Brief Summary of the Technical Fiche

Lead

Relevant to TF-1

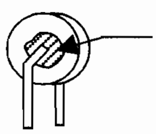
Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Lead contained in high melting temperature type solders (with more than 60 mass % of Lead) for below mentioned applications. 1. Solder used within an electronic component for internal connection purpose between functional element and wires, terminals, heat sinks etc. 2. Solder used for mounting electronic components onto sub assembled module or sub-circuit board. 3. Solder used as a sealing material to seal metal roof and ceramic package and etc. Such high melting temperature type solders are specified in ISO9453.	Resistors, Capacitors, Chip coil, Resistor networks, Capacitor networks, Power semiconductors, Discrete semiconductors, ICs, Chip EMI, Chip Beads, Chip Inductors, Chip Transformers etc. Hybrid ICs, Modules and so on SAW(Surface Acoustic Wave) filters, Quartz resonators and filters etc,.	A (Impossible to be substituted by 2008)

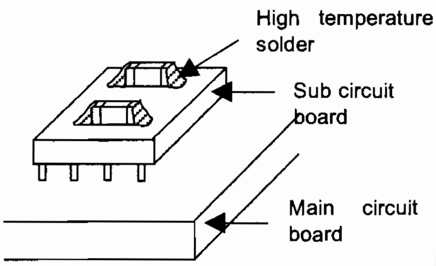
Reason of usage

<table>
<tr><th>Portion of usage(Sketch)</th><th>Reason of usage</th></tr>
<tr><td>

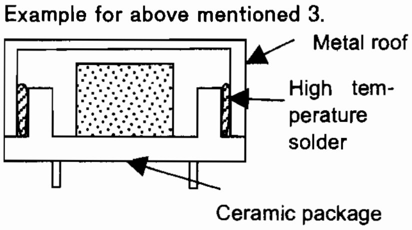
Example for above mentioned 1.



Example for above mentioned 2.



Example for above mentioned 3.



</td><td>

There is no substitution for high melting temperature type solders with more than 60 mass % of Lead (hereinafter "High temperature solder").
It can not be banned in the year 2008.

After being delivered to equipment manufacturers, electronic components are to be soldered by equipment manufacturers onto PC boards with Sn-40Pb solder. Soldering temperature at that stage is 230 to 250 degree C. Sn-40Pb solder melts completely at around 183 degree C. (which is far below 230 degree C)

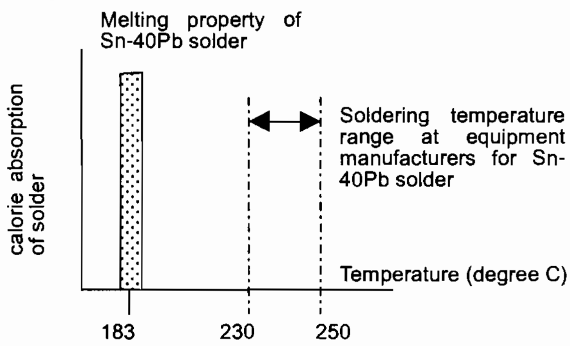


Fig.1

However, internal solder connections of electronic components have to withstand soldering temperature of 230 to 250 degree at equipment manufacturer's soldering process without being melted.
In order not to completely melt at 230 to 250 degree C, internal solder connections of electronic components are done with high temperature solder with more than 60 mass % of Lead.
Fig.2 shows an example of Sn-70Pbsolder as a high temperature solder.

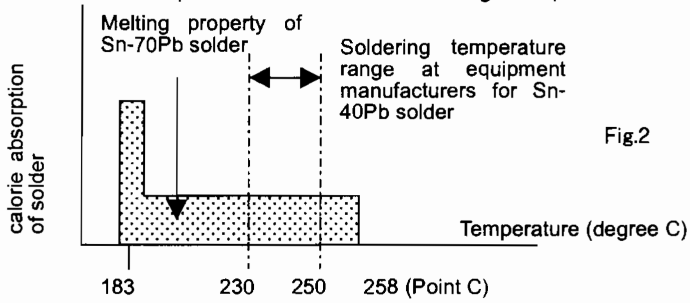


Fig.2

The temperature at Point C, where the solder completely melts, rises as contents of lead in the solder increases.

</td></tr>
</table>

	Shipment quantity of such high temperature solder (with more than 60 mass % of Lead) is estimated to be at maximum 5% of entire solder shipment quantity.

Substitution Difficulties

There has been no material found as substitution candidate which gives such melting properties within a practical price range and supply stability.

For example, Fig.3 shows the melting property of Sn-Ag solder, which is a candidate of lead free solders, however with higher silver(Ag) content up to 9% in order to rise the point C. The required melting property is not obtained even though point C rises, because most of calorie absorption of the solder appears at around 225 degree C and the solder almost completely melt below the temperature range of 230 to 250 degree C. This is the same for Sn-Cu solder.

