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Materials Science Paves the Way to Smaller High Frequency Inductors

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Here is a look at one manufacturer's application of recent developments in materials to make smaller-size chip inductors for high frequency designs

The complex functionality of today's portable electronic devices has certainly impacted their users, but don't forget the poor design engineers who must somehow figure out how to accommodate more bells and whistles while sacrificing nothing in the way of performance and portability. Still/video cameras and Internet browsing are now being joined by music and video downloads, TV reception, GPS, monetary transactions and other highly complex functions that are being integrated quickly into each new-generation device.

The core communication function is controlled by the radio frequency block, a critically important element that is being crowded, out of necessity, into ever smaller spaces. As cell phone functions multiply, the RF block has been forced to surrender more board territory to the power supply, base band circuits and to the controls of the various functions.

As a result, RF circuits themselves are demanding smaller parts and are seeing the use of modules for the various circuits, accompanied by the need to miniaturize those very modules to better optimize space requirements. Consequently, the challenge is to develop more compact form factors while at the same time maintaining or increasing high-frequency performance.

Taiyo Yuden has developed smaller inductors for space-conscious wireless designs.

Enter the High-Frequency Inductor

Multilayer chip inductors are widely used in the circuits of cell phones, power amps, voltage-controlled oscillators (VCO) and other high-frequency modules or tuners. Uses include impedance matching and filtering in low-inductance scenarios, and as choke coils in higher inductances, above 10 nH. For the previously stated reasons, the need to miniaturize is so strong that even the industry-standard EIA 0402 case size (1.0 × 0.5 × 0.5 mm) inductor is under pressure to downsize. The move to 0201 case size (0.6 × 0.3 × 0.3 mm) is already underway, but until recently, technical hurdles have hampered large-scale implementation. Taiyo Yuden estimates that the ratio of 0201 to 0402 inductors is presently stalled at about 10% due to the difficulty of obtaining the high inductance needed from a 0201-size device. For years, the industry had been unable to achieve inductance values above 47 nH in this form factor. However, with recent advances in material science and multilayer fabrication techniques developed by Taiyo Yuden, 0201 devices are now available in production quantities with inductance values up to 100 nH.

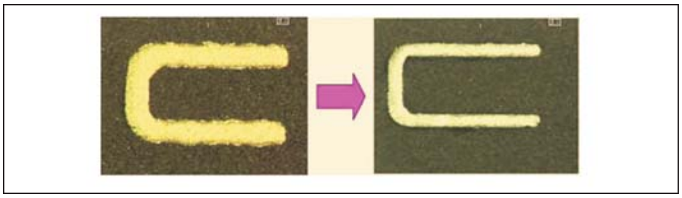

Figure 1 · In contrast to conventional (left) internal conductor patterning technology, super-fine printing techniques enable production of thinner, more compact multilayer structures.

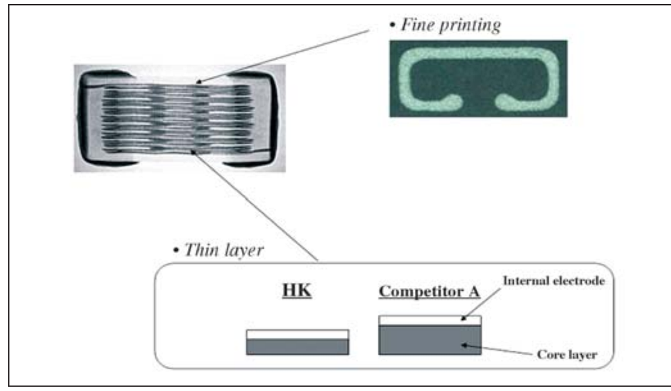

Figure 2 · Super-fine printing resulting in thinner dielectric layers is key to producing smaller, higher-performance inductors.

How Material Science Impacts Miniaturization

The key to making chip inductors smaller, while maintaining optimum inductance values, lies in the ability of the manufacturer to increase the number of inductive layers in the device. Taiyo Yuden's years of experience in the multilayer technology used to produce its main product line—capacitors—have resulted in continual improvements to the company's fine-grade dielectric powders, along with thinning of each individual layer, to obtain both compact size and high inductance values. A similar advance in internal conductor patterning technology called "super-fine printing" resulted in the formation of thinner, higher-precision conductors (Figure 1) that further made possible the development of more compact multilayer structures (Figure 2).

Further technical strides in material science and multilayer fabrication techniques, under continuous development, will further pave the way for the next generation of smaller, more feature-rich portable devices. The multilayering technology used to develop and produce ceramic capacitors also applies to the development of high-frequency inductors, as shown in Figure 3.

