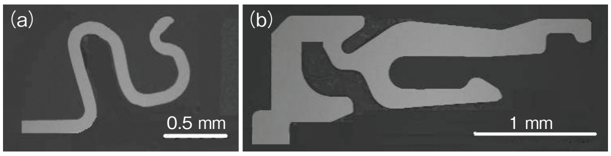
Development of High-Performance Alloys for Electronic Connectors

1. INTRODUCTION

In recent years there have been rapid advances in mobile equipment and digital home appliances, as well as in the trend to automotive electronics, leading to improved performance and increased density of electronic components and the use of large numbers of miniaturized connectors. Figure 1 shows connectors that illustrate this trend. The example shown in Figure 1 (a), known as a B-to-B connector, is formed in a complex “bellows” bend, while the FPC connector in Figure 1 (b) is the type connected via a flat cable. The technological issues involved with the most advanced connectors are small size, low profiled, narrow pitch, increased number of poles, and higher transmission speeds. Further requirements are lower cost and higher quality.

The copper alloys used in the miniaturized connectors for electronic components need to have strength, conductivity, stress relaxation properties and bending workability, and as high-performance alloys that satisfy these requirements, we have developed EFTEC-97 and EFTEC-98S, as well as F5218 and F5248S.

Table 1 shows the composition (typical values), and Table 2 selected mechanical and physical properties for these new alloys. EFTEC-97 and -98S are materials with a Cu-Ni-Si (Corson) alloy base, to which trace amounts of Zn, Sn, Mg and Cr have been added. These are materials in which the stress relaxation properties and bending workability have been improved by heat treatment control technology to effect the nano-level fine precipitation of Ni_2Si compound. F5218 and F5248S, on the other hand, are materials with a base of spring phosphor bronze with trace amounts of Fe and Ni in which crystal grain diameter is controlled, thereby increasing strength and improving bending workability. None of these materials contains any substance that imposes environmental load as regulated by RoHS directive or similar standards.



(a) Bellows connector (b) FPC connector

Figure 1 Typical miniaturized connectors.

2. BENDING WORKABILITY

Bellows connectors like that shown in Figure 1 (a) must have superior bending workability to accommodate to complex bends, and the material must also be strong. Figure 2 shows the relationship between bending workability (90°W-bend) parallel to the rolling direction (BW) and 0.2 % yield strength (YS). Workability in the longitudinal axis is normalized for sheet thickness (*t*). Comparing with the workability of C5210 (Spring phosphor bronze), all the new alloys show improved strength while bending workability is also satis-

Table 1 **Chemical composition of copper alloys developed here (typical values). (mass %)**

EFTEC-97	Cu-2.3Ni-0.55Si-0.15Sn-0.5Zn-0.1Mg
EFTEC-98S	Cu-3.75Ni-0.9Si-0.15Sn-0.5Zn-0.1Mg-0.2Cr
F5218	Cu-8Sn-0.1Fe-0.15Ni-0.03P
F5248S	Cu-10Sn-0.1Fe-0.15Ni-0.03P

Table 2 **Selected properties of copper alloys developed here (typical values for each quality level).**

	Temper	TS (MPa)	YS (MPa)	Hv	E (GPa)	EC (%IACS)
EFTEC-97	HC	690	600	205	132	40
	EH	740	660	225		
	SH	780	750	235		
EFTEC-98S	H	810	725	245	132	35
	EH	850	750	265		
	SH	910	870	280		
	ESH	980	950	300		
F5218	H	775	730	230	110	13
	EH	800	750	250		
	SH	850	810	260		
	ESH	900	860	265		
	XSH	940	910	270		
F5248S	H	810	780	230	109	12
	EH	855	810	250		
	SH	930	885	260		
	ESH	965	920	265		
	XSH	1020	980	270		

TS: Tensile strength YS: Yield strength (0.2 %) Hv: Hardness
E: Young's modulus EC: Electrical conductivity

factory, and at YS≒680 MPa, all the alloys show R/t≒0.

Further, while increased strength does produce deterioration in workability, EFTEC-98S workability at YS≒750 MPa shows R/t≒1, a satisfactory level of bending workability equivalent to C1720 (HM temper).

3. STRENGTH AND YOUNG'S MODULUS

FPC connectors like that shown in Figure 1 (b) require materials of high contact pressure, that is to say, high strength. (It is considered that of the materials shown in Table 2, the higher quality categories--SH, ESH and XSH--are suitable.) Among these, F5218 and F5248S, because of their characteristically low Young's modulus, undergo greater sag (displacement) when subjected to the same contact pressure and have less change in displacement with respect to changes in contact pressure, so as a result reliability is higher. EFTEC-97 and -98S, on the other hand, have a higher Young's modulus, giving them the advantage that at displacements limited by low profiled, high contact pressure can be obtained with only slight sag (displacement).