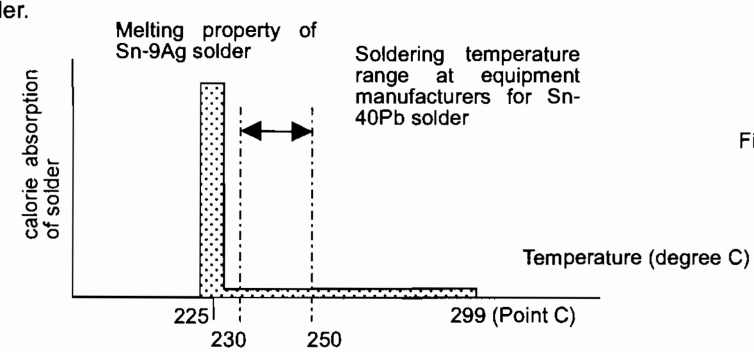


Fig.3

Furthermore, when lead free solders are used for assembling purpose of PC boards at equipment manufacturers, the matter becomes worse. In this case, internal connections of electronic components have to be done with high temperature solder with more than 80 mass % of lead contents. See Fig.4.

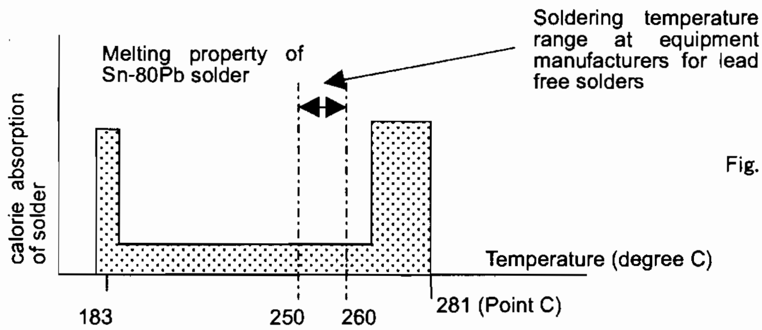


Fig. 4

Other materials such as Sn-80Au or Bi-2.5Ag also offer high melting temperature, but unfortunately these materials are not for practical wide use because they are very costly, poor in rigidity or wetting.

Thus, phasing out of lead in high melting temperature type solders will not be expectable even in 2008, and on the contrary even increase is foreseen.

However, this fact will not give a big negative impact to every effort of phasing out lead in solders, and should be accepted because shipment quantity of such high melting temperature type solders (with more than 60% lead) is estimated to be at maximum 5% of entire shipment quantity of all solders.

Thus, high melting temperature type solders (with more than 60% lead) must be exempted from ban.

Explanation of technical terms

Technical terms	Explanation
Sn-40Pb solder	A solder which contains 60 mass % of tin and 40 mass % of lead.
Calorie absorption of solder	It means that solder absorbs heat and melts. It is explained in this fiche as degree of melting of solder.
Liquidous temperature (Point C in this fiche)	The temperature where solder completely melts. (On the contrary, solidous temperature is the temperature where solder starts to melt. Liquid and solid states both exist between solidous and liquidous temperature.)
Sn-Cu solder	A solder which consists of tin and copper.
Sn-Ag solder	A solder which consists of tin and silver.
Sn-80Au solder	A solder which contains 20 mass % of tin and 80 mass % of gold.

Brief Summary of the Technical Fiche

Lead

Relevant to TF-2

Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Lead in thick film resistive layers as resistive elements of various resistive components.	RC networks, Potentiometers, Hybrid ICs Chip Resistors, Chip resistor networks, Chip RC networks, Chip capacitor networks, Chip resistor arrays, Trimmer potentiometers and so on	A (impossible to be substituted by 2008)

Reason of usage

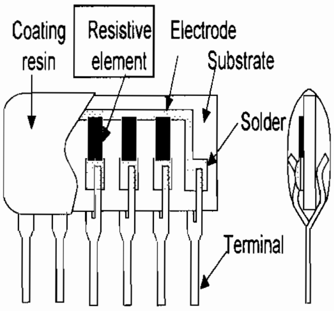
Portion of usage(Sketch)	Reason of usage
(Example) R-network 	Thick film resistive layers are obtained by firing alumina plates on which resistive paste is screen-printed. As for the thick film resistive layers, the manufacture cannot be done without lead. Table 1 shows an example of contents of typical resistive paste.

Table 1

	Material		Content (wt%)
◇	Conductive material	**$Pb_2Ru_2O_7$**	15 to 20
◇	Glass frit	**Pb**-Si-B-O	20 to 45
	Vehicle	Resin, Solvent	30 to 45
	Metal oxide additive	MnO, CuO etc	0.1 to 5

Lead (Pb) is contained in conductive material Lead-Ruthenium-oxide ($Pb_2Ru_2O_7$) as well as in glass frit.
Lead (Pb) is the key material for resistive layer to offer wide ranged resistivity (10^{-3} to 10^{4} Ohm-Cm), excellent TCR (+/-100 to +/-250ppm/deg.C between -55 to 150 deg.C), high power endurance and low contact resistance.
Lead-Ruthenium-oxide ($Pb_2Ru_2O_7$) construction conductive material offers wide resistivity. Lead-Ruthenium-oxide also offers excellent balance of fine particles and coarse particles, which results to high power endurance and low contact resistance. See Fig.1.

