» New Products

Cu-Based Resistance Alloy EFCR Series Lineup Expansion

1. INTRODUCTION

Resistance materials are used in resistors that control current and adjust voltage in electric and electronic circuits. Resistors are essential for cutting-edge technologies such as Artificial Intelligence (AI), which is being developed in recent years, computers that process huge amounts of data in the rapidly increasing number of data centers, various sensors (Light Detection And Ranging (LiDAR), cameras, radars, etc.) that detect the surrounding environment that is essential for autonomous driving, and in battery charging controls for hybrid and electric vehicles. In the development of smaller and more accurate resistors, as the applications and designs of resistors are becoming more diverse, resistive materials are required to have a wide range of resistivities from low to high, and to maintain stable resistivity over the wide temperature range in which the resistors are operating.

We are currently developing a lineup of the EFCR series of copper-based resistance materials, which alloys are designed to minimize the Temperature Coefficient of Resistance (TCR) and thermal Electromotive Force (EMF) against copper at each resistivity, which are important properties of high-performance resistors. Following the launch of "EFCR-100", which has one of the highest volume resistivities in the world as a copper-based resistance material, we have added "EFCR-25", "EFCR-38", and "EFCR-50". Along with the already well-received "EFCR-30 (HRR)" and "EFCR-44 (CMR)", this new series can accommodate a wider range of resistivities while maintaining the properties (TCR, EMF, etc.) required for our customers' resistors to be more compact and highly accurate. This article will introduce the features of the new resistance materials EFCR-25, EFCR-38 and EFCR-50, which were added to the EFCR series.

2. FEATURES

(1) EFCR-25

EFCR-25 has the lowest volume resistivity (25 μΩ·cm) in the EFCR series. Table 1 shows the electrical properties of the EFCR series, and Figure 1 shows the rate of change in resistivity vs. temperature in the EFCR series. The resistivity of general metal materials increases as the temperature rises. For example, the TCR of pure copper (25 to 125°C) is extremely large at 4×10^3 ppm/°C. However, the high-performance resistance material we have developed contains optimal amounts of various elements and uses our unique heat treatment technology to control the TCR, achieving a good balance between the low volume resistivity and the TCR. Because it is a low resistance material, it can contribute to suppressing heat loss when electricity is applied to electric vehicle batteries, or to downsizing devices with design constraints, such as smartphones.

Table 1 Electrical properties of the EFCR series.

	Volume resistivity μΩ·cm	Thermal electromotive force against copper μV/°C	Temperature coefficient of resistance (TCR)* ppm/°C		
			20-60 °C	25-125 °C	−60-160 °C
EFCR-25	25	0.7	40	30	45
EFCR-30	29	0.1	3	5	4
EFCR-38	38	0.0	0	−25	22
EFCR-44	43	0.4	3	−35	5
EFCR-50	49	4.0	−10	−25	1
EFCR-100	98	0.2	5	−35	2

*TCR is the value obtained by dividing the rate of change in volume resistivity when the temperature environment is changed by the temperature difference caused by the change.

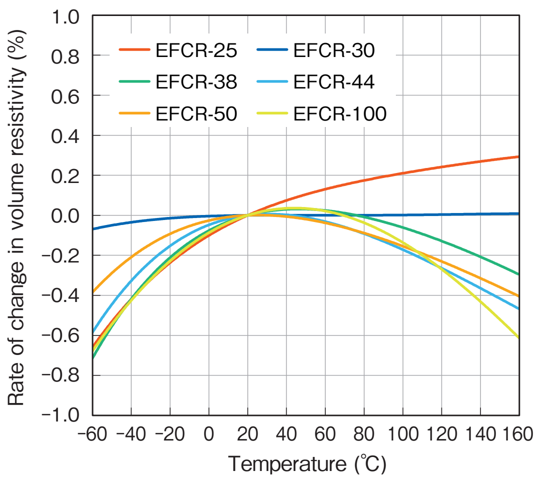

Figure 1 Rate of change in volume resistivity vs. temperature in the EFCR series.

(2) EFCR-38

EFCR-38 has a volume resistivity (38 μΩ·cm) that is roughly intermediate between "EFCR-30" and "EFCR-44". By increasing the number of resistance materials with different resistivities, we aim to expand the selection of resistance materials available to customers when designing resistors, contributing to more efficient designs. In addition, the TCR is between that of EFCR-30 and EFCR-44, and the EMF is extremely small as EFCR-30 and EFCR-44 (see Table 1 and Figure 1), so it can contribute to high-precision resistors as a resistance material that maintains a stable resistivity to temperature changes.

