (systems in package).](image-url)
Further miniaturization with CSSP too

Mobile phone manufacturers often opt to employ discrete dupplexers and filters instead of modules. Further innovations in RF360’s CSSP3® (chip-sized SAW package) technology are reducing the size of these components as well. The new standard package sizes for the different product categories are:

- Duplexers: 1.8 mm x 1.4 mm
- 2in1 filters: 1.5 mm x 1.1 mm
- Single filters: 1.1 mm x 0.9 mm

Today, duplexers are offered in 1.8 mm x 1.4 mm packages for WCDMA and LTE frequency bands. Discrete 2in1 filters are available in 1.5 mm x 1.1 mm packages for all bands. Future duplexer roadmaps will showcase smaller components in 1.6 mm x 1.2 mm package size.

The latest product development in CSSP3 packaging technology is an input diplexed 4in1 LTE diversity filter, which integrates four diversity receive filters in a single 2.0 mm x 1.6 mm package.

The new concept allows not only for miniaturization, but also for cost savings on a system level:

Input diplexing is used to reduce the number of throws of the antenna switch 4 to 1, thus enabling the use of a less costly switch. The configuration also allows for any downlink carrier aggregation band combination, from 2 up to all 4 bands.