Glass layer

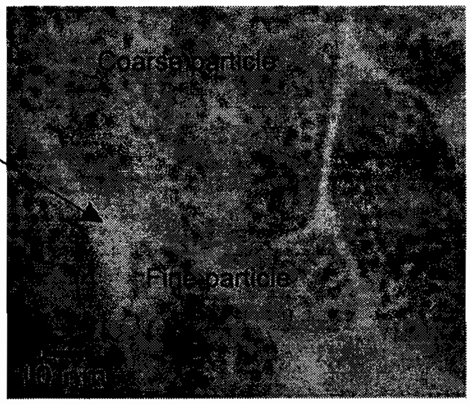


Fig.1

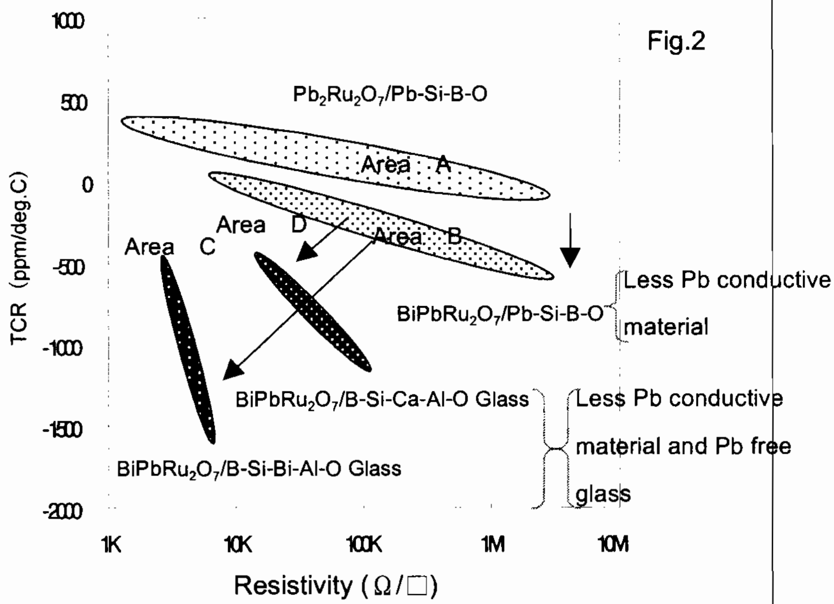
Yet-Ming Chiang, Lee A.Silverman, Roger H.French and Rowland M.Cannon,"Thin Glass Film between Ultrafine Conductor Particles in Thick-FilmResistors", J.Am.Ceram.Soc., 77[5] 1143-52 (1994)

Lead-containing glass offers wide softening temperature. It also offers excellent wetability with conductive particles, with which thin layer of glass between particles can be formed easily. This property also deeply concerns to TCR characteristics.

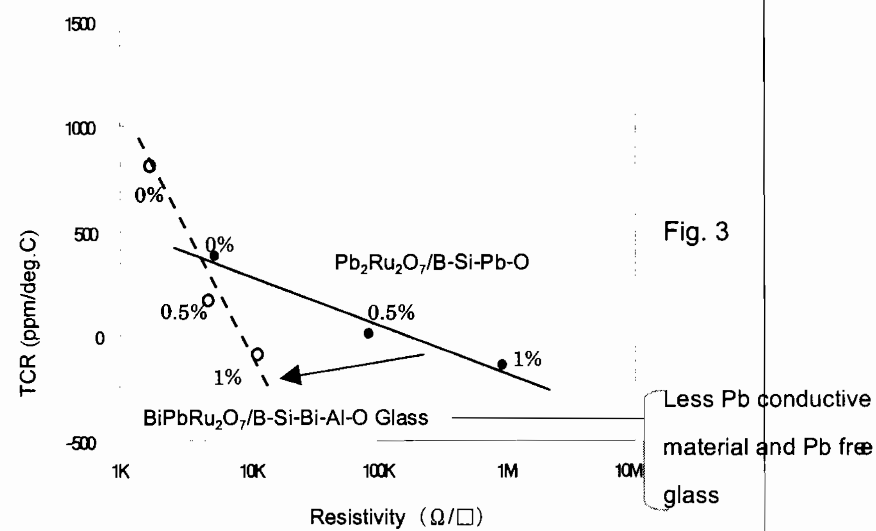
Substitution Difficulties

Fig-2 shows the result when Bi replaces a part of lead (Pb) in Lead-Ruthenium-oxide construction. (Conductive material: $BiPbRu_2O_7$ and Glass material: Pb-Si-B-O)

The original property area "A" changed to area "B" which has narrower resistivity range and wider TCR characteristics range. (No longer possible to maintain TCR within required range.) And when Ca-Al or Bi-Al replaces lead (Pb) in the glass material of above -mentioned trial, the property area "B" changed to area "C" or "D" where resistivity and TCR characteristics no longer lay in useful range.



Metal-oxide additives (MnO or CuO) are used as TCR adjusters in order to bring TCR of resistive film into a specific required range. Pb-less conductive and glass material violate such property of metal-oxide additives. See Fig.3.



It should be also noted that the replacing lead-free substances used in above-mentioned trials were considered as the most feasible choices.

Explanation of technical terms

Technical terms	Explanation
Paste	The one that a large amount of fine solid particles into liquid was dispersed.
TCR	When surrounding temperature rises at 1℃, ratio into which resistance changes. Temperature Coefficient of Resistance.
Contact resistance	Electric resistance which exists in contact side of two objects.
Softening temperature	Temperature that material becomes soft.
Wetability	The glass infiltrates the space between conductive particles and it becomes attached to them.

Summary of the Technical Fiche

Relevant to TF-3

Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Lead grass used with protective coating for resistive layers.	Resistors, High voltage resistors, Resistor networks, Resistor arrays, RC networks, Capacitor networks, etc	**B** Uncertain to be substituted till 2008

Reason of usage

<table>
<tr><th>Portion of usage (Sketch)</th><th>Reason of usage</th></tr>
<tr><td>
The structure of chip resistors, the sample of application of using glazing glass, is shown as Fig 1. The lead compounds are contained in material of protective coating (lead glass). The protective coating consists of 2 layers. One is the pre-coating glass layer, other is the protective glass layer.