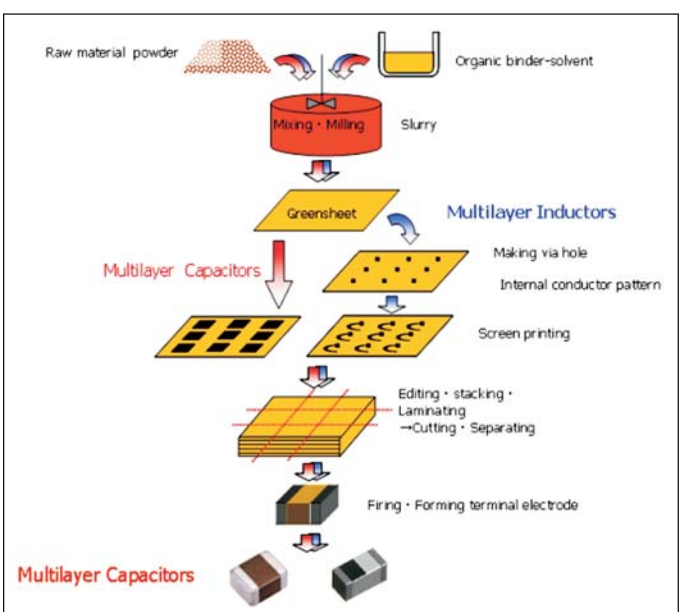

Figure 3 · The multi-stage method of fabricating passive components depends equally on materials and processes to achieve desired results.

Q, or Quality Factor, describes the degree of efficiency with which an inductor stores energy as a magnetic field. The higher the *Q* value, the more effectively it operates as a filter. *Q* value is typically expressed as a numerical value in conjunction with a specific frequency. In response to the continuing industry demand for smaller, more feature-rich portable designs, Taiyo Yuden recently announced two significant new additions to the company's expanding series of high-frequency multilayer chip inductors: the high-inductance HK series and the high-*Q* HKQ series—both available now in production volume in 0201 case size.

New High-Inductance and High *Q* Inductors

The high-inductance HK series introduced the industry's first 100 nH-rated chip inductor in 0201 case size. Available components in the series provide a wide induc-

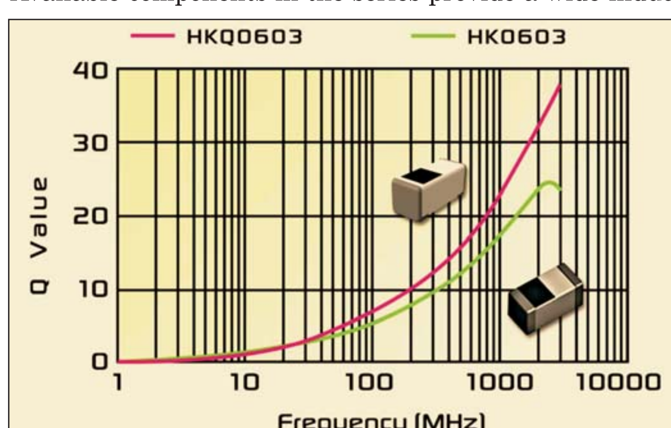

Figure 4 · Advances in dielectric powdering and multilayering technology have improved *Q*-values up to 30% in frequency ranges above 1 GHz at 6.8 nH.

Part Number	Inductance Rating (nH)	Rated Current (mA)	RDC (Ω)	Case Size
HK0603 68N	68	50	3.0	0201
HK0603 82N	82	50	3.5	0201
HK0603 R10	100	40	4.0	0201

Table 1 · Newest higher inductance additions to the HK series in 0201 size.

Part Number	Inductance Rating (nH)	Q @ 2GHz	Current (mA)	RDC (Ω) (typical)	Case Size
HKQ06031N0S	1	47	250	0.04	0201
HKQ06031N2S	1.2	47	250	0.08	0201
HKQ06031N5S	1.5	39	250	0.07	0201
HKQ06031N8S	1.8	39	250	0.08	0201
HKQ06032N2S	2.2	39	200	0.12	0201
HKQ06032N7S	2.7	37	200	0.11	0201
HKQ06033N3S	3.3	37	200	0.17	0201
HKQ06033N9S	3.9	37	150	0.27	0201
HKQ06034N7S	4.7	34	150	0.22	0201
HKQ06035N6S	5.6	35	150	0.35	0201
HKQ06036N8J	6.8	34	150	0.38	0201
HKQ06038N2J	8.2	33	150	0.45	0201
HKQ060310NJ	10	32	150	0.52	0201

Table 2 · HKQ Series inductor ratings.

tance range of 1 nH (250 mA) to 100 nH (40 mA). The most recent additions are listed in Table 1.

Also introduced was a new line of 0201 high-*Q* chip inductors (1-10 nH) offering 30% higher *Q* values—relative to case size—than comparably rated 0402 devices, the current industry norm. Figure 4 shows a comparison of the new high-*Q* devices (HKQ) versus the company's previous generation inductor (HK). Key ratings for the newest additions to the HKQ series are presented in Table 2.

Conclusion

The widespread availability of high-inductance and high-Q inductors in 0201 case size will materially help to achieve higher-density PCB mounting, more features and the production of smaller end devices by greatly reducing the size of critical RF circuit noise-suppression components. Equally important, it allows the majority of existing 0402 and larger inductors commonly used in choke-coil applications to be down-sized to 0201-providing a minimum circuit board real estate savings of 64% area and 78% volume per component. In the shrinking world of portable electronics, that's huge.

About Taiyo Yuden

Now in its 57th year, Tokyo-based Taiyo Yuden Co., Ltd. is a worldwide manufacturer of surface-mount and leaded passive components, Bluetooth modules, power electronics modules, power supplies and recordable digital media. U.S. sales offices are located in Illinois, North Carolina, Texas and California.

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