RF Thin film Passive Devices

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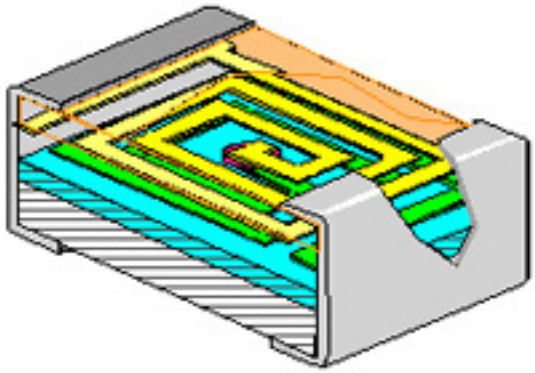
 An RF designer’s wish list for an ideal high frequency capacitor would include extremely high temperature stability, a sharp self resonance (high Q) free from harmonics, extremely tight capacitance tolerance, low ESR (equivalent S\series R\resistance), low ESL (equivalent series inductance), complete reproducibility (no variation capacitor to capacitor, lot-to-lot from bench prototype to mass production) zero voltage coefficient, and zero piezo noise in a compact SMD design. Thin film technology can accomplishes just that.

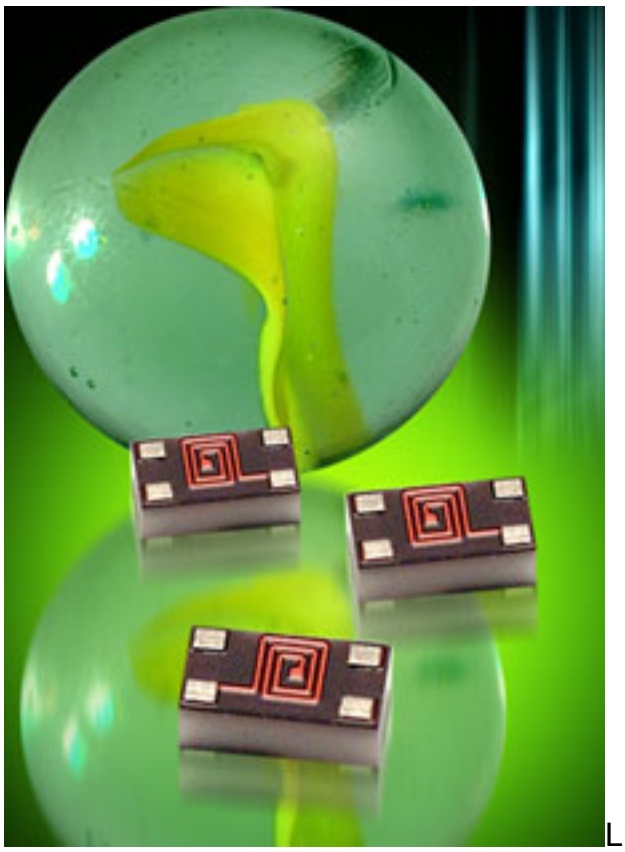
Based on the use of highly stable dielectrics (e.g. SiO2), thin film devices have the dielectric deposited on a stable alumina base with conductive elements (capacitor plate electrodes) added by photolithography and PECVD (plasma enhanced chemical vapor deposition) processing. The photolith method gives extremely precise geometry resulting in extremely high accuracy and tight tolerance electrode (capacitor plate) geometry, while the low temperature PECVD process enables high conductivity materials to be used for the electrode layers, which translates into greater power handling capability. The process is ideal for wafer / dice fabrication, so it can be used to make highly stable capacitors down to 0201 size.



Essentially, this technology can be viewed as a surface mount version of traditional glass technology, which has been for many years the worlds most stable and precise through-hole capacitor technology material, with no temperature or voltage coefficient and no ageing characteristic. Because it uses a single layer construction (which eliminates harmonics), is readily modeled and extremely reproducible – designs bread-boarded on the bench will be precisely reproduced in mass production at the manufacturing location, month-to-month and year-to-year.

Due to their precision, these devices can be used to fine tune any application or modification, or even for last minute tuning for FCC compliance, etc. Another advantage of thin film precision is the ability is the possibility to supply custom capacitance values if the circuit tuning requires this.