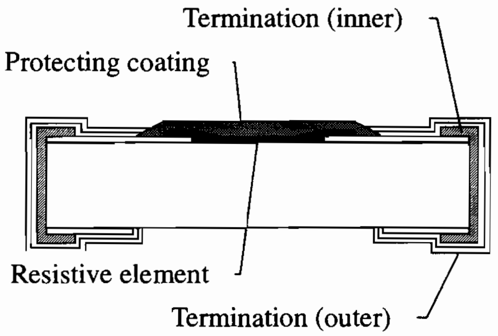


Fig.1 The structure of chip resistors
</td><td>
<u>Pre-coating glass layer</u>
1. Low melting point
The heat of laser trimming to adjust resistance cuts the pre-coating glass with resistive element clearly.
So the pre-coating glass layer formed on the resistive element has to be fired at the low temp. about 600°C.

2. Suitability for humidity and acid
The pre-coating glass protects resistance from humidity, acid and so on.

Therefore we use the glass contained lead compounds.

<u>Protective glass layer</u>
We can use substitution for protective glass layer contained the lead compounds.
</td></tr>
</table>

Substitution Difficulties

<u>Pre-coating glass layer</u>

The characteristic of the pre-coating glass contained the lead compounds is stronger for humidity and acid than any other kind of glass.

The substitution Materials ○ : good, △ : little bad × : bad

Material	Trimming	Acid	Humidity	Heat
Lead glass	○	○	○	○
Bismuth glass	○	×	△	○
Phosphorous glass	○	×	△	○

Explanation of technical terms

Technical terms	Explanation
Pre-coating glass	Material that prevent the resistance from being changed in the subsequent process
Protective glass	Material that protects the resistance element
Laser trimming	The procedure of resistance element to obtain the desired resistance

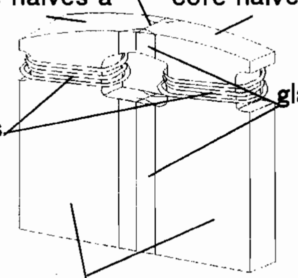
Brief Summary of the Technical Fiche

Relevant to TF－4

Substance／Usage

Sort of Substance	Related Usage	Reduction difficulty level
Lead(Pb) contained in bonding glass for magnetic head	Magnetic head(Bonding-glass to use for the adhesion of magnetic materials. ex,ferrite)	A (impossible to be substituted till 2008)

Reason of usage

Portion of usage(Sketch)	Reason of usage
magnetic head gap c core halves a core halves b  glass coils Mn-Zn ferrite	A pair of magnetic core halves a,and b which are made by magnetic oxides such as Mn-Zn ferrite, are bonded together with solder-glass. The solder-glass need to satisfy the following conditions so as to guarantee both the performance and the reliability of the magnetic head. 1.Solder-glass must melted at a low temperature.(Sealing at high temperature would cause the deterioration in magnetic performance.) 2.The thermal expansions of glass and the magnetic materials must be identical. (When a thermal expansion is different, the exfoliation between glass and magnetic material and so on occurs. 3.The glass should have high abrasion resistance and high humidity resistance when in contact with magnetic tape.

Substitution Difficulties

In the production process of magnetic head, adhesives are need for gluing magnetic materials such as ferrite. As adhesives, usualy solder-glasses which have low melting temperature are use.
Usualy,solder glasses contain the lead oxide as major component.

In the magnetic head production process ,it must be avoid high sealing temperature, since magnetic performance is deteriorated at high temperatures.
The solder-glasses containing lead oxide satisfies this reqirement as well as other technical requirement.

On the other hand, non-lead glasses with low melting point,for example, such as borate glass,phosphate glass, tellurite glass, chalcogenide glass, etc. have poor water resistance,or have large thermal expansion coeficients.
Accordingly it is impossible to use these non-lead-glasses practically.

	melting temp.(℃)	thermal expansion	humidity resistance
lead oxide glass	550	○	○
borate glass	550	○	×
phosphate glass	450	×	×
tellurite glass	500	×	×
chalcogenide glass	400	×	×

Technical items	Explanation
solder-glass	The glass which has melting temperature below 800℃. For comparison, melting temperature of usual window glass is 1600℃.
Mn-Zn ferrite	The magnetic materials which contain manganese-oxide,zinc-oxide,and iron-oxide,has high magnetic performance.This ferrite has high abrasion resistance when in contact with magnetic tape.

Brief Summary of the Technical Fiche

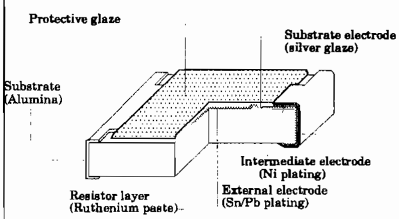
Relevant to TF-5

Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Glass flit contained in thick film materials to get electronic functional devices	Resistors, Capacitors, Chip coils, Chip inductors, Resistor networks, Capacitor networks, Hybrid ICs etc.	B Uncertain to be substituted till 2008

Reason of usage

Portion of usage (Sketch)	Reason of usage
ex. Chip resistor	Properties of glass frit for thick film technology



	Pb	Zn	P-Sn	Na-Al-P-B
Affinity with materials	○	△	△	○
Low softening points	○	△	○	○
Matching of thermal expansion	○	○	○	△
Weather resistance	○	○	△	△

Lead containing glass compositions are widely used because of the superior characteristics and low cost.