(3) EFCR-50

EFCR-50 has a volume resistivity (49 μΩ·cm) that is nearly equivalent to the resistance material Cu-40-50 wt%Ni alloy (GCN49, JIS C2532) used in standard electrical resistance wires and thermocouples for temperature measurement, making it a viable substitute. Compared to EFCR-44, this material has a higher volume resistivity and its change in resistivity with temperature change is less, making it suitable for precision resistors in communication devices and electrical measuring instruments. In addition, the change in the thermal electromotive force (EMF) with temperature change is significantly lower than that of Cu-Ni-based alloys (39 μV/°C). Figure 2 shows the thermal electromotive force vs. temperature in the EFCR series. If the EMF is large, the voltage fluctuation caused by the temperature change becomes large, and the performance of the resistor becomes sensitive to temperature, which will increase error and noise and lower measurement accuracy. Compared to Cu-Ni-based alloys (thermal electromotive force of 3 mV (80°C)), all of the EFCR series have a smaller thermal electromotive force, making them suitable for DC precision resistors that require high voltage detection sensitivity.

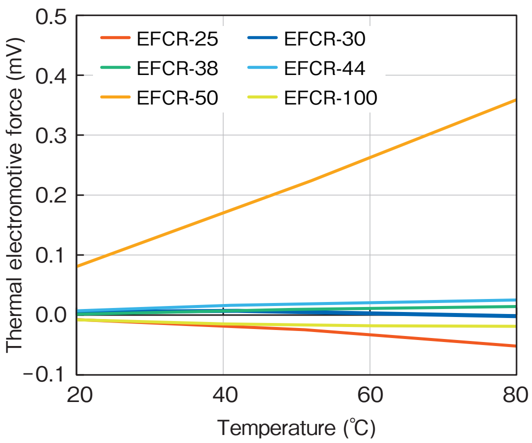

Figure 2 Thermal electromotive force vs. temperature in the EFCR series.

(4) Mechanical Properties

Table 2 shows the mechanical properties of the typical tempers (0.2% yield strength, tensile strength, elongation, Vickers hardness). The shape of the EFCR series is not particularly limited, so we can provide strips, plates, round wires, rectangular wires, etc. with the mechanical properties shown in Table 2. In addition, the mechanical properties are not limited to these, so we can customize them depending on the customer's manufacturing process and product design.

Table 2 Mechanical properties of the EFCR series (typical values).

Product name	Temper	0.2% yield strength MPa	Tensile strength MPa	Elongation %	Vickers hardness
EFCR-25	O	200	350	40	100
	HS	440	450	10	140
EFCR-30	O	220	390	40	110
	HS	480	530	10	170
	H	590	600	3	200
EFCR-38	O	190	400	38	90
EFCR-44	O	280	450	35	120
	HS	550	580	10	170
	H	690	700	3	210
EFCR-50	O	200	480	30	100
EFCR-100	O	280	590	38	135
	HS	670	740	10	220

3. CONCLUSION

Figure 3 shows the resistivities of the resistance materials already on the market and those newly developed. The addition of this newly developed product to the lineup has enriched our product offering. In-vehicle Lithium-ion Batteries (LiBs), which require highly accurate current detection, are becoming increasingly voltage-intensive, and electronic devices are becoming ever more compact, so the needs for resistors are becoming more diverse. Resistor manufacturers have told us that it makes design easier even when there are subtle differences in the resistivity of resistor materials. In addition, our resistance material series is compatible with resistor processing, and we can provide not only strips and plates, but also round and rectangular wires.

In addition, one of the features of our resistance materials is that we utilize alloy designs and process design technologies that we have developed over many years to control TCR and EMF, and we expect that these advantages will be utilized in high-precision resistors.

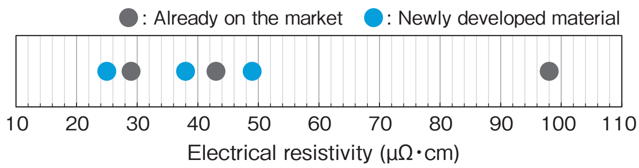

Figure 3 Resistivities of the EFCR series.

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