

Development of High-Performance Copper Alloy Wires and Rods

1. INTRODUCTION

With recent reduction in the size and weight of electronic equipment, and improvements in its performance, the electronic components used have also become smaller while delivering higher performance. The requirements imposed on the wire and rod stock materials used for the leads, connectors and other conducting portions of the electronic components have also increased, and to prevent any deficit in strength or electrical conductivity caused by smaller diameters and thinner stock, there is a need for materials having greater strength and conductivity than those currently in use. Accordingly Furukawa Electric has brought out products made from EFTEC-194 and EFTEC-64 wires (W) and rods (BD) that specifically emphasize conductivity to target lead pin and similar applications, and products made from EFTEC-97 and -98 wires and rods that specifically emphasize strength to target connector and similar applications.

Figure 1 shows the relationship between tensile strength and electrical conductivity for wires, and Figure 2 shows the relationship between Vickers hardness and electrical conductivity for rods. Compared to the copper, brass and phosphor bronze that have been used up till now, the alloys developed here exhibit an excellent balance between strength and conductivity.

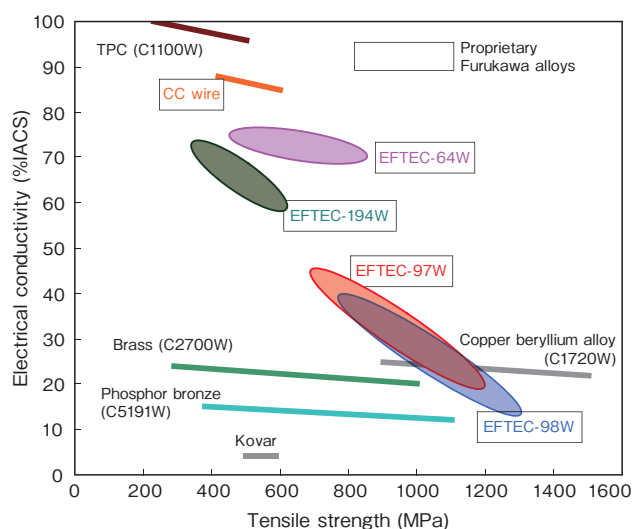


Figure 1 Relationship between tensile strength and electrical conductivity for wires.

Table 1 shows the chemical composition of selected alloys (typical values), and Table 2 shows the physical properties (typical values for electrical conductivity and thermal conductivity). None of the alloys contains any Pb, Hg, Cd, Be or other harmful elements, and can therefore be used with confidence.

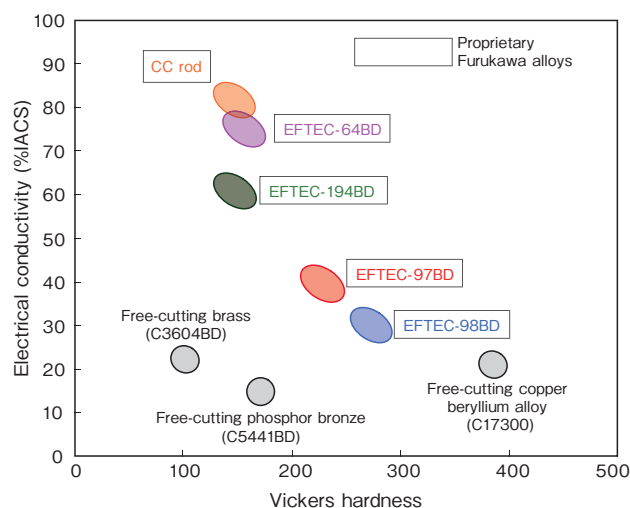


Figure 2 Relationship between Vickers hardness and electrical conductivity for rods.

Table 1 Chemical composition of selected alloys. (mass %)

EFTEC-194	:	Cu-2.4Fe-0.13Zn-0.04P
EFTEC- 64	:	Cu-0.3Cr-0.25Sn-0.2Zn
EFTEC- 97	:	Cu-2.3Ni-0.55Si-0.15Sn-0.5Zn-0.1Mg
EFTEC- 98	:	Cu-3.75Ni-0.9Si-0.15Sn-0.5Zn-0.1Mg

Table 2 Physical properties of selected alloys.

	Coefficient of thermal expansion $\times 10^{-6}/^{\circ}\text{C}$	Thermal conductivity W/(m · K)	Electrical conductivity %IACS	Modulus of elasticity GPa	Density g/cm ³
EFTEC-194	17.4	260	65	121	8.8
EFTEC-64	17.3	280	70	119	8.9
EFTEC-97	17.8	160	40	125	8.8
EFTEC-98	17.8	140	35	125	8.8
Kovar (Ref.)	11.5	16.8	4	137	8.3
C1720 W (Ref.)	17.8	109	23	127	8.3