Substitution Difficulties

Many kinds of glass compositions have been studied for lead free glass.
But any compositions cannot satisfy the conditions stated above yet.
For instance, P_2O_5-SnO compositions and also Na_2O-Al_2O_3-P_2O_5-B_2O_3 compositions are developed and tested for lead free glass frit. But they are inferior in weather resistance characteristics.
There are many kinds of lead containing glass compositions for various purposes. So, it takes so long time to develop a compatible lead free glass composition.

Explanation of technical terms

Technical terms	Explanation
·Thick film technology	·Functional devices (conductor, resistor, capacitor, etc.) are formed on a substrate by using a screen printing technology. Materials are processed by using pastes, then fire around 800℃.
·Glass frit	·Pulverized glass powder

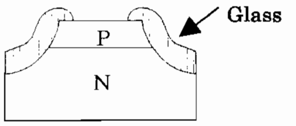
Brief Summary of the Technical Fiche

Relevant to TF-6

Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Lead-glass used for passivation of power semiconductor devices	Bridge rectifier, power diodes, power thyristors, power transistors etc.	A Impossible to substitute in 2008

Reason of usage

Point of usage(Sketch)	Reason of usage
 Cross section of power diodes	Lead-glass is widely and commonly used for P-N junction passivation of power semiconductors. Glass materials of this purpose have to satisfy all following conditions. ① High electrical stability ② Almost equal thermal expansion to Silicon ③ Firing temperature should be lower than 1000 deg.-C ④ High chemical stability Lead-glass have all above ① to ④ characteristics.

Substitution Difficulties

Lead-glass consists of PbO as major material and Al_2O_3, SiO_2 as sub materials. This glass does not contain material which degrades chemical stability and is quite stable against chemicals used in the semiconductor process. Furthermore the thermal expansion coefficient can be controlled by the composition of PbO and SiO_2 to get a thermal expansion coefficient that is relatively similar to Silicon. Firing temperature for that time is also low enough, as it is below 1000 deg.-C, which does not effect the P-N junction characteristics.

It can make a thick layer which give high anti humidity characteristics and few hundreds to one thousand Volts high voltage stability.

On the other hand, there are Lead free glass such as Zinc-glass, Silica glass and Boron-Silicate-glass. Table 1 below shows key characteristics of those and Lead-glass.

Sort of glass	Electrical stability	Thermal expansion	Low firing temperature	Chemical Durability
Lead-glass	O	O	O	O
Zinc-glass	O	O	O	X
Silica-glass	O	X	X	O
Boron-Silicate-glass	X	O	X	O

Table 1

A substitution lead free candidate is Zinc-glass, however its Zinc is so easily dissolved by acid that chemical stability is extremely poor.

Fig.1 shows Zinc-glass was heavily damaged by acid treatment, on the other hand Lead-glass has no damage at the same condition. As a conclusion Zinc-glass can not be used as a substitute.

Silica-glass has too low temperature expansion coefficient, and the firing temperature is too high to be a substitute.

Boron-silicate-glass also has too high firing temperature and the alkaline composition of the glass greatly degrades electrical characteristics.

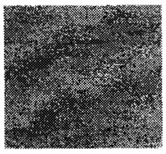
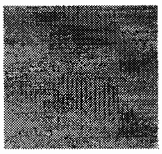
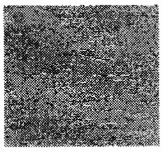
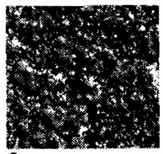
Lead-glass($PbO-SiO_2-Al_2O_3$)		Zinc-glass ($ZnO-SiO_2-B_2O_3$)	
			
initial	after treatment	initial	after treatment

Fig.1 Scanning Electron Microscope(SEM) photos $\times 150$
Acid treatment : Nitric Acid (HNO_3) boil 3 minutes

For the above reasons it is impossible to use these Lead free glass as a substitution of Lead-glass.

Explanation of technical terms

Technical term	Explanation
Passivation	A stabilization layer on semiconductor surface
Bridge rectifier	
Diodes	A kind of semiconductor devices
Thyristors	
Transistors	
P-N junction	Fundamental of semiconductor devices
Firing temperature	Glass layer manufacturing process temperature
Zinc-glass	Glass made of ZnO as main material
Silica-glass	Glass made of SiO_2 single composition
Boron-silicate-glass	Glass made of SiO_2,B_2O_3 and Na_2O as major material

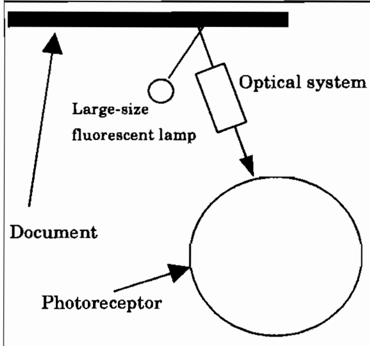
Brief Summary of the Technical Fiche

Relevant to TF-7

Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Mercury in the fluorescent lamp, 400 mm or longer in length, equipped in copiers for drawings and large-size sheet readers	Fluorescent lamp for light source	B (uncertain to be substituted till 2008)

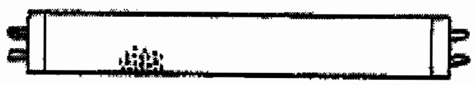
Reason of usage

Portion of usage(Sketch)	Reason of usage
	Reason for usage Copier irradiates the document with light to make a latent image on the photoreceptor and therefore requires a light source of high luminance. Besides, to copy a large-size document such as drawing, a large-size high-power light source that can uniformly irradiate light is necessary. Such large-size fluorescent lamps for copiers are charged with mercury. Deviation in the quantity is uncertain but may be 40 mg or more.