The designer’s wish list for the ideal RF capacitor is equally applicable to other passive components, and the beauty of thin film technology is its versatility when applied to the necessary geometries required for inductors.



LNA (low noise amplifier) applications are among the more critical sections in the receiver circuitry and to maximize the performance it is essential to have stable biasing and accurate impedance matching. Thin Film provides discrete capacitors and inductors which are high Q, low ESR and have accurate capacitance values (±.01pf) and inductance values (±.1nH).

Given the absence of any batch-to-batch variation, thin film capacitor S21 response tracks identically between parts. This not only improves the quality of the LNA, it can actually improve the yield in manufacturing by eliminating the fine tuning of circuits in production.

As thin film passives are single layer devices, they show no harmonic resonances at higher frequencies. This is important, not just for the capacitors, because the same components can be used to accomplish the critical matching of the input and output of a power amplifier. By using low loss thin film capacitors and inductors, more power can be sent to the amplifier transferred to the antenna. This results in improved performance and increased efficiency of the power amplifier, as well as improving temperature performance.

Antenna matching itself is also a critical design issue. The available real estate for the antenna is continually decreasing which generally leads to a non-ideal form factor design. This almost always requires an impedance matching circuit for the antenna. Thin film capacitors and inductors are ideal for this application, providing an accurate match of impedance to the antenna to maximize energy transfer under all conditions to minimize losses from the PA or to the LNA.

Because these parts are discrete circuit elements, there are no up-front design costs and full design flexibility is maintained throughout the program lifetime.

One wish-list item taken for granted is size, given that these components are available down to 0201 and 0402 sizes, but in reality the targeted application for these devices is the hand-held marketplace, which is driving even denser real-estate utilization. For inductors, an LGA (land grid array) termination option was developed, which gives better utilization of the full component area with an internal via system to maximize the on chip coil pattern dimension

 Beyond high accuracy micro-miniature capacitors and inductors, thin film PECVD technology also lends itself to integration. By combining both a capacitor and inductor element on the substrate, an LC low pass filters (LPF) can be formed. These can be made in the same small form factors - 0402 and up - and so use very little board space while saving cost through component count reduction. These thin film filters provide a high out of band attenuation (>30dB) while maintaining the lowest insertion loss available to the RF designer (<.3dB).

They can also be used to isolate the frequency of interest on the output of the mixer after conversion. The filters are internally matched to 50O so no external matching is necessary, and the conductor materials used make them capable of handling up to 3W continuous power.

A directional coupler is a device that samples an RF/microwave signal while minimizing loss to the signal. Thin film devices, based on back-to back inductors, produce very high directivity (isolation – coupling), low insertion loss directional couplers. These couplers offer the highest amount of directivity found on the market today, in small package sizes down to 0402. The coupler can be used to sample the output and send the sample to a gain control circuit for the power amplifier. As with the LPF, the couplers are also capable of handling up to 3W continuous power.

Directional couplers work from the principal of field coupling. The electric field produced by a transmission line in series with the signal is coupled onto an adjacent conductor through the air or dielectric medium. Coupler elements can be included within LTCC modules; the technology allows lumped elements, rather than coupled

lines, to produce directional couplers to 10dB. However, thin film technology has a number of advantages in this area; the finer line widths maximize the coupling coefficient, making available hybrid couplers to 3dB in 0603 size.

This coupler is designed to couple 3dB of power (half) to another channel, with the addition of a 90o phase shift to the signal. This can be very useful in designs utilizing an I-Q architecture where the channels are 90 degrees out of phase.

By using a hybrid coupler on the output of the oscillator, the LO (local oscillator) can be generated for both I and Q sections. It can also be instrumental when using two amplifiers to improve the linearity by splitting the power between the two circuits and then recombining after amplification. This reduces harmonic emissions, improves efficiency and increases gain from an amplifier.

The applications that continue to drive this technology are cellular telephones, data cards, base stations and satellite communications, where new products are constantly being added to the portfolio, such as splitters / dividers, high pass filters, 0402 low pass filters and band pass filters.

These systems often require multi-functionality between current and emerging standards. In common the base capacitor and inductor products, new RF thin film product releases incorporate a wide selection of precise, application-specific characteristics - targeted to an increasing list covering 802.11, WIMAX, Bluetooth, LTE, Zigbee 4g, UMTS etc. – whatever the designer needs.