by Tetsuya Sumida

Recent Advances in Thick-Film Resistors and Target Applications

Thick-film resistors are the preferred resistor type for a wide range of industrial and consumer applications, including current detection and overvoltage protection, due to their relatively low cost. Unlike thin-film resistors, which are similar in appearance, thick-film resistors have contrasting properties and manufacturing processes. And, as their names imply, another key difference between the two is their thickness. While thin-film resistors measure up to a maximum of 0.1 μm, the thickness of thick-film resistors can be 0.1 mm or more. The ever-present need for low power consumption and circuit protection in relevant applications is driving the demand for high-performance thick-film resistors. This article gives an overview of thick-film resistors, noting some recent advances and the applications they address.

The Basics of Thick-Film Resistors

Thick-film resistors are manufactured by firing a special paste consisting of a binder, carrier, and metal oxides on a substrate (Figure 1). While the binder is a glassy frit, the carrier is made up of plasticizers and organic solvents. These oxides of iridium, ruthenium, and rhenium-based resistor pastes (also known as cermets) are printed onto the substrate at a temperature of 850°C. Due to the glass-like properties of the paste, they assume a moisture-resistant capability, in addition to their 95% alumina ceramic substrate. These surface mount (SMD) chip resistors are low-cost compared to other resistor technologies.

Figure 2 depicts a graphical presentation of the complete firing process for manufacturing thick-film resistors. This process is additive as manufacturers sequentially add resistive layers onto the substrate throughout the process to form resistance values and conduction patterns. With temperature coefficient of resistance (TCR) values above 300 ppm/°C at tolerances ranging from 1-5%, thick-film resistors offer comparatively higher TCRs, making them suitable for applications that call for low stability and high TCR values.

Benefits and Limitations of Thick-Film Resistors

Low cost is the principal benefit of opting for thick-film resistors in industrial and consumer applications.

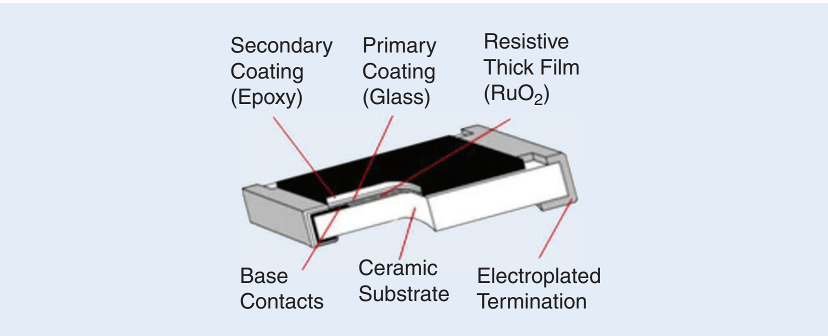

FIG 1 Schematic of a Thick-Film Resistor.

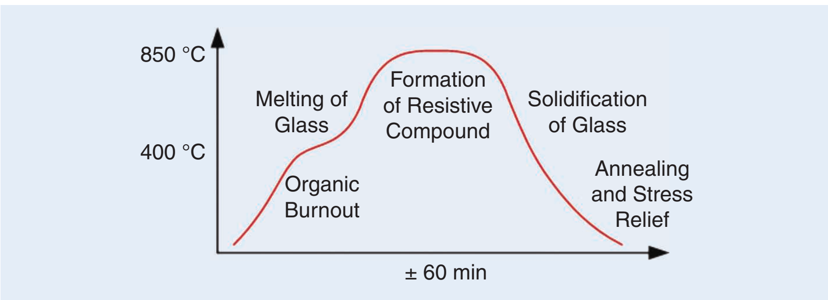

FIG 2 Thick-Film resistor firing process.

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However, these resistors offer other benefits, such as high power handling capability, an extended resistance value range, rapid frequency response, and the ability to withstand higher surges. Moreover, the high resistance density of thick-film resistors provide greater versatility, while their glassy protective coatings make them resistant to environmental impact.

On the other hand, this resistor type is plagued by low precision, high noise, and low stability. The glass matrix particle-to-particle contact-based resistance track of thick-film resistors reduces stability. Similarly, their low metal content granular structure causes greater noise susceptibility. Fortunately, recent advances in thick-film resistor technologies by leading manufacturers such as ROHM are addressing these challenges and limitations, leading to greater adoption in more sophisticated circuits.