Substitution Difficulties

1. Functions of mercury in fluorescent lamp

Mercury in a sealed fluorescent lamp is a liquid under the condition shown in the following figure. If the fluorescent lamp is turned on, the mercury is evaporated into mercury vapor. As electric discharge occurs through the fluorescent lamp, the mercury vapor emits ultraviolet rays. The ultraviolet rays collide with the fluorescent substance applied to the inside wall of the fluorescent lamp and the fluorescent substance emits visible rays.



2. Can you develop any technology for dropping a small-amount of mercury in near the future?

At present, we and other companies are tackling a challenge of technological development for dropping a small and certain amount of mercury onto the internal surfaces of glass tubes. A few years ago, we developed successfully the technology for dropping a small amount of alloy of mercury and any other metallic element and have introduced it into manufacturing of ordinary fluorescent lamps for lightning. On the other hand, no new technology for copiers' fluorescent lamps has been developed.

The fluorescent lamps for copiers are characterized by their large sizes and higher output. Before these lamps can be put on the market, we must have further developed the manufacturing technology in depth, for example, verification of the characteristics of their life spans. It will take considerable time to achieve it successfully.

3. Can you develop any alternative light source for copiers in the near future?

As an alternative technology, LED right source, halogen lamp, and xenon lamp are candidates to be considered. However, LED right source cannot produce enough ligh volume to read characters on a sheet, and no lengthy type is available for halogen or xenon lamp that can read large-size drawings.

Explanation of technical terms

Technical terms	Explanation
LED	Light emitting diode. Solid light emitting element
Halogen lamp	Incandescent lamp charged with halogen gas to achieve high luminance and long life
Xenon lamp	Discharge lamp charged with Xenon gas

Brief Summary of the Technical Fiche

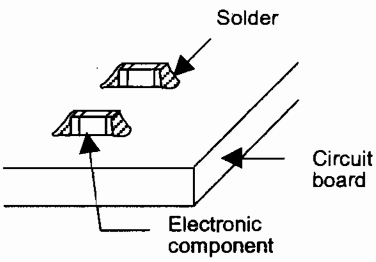
Lead

Relevant to TF-8

Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Lead (Pb) contained in solder (with approx. 40wt% of Lead) for general electrical connection purpose	General printed circuit boards and so on	B (Usage will decrease, but cannot be completely eliminated by 2008)

Reason of usage

Portion of usage(Sketch)	Reason of usage
	Solders of which lead content is approximately 40wt% (hereinafter "leaded solders"), are mainly and widely used for jointing components (e.g. IC, a variety of passive components etc.) onto printed circuit boards in the process of electronic circuits manufacture. The advantages of such solders are; * Plastic parts and/or low heat resistant components are able to endure the soldering temperature. * Excellent wetting. See below table for typical leaded solders that fall under this category.

	Contents (mass %)
Sn-40Pb	Tin 60%、 Lead 40%
Sn-37Pb	Tin 63%、 Lead 37%
Sn-36Pb-2Ag	Tin 62%、Lead 36%、Silver 2%

Substitution Difficulties

Electric and electronic industry is paying a lot of effort for introducing soldering with lead free solders. So it is expected that lead contained in solders will be rapidly substituted.
However;

A) It will take long time to solve below mentioned technical difficulties, and to standardize solders and soldering processes.
B) It will take long time before lead free soldering diffuses widely into all segments of electric / electronic market , or into all the worldwide manufacturers who ship their products to European market
C) We have to also assume that there may be some specific areas of electric and electronic application remain where elimination of leaded solders is by all means impossible for some technical / commercial reasons.

Taking these into consideration, it is impossible to eliminate entire usage of leaded solders by the year 2008. Leaded solders should be exempted from banning for now, and should be described in the directive as "To be re-examined in the year 2006".

【Technical difficulties】
The industry picked up Sn-Ag, Sn-Cu, Sn-Ag-Cu, Sn-Zn, (and other) based solders as candidates of lead free solders and has conducted various evaluations for introduction of these materials. Through these evaluations, below mentioned difficulties or problems have been pointed out.

(1) Estimated soldering temperatures of the major candidates of lead-free solders are expected to rise by 20 to 30 degree C compared with the leaded solders. For this reason, Some active components, passive components, plastic materials, printed circuit boards and so are short of heatproof. Their present characteristics are not attainable.
Furthermore, Some of high melting temperature type solders used in components or sub-assembly circuit boards become no longer useful. (See TF-1 for details)

(2) Candidates of Pb-free solders are mostly made from Sn rich materials. So, intermetalic compound layer, which is formed by surrounding metal's (Ag, Cu etc.) diffusion into solder at the time of soldering, signifi-

cantly grows compared to leaded solder. Since the intermetalic compound is hard and brittle, solder tends to peal along the diffusion layer under thermal stress.
So-called “leaching” problem is also reported. Especially Cu (copper) spreads into solders.
Firm solution for this phenomenon is not yet built up.