2. EFTEC-194W/BD AND EFTEC-64W/BD HIGH-CONDUCTIVITY COPPER ALLOYS

EFTEC-194W is used for the lead pins of the pin grid arrays (PGAs) in personal computer CPUs. Formerly these PGA pins have used iron-based alloys like Kovar (Fe-26 %Ni-17 %Co) or 42 alloy (Fe-42 %Ni), but to dissipate the heat generated by larger scales of CPU integration and higher operating speeds there is a need for materials that have higher thermal conductivity without compromising strength. We have developed products that meet that need. This alloy, as shown in Table 1, is a Cu-Fe based alloy, and is the CDA19400 alloy, which meets the global standard established by the Copper Development Association (CDA). CDA19400 is a copper alloy with a solid track record for lead frames and other strip products, but with our development of proprietary manufacturing processes to control the size and density of precipitates it was superior in electrical conductivity, that is to say thermal conductivity, and exhibited superior strength, and specifically the repetitive bending workability required for PGA pins. Figure 1 and Table 2 also show the characteristics for the Kovar alloy used in the past, and we can say that EFTEC-194W, while equivalent to Kovar in terms of tensile strength, represented a more than 15-fold improvement in electrical and thermal conductivity, making it extremely advantageous for PGA pin applications.

EFTEC-64 is one of our company's proprietary copper alloys, and has an extremely good track record as a lead material for QFPs and QFNs. Since it outperforms EFTEC-194W/BD in strength and electrical conductivity, it is a material for which we can look forward to developing applications as lead pins, terminal components and solid-state components.

All of these materials exhibit good header machinability and cold forgeability, and can be formed into a wide variety of shapes.

3. EFTEC-97W/BD AND -98W/BD HIGH-STRENGTH COPPER ALLOYS

EFTEC-97 and -98 are our company's proprietary alloys consisting of a Corson (Cu-Ni-Si) alloy base with the addition of trace elements (Zn, Sn and Mg). In addition to high strength and high electrical conductivity, they exhibit superior resistance to heat and stress relaxation, platability and solder adhesion properties. This makes a significant contribution to raising the reliability of electronic components. As Figure 1 shows, EFTEC-98 wire (W) provides high strength verging on that of copper beryllium (C1720), and since, as shown in Table 2, EFTEC-98 and C1720W are equivalent in terms of coefficient of thermal expansion and modulus of elasticity, it can be considered as a replacement for C1720. EFTEC-97W/BD is inferior to EFTEC-98 in strength, but its electrical conductivity is higher, making it highly suitable for applications in which electrical and thermal conductivity is important.

Figure 3 shows the strength relaxation resistance (test temperature: 150°C, load stress: yield strength x 0.8).

Low-temperature annealed EFTEC-97W shows a similar level of stress relaxation resistance to age-hardened C1720W, and low-temperature annealed EFTEC-98W has properties superior to C1720W. This shows that EFTEC-97W and -98W undergo little change in spring pressure over time, and therefore provide high reliability in spring applications.

4. CONCLUSIONS

Figure 4 shows examples of products using EFTEC-194W, EFTEC-97BD and EFTEC-98BD. EFTEC-97BD and -98BD show outstanding machinability, and are well suited for use in coaxial connectors, contact pins, etc., as a replacement for free-cutting phosphor bronze (C5441) or free-cutting copper beryllium (C17300).

For more information, please contact:

No. 2 Sales Dept., Metals Co., Furukawa Electric

TEL: +81-3-3286-3831 FAX: +81-3-3286-3663

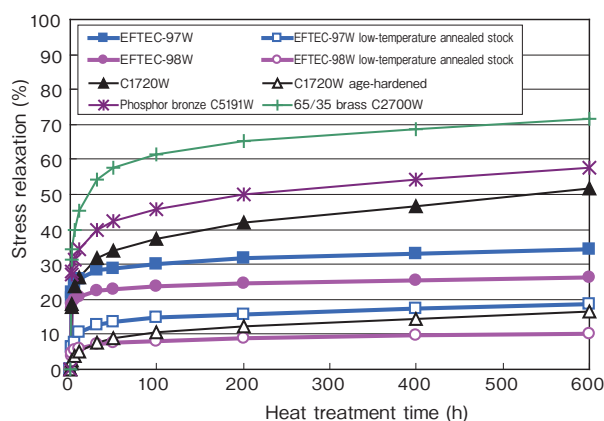
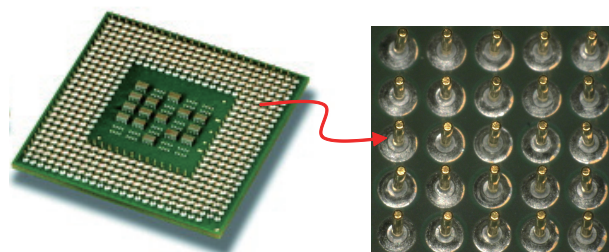


Figure 3 Stress relaxation resistance.



(a) Use of EFTEC-194W in CPU pins.



(b) Use of EFTEC-97BD and -98BD in coaxial connectors.

Figure 4 Representative applications.