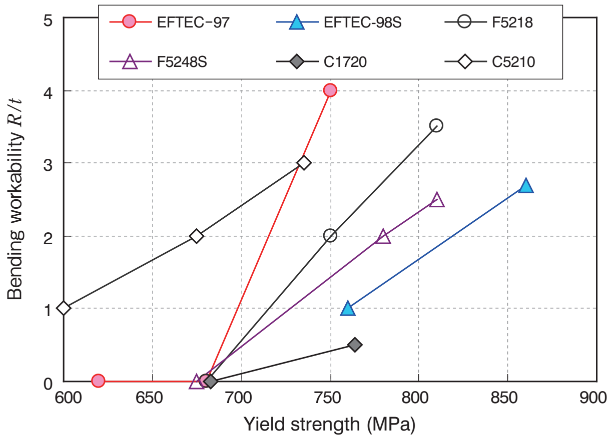


Figure 2 **Relationship between bending workability (90°W-bend) and 0.2 % yield strength.**

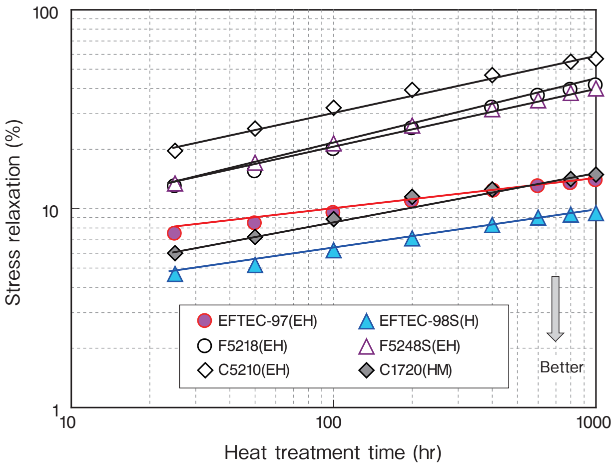


Figure 3 **Stress relaxation properties.**

4. STRESS RELAXATION PROPERTIES

Figure 3 shows the results of an investigation of stress relaxation properties*. Since EFTEC-97 and 98S have excellent stress relaxation properties, they suffer a smaller long-term drop in contact pressure, even in higher-temperature environments, contributing to the reliability of electrical contact. F5218 and F5248S, for their part, have properties equal or superior to spring phosphor bronze (C5210).

Figure 4 shows simulation of actual connectors, plotting the results of direct measurement of changes in the contact pressure (load) when heated at 150°C for (1) cantilever beam test pieces, and (2) 90°V-bent test pieces to which a load stress of 0.8 x YS has been applied. The rate of change in longitudinal contact pressure is normalized to initial contact pressure and the relationship to heat treatment time is shown. For C5210, contact pressure dropped by approximately 40-50 % over 200 hr for both test pieces (1) and (2), but with EFTEC-97 higher contact pressure was maintained, the rate of drop being in the order of 10-20 % for both test pieces (1) and (2).

* Test method: in conformity to EMAS-3003, cantilever beam method, test temperature: 150°C, applied stress: 0.8 x YS.

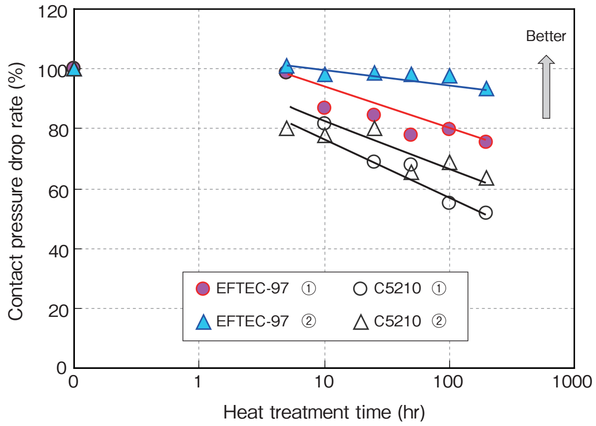


Figure 4 **Change in contact pressure drop rate (stress relaxation properties).**

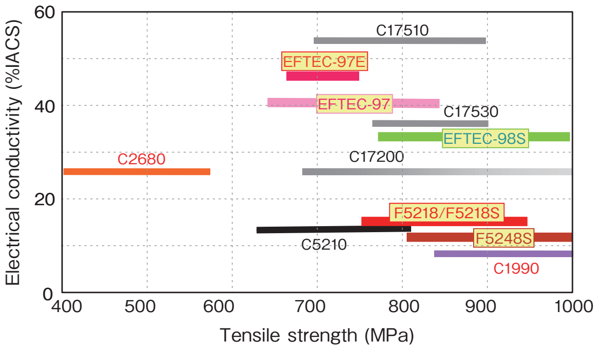


Figure 5 **Relationship between tensile strength and electrical conductivity.**

5. CONCLUSION

Figure 5 shows the relationship between tensile strength and electrical conductivity for selected connector materials (JIS alloys and the alloys developed by us). For EFTEC-97 and 98S, strength and electrical conductivity are in good balance, and stress relaxation properties are superior. F5218 and F5248S, for their part, exhibit both high strength and good bending workability. These materials are thus well suited to low profiled, narrow pitch miniaturized connectors.

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