(3) Many of candidates for lead-free solders, generally speaking, are multicomponent alloy of which behavior has not yet been well known. For example, when lead-free solders are cooled down at soldering process, various metals unevenly crystallize. This is called as “Segregation”.
How this segregation effects to the joint performance or to the reliability is not well assessed and known yet.
So-called “Lift off” phenomenon, which is pealing off of lead free solder along joint surface, is considered to occur due to Segregation.

(4) In order to keep the upper limit temperature as low as possible, and to heat various different sized components on a printed circuit board to an even temperature, soldering equipment, such as kilns, also have to be improved. It may take 5 to 10 years to completely replace the existing soldering equipment with the new one because it will require high investment.

(5) Further improvement on candidates of lead-free solders is necessary. It has been reported that joint reliability on specific combination of certain candidate of lead-free solders and certain metal is deteriorated.
Furthermore, lead-free solders’ wetting and expansion is poorer because the surface tension is stronger compared with that of leaded solder.

Explanation of technical terms

Technical terms	Explanation
Wetting	It means that solder smoothly covers entire joint surface.
Segregation	The phenomenon that metal elements in alloy are unevenly distributed during solidification.

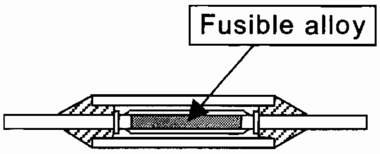
Brief Summary of the Technical Fiche

Relevant to TF-9

Substance/Usage

Sort of Substance	Related Usage	Reduction difficulty level
Thermal fusing materials used for electronic components	Thermal Links, Fuse resistors, Ta electrolytic capacitors with fuse, and etc.	**B** Uncertain to be substituted till 2008

Reason of usage

Portion of usage(Sketch)	Reason of usage
	As an abnormal behavior of a electronic component happen to rise an ambient temperature, a fusible alloy as a fusing element of a thermal links is heated up to its melting point and fuses off. Therefore an assembled thermal links can prevent an electronic component from overheating by cutting off its electronic circuit. Almost of all fusible alloys used for thermal links have melting points in a range of 70 to 185 degrees C. The performances for a thermal links required from users are having a high accuracy of functioning temperature, having a low resistance, having a high assurance and so on. To meet these demands and a good productivity, only five metals, tin (Sn), lead (Pb), bismuth (Bi), indium (In) and cadmium (Cd), are available for materials of thermal links. In fact almost of all fusible alloys for thermal links are made from some of these five metals.

Substitution difficulties

As shown above, only five metals, tin, lead, bismuth, indium and cadmium, are available for fusible alloys and it is necessary for almost of all kinds of fusible alloys to use lead (Pb) to meet the requirements for the thermal links.
If using lead is forbidden, it will become impossible to produce almost of all the thermal links used fusible alloys.

Temp.range ℃	70～ 90	91～ 105	106～ 120	121～ 139	140～ 150	150～ 160	161～ 180	181～ 185
Pb contain	O	O	×	O	O	×	O	O

O : contain × : not contain

Explanation of technical terms

Technical terms	Explanation
Functioning temperature	The functioning temperature at which a thermal links changes its state of conductivity to open circuit in the ambient air oven which rises temperature by 1 degree C. per minute and with loading the detective current 0.1A or less.

Brief Summary of the Technical Fiche

Cadmium | Relevant to TF-11

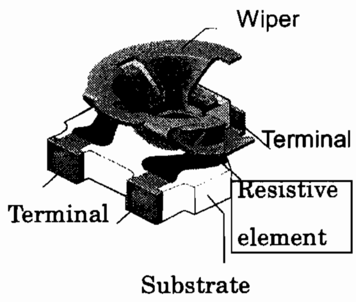
Substance / Usage

Sort of Substance	Related Usage	Reduction difficulty level
Cd in thick film resistive layers as resistive elements of potentiometers	Potentiometers	B (uncertain to be substituted till 2008)

Reason of usage

Portion of usage(Sketch)	Reason of usage

Potentiometer



Thick film resistive layers of potentiometers are obtained by firing alumina plates on which resistive paste is screen-printed.
Table 1 shows an example of composition of typical resistive paste of potentiometers.

Table 1

Material		Content (wt%)
Conductive material	$Pb_2Ru_2O_7$	70 to 80
◇ Glass frit	B-Si-Pb-**Cd**-O	
Vehicle	Resin, Solvent	10 to 20
Metal oxide additive	MnO_2	1 to 5

Cadmium (Cd) is contained in glass frit. Cadmium (Cd) is the key material for resistive layer to offer excellent TCR.
Cadmium is also essential for good process sensitivity (wide firing temperature range) and low total resistance change in temperature cycling.
Cadmium contained in glass (B-Si-Pb-Cd-O), offers lower softening temperature. It also offers excellent wetability with resistive particles, with which thin layer of glass between particles can be formed easily. This property also deeply concerns to TCR characteristics.
Cadmium was in the past contained in most of the thick film resistive layers of the potentiometers.
Efforts to remove cadmium have been successfully paid for resistive layers with TCR rougher than +/-250ppm/deg.C.
However so far, removing cadmium from resistive layers with TCR tighter than +/-250ppm/deg.C has not been feasible.

Substitution Difficulties

It is demanded that TCR is ±100ppm/deg.C in the industry. If the resistive element with this characteristic does not use the glass frit with cadmium, cannot do the manufacture.
See following data showing the difficulties.

Fig.1 shows the result when Cd in glass frit is made free. (Glass material: B-Si-Pb-O) The original property area "A" changed to area "B" which has poorer TCR characteristics.

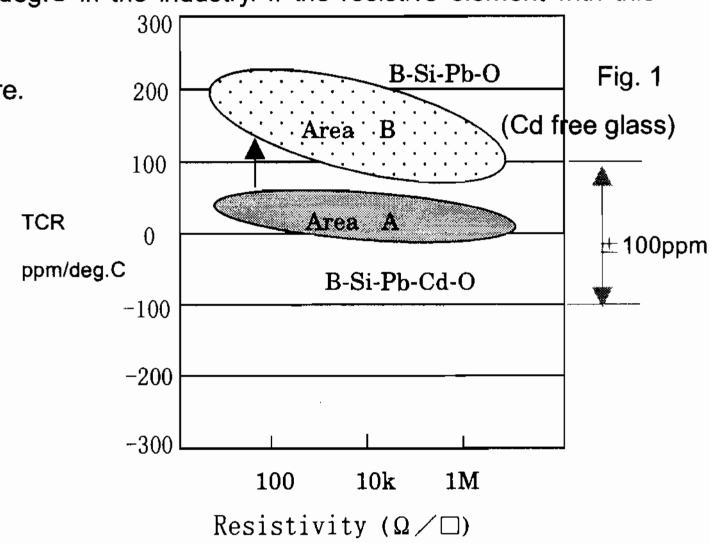


Fig.2 is the result of another trial of Cd-free glass frit. The resistive paste is usually fired at 850deg.C. When firing temperature is lowered from 850 deg.C to 845deg.C as showing in Fig.2, TCR of resistivity of the middle area (near 10 kΩ/□) shifts to a minus side greatly in case without Cd. And when firing temperature is raised from 850deg.C to 855deg.C, it is similar, too. Cd in the glass frit has working by which TCR is not shifted even if the firing temperature lowers from 850 deg.C to 845 deg.C or it raises from 850 deg.C to 855 deg.C.

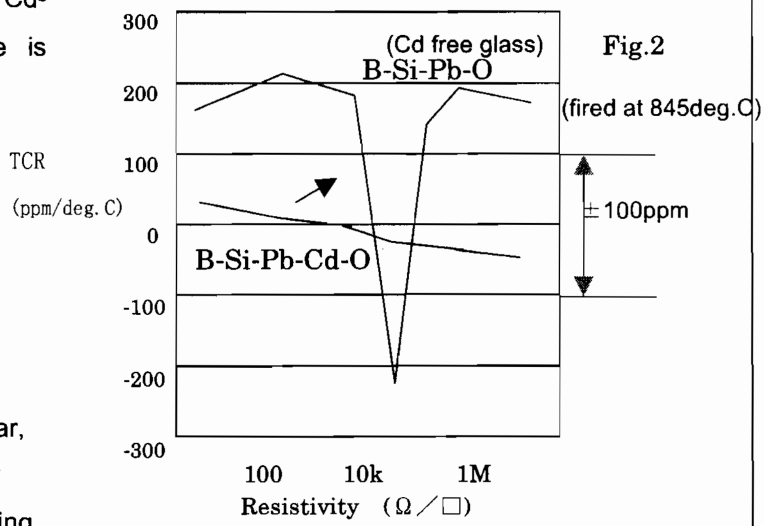
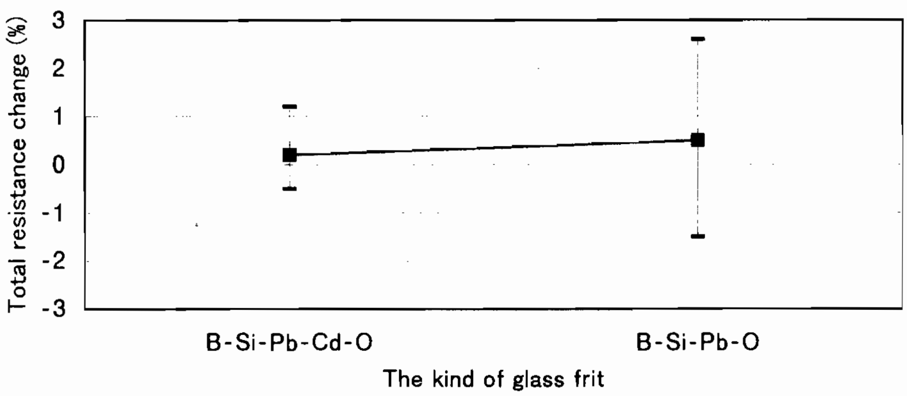


Fig.2

Fig.3 is the result of another trial of Cd-free glass frit.

The potentiometer of Cd-free glass frit has poorer total resistance change by temperature cycling test (from −25 deg.C to 85 deg.C / 5times). The total resistance change of Cd-free glass frit is about two times as large as that of Cd-contained glass frit.

Fig 3



Explanation of technical terms

Technical terms	Explanation
Paste	The one that a large amount of fine solid particles into liquid was dispersed.
TCR	When surrounding temperature rises at 1℃, ratio into which resistance changes. Temperature Coefficient of Resistance.
Temperature cycling	Examination to judge to