Thick-film resistors have evolved throughout the years into higher performing semiconductor electronic components. To meet the increasing energy-saving needs of industrial and consumer applications, designers are developing thick-film resistor solutions that offer high power ratings with significantly lower TCR characteristics. For instance, ROHM recently expanded its LTR series with the LTR100L thick-film shunt resistor that provides industry-leading rated power for high power current detection applications. Leveraging an original approach involving resistor material revision and terminal temperature derating led to a higher-performing thick-film resistor solution. As a result, in addition to favorably competing with existing metal shunt resistors, significant improvements were achieved over conventional thick-film resistors.

This allows customers to switch from metal shunt resistors to cheaper thick-film resistors. Lower TCR enables higher current detection accuracy compared to existing thick-film resistors. Figure 3 shows a comparison between ROHM's LTR100L and conventional thick-film resistors. The higher TCR values of conventional thick-film resistors translate to comparatively lower current detection accuracy of up to 12% E_{rr}. Conversely, the LTR100L, with $E_{rr} \leq$ 7%, ensures higher current detection accuracy by significantly reducing TCR values below 300 ppm/°C.

In addition to lower TCR values, ROHM thick-film resistors deliver a high power rating ideal for high power-intensive applications—achieved by configuring the electrodes on the long sides of the substrate. This approach increases heat dissipation, ramping up the rated power to up to 4 W. Designers can achieve further improvements by replacing two general-purpose resistors with a single LTR100L, saving space while ensuring adequate heat dissipation in industrial and consumer applications.

Key Applications

Thick-film resistors are widely adopted for current detection in motor drive and battery protection circuits for a broad range of industrial and consumer applications. For industrial sets, thick-film resistors are essential in power supplies, motor-peripheral circuits, high-pressure pumps, and factory automation. Many engineers incorporate them into consumer appliances as well, such as vacuum cleaners, air conditioners, refrigerators, and washers. Thick-film resistors are even adopted in automotive applications

