

# The Conduction Mechanism and Characteristics of the RuO<sub>2</sub>/CB System Thick-Film Resistors

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## RuO<sub>2</sub>/CB厚膜抵抗体の導電機構と特性

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**概要** 最近、低いインピーダンスが電子回路に採用される傾向にあり、厚膜抵抗器にも優れた特性の低い抵抗値が求められている。樹脂系厚膜抵抗体ではCB(カーボンブラック)が主要な導電粒子として使用されてきたが、CB分率を増加して低い抵抗値を得ようとする、CBの持つ負のTCRにより、負のTCRの抵抗体が得られる。一方、ガラス系厚膜抵抗体に採用されているRuO<sub>2</sub>粒子は正のTCRを持っており、かつ、その電気抵抗率はCB粒子より4桁ほど小さい。ここでは、CB粒子とRuO<sub>2</sub>粒子を適切な分率で混合することでゼロのTCRを持つ低いシート抵抗率が得られること、周波数特性や電流雑音の発生要因などを分析、検討した。

### Abstract

Recently, there is a tendency for low impedance to be adopted by various electronic circuits, and such demand is also appearing in the field of thick-film resistors. The CB (Carbon Black) has been used for a long time as a main conductive particle which is dispersed in resin system thick-film resistors. Only the resistor of negative TCR is obtained, because CB particles have rather large negative TCR, even if we intend to obtain low resistance in response to this demand by increasing CB fraction. On the other hand, the RuO<sub>2</sub> particle which is adopted in the glass system thick-film resistor has positive TCR, and its electric resistivity is 4 digits smaller than CB particles. Therefore, it was presumed that the low resistivity having zero TCR may be acquired, if an appropriate fraction of CB particles is mixed with RuO<sub>2</sub> particles. On the basis of this thinking, we tried to develop a new resin system thick-film resistor of low resistivity with zero TCR by using a mixture of RuO<sub>2</sub> and CB. As a result of an experiment, zero TCR<sub>tot</sub> and a low resistivity of 100Ω/□, which was the initial purpose, was obtained by using the RuO<sub>2</sub>/CB=12vol.%/3vol.% mixture, and the impedance was steady up to 10 MHz. It was also confirmed that optional TCR from negative to positive range is freely obtained by changing the blend ratio of CB and RuO<sub>2</sub>. Next, the current noise index and the equivalent elements of impedance were measured in order to examine the characteristics of contact point, and then the correlation among these was discussed. It was especially shown that the contact resistance of the conductive particles are the main source of the current noise. The resistor of this type is expected to be used in the multilayer printed wiring circuit as embedded resistors in addition to general use, because the TCR is freely controllable between negative and the positive value.

**Key Words:** Thick-Film Resistor, RuO<sub>2</sub>, Carbon Black, TCR, Current Noise, Equivalent Circuit.