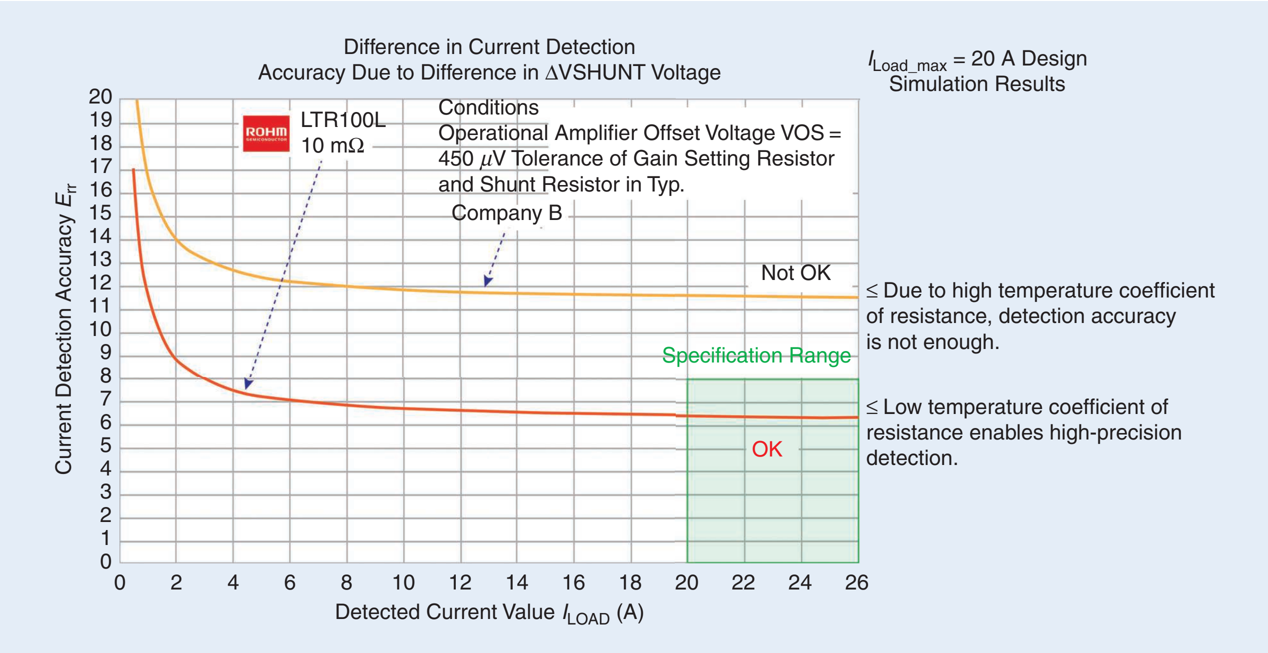

FIG 3 LTR100L vs conventional thick-film resistor.

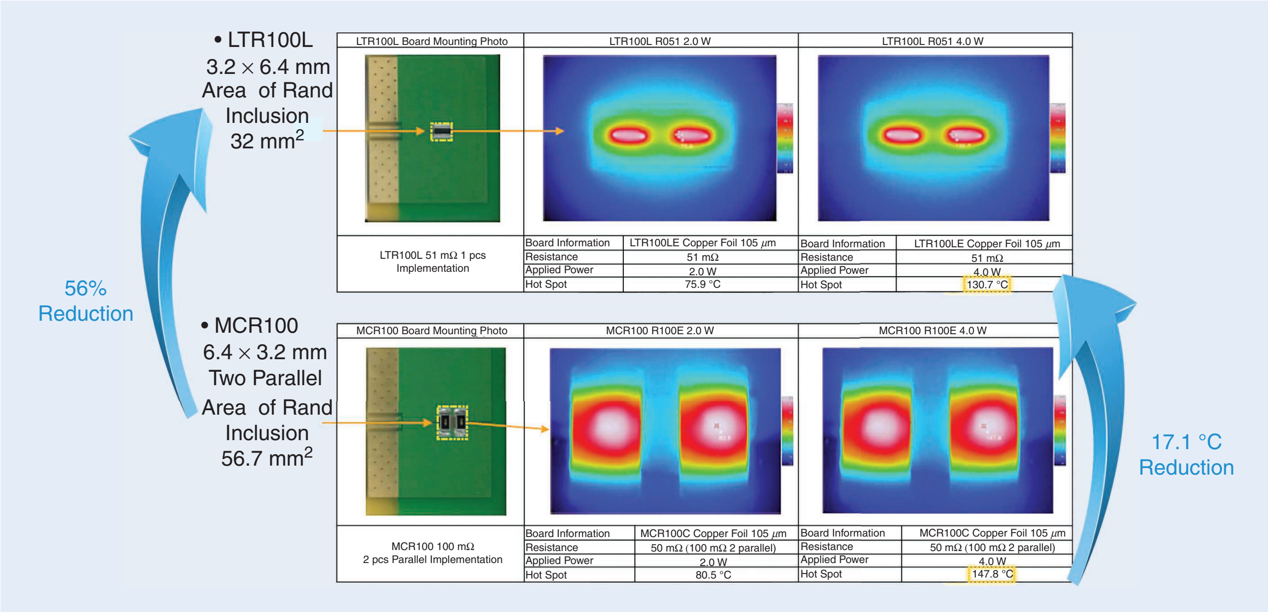

FIG 4 High power rating by improving heat dissipation in a thick-film resistor.

that include electric scooters, two-wheel vehicle headlamps, and battery management systems. The new LTR100L series is particularly suited for high-speed applications, such as overcurrent protection in switch-mode power supply and industrial inverters and motor control in white goods.

Conclusion

The TCR and heat dissipation characteristics have a significant effect on the power rating and overall performance of thick-film resistors. Typically, customers will opt for conventional thick-film resistors despite high TCR values in applications due to their lower costs. However, these recent improvements made by ROHM using proprietary technologies allow customers to enjoy the benefits of thick-film resistors while providing higher current detection accuracy and superior electrical performance at a lower cost than similarly performing metal plate types.

About the Author

Tetsuya Sumida is the product marketing manager for resistors, discrete products and power devices for ROHM Semiconductor in North America. Sumida has worked at ROHM since 2004, moving to the USA in 2018. His role is to analyzing market trends and formulate strategies for the products under his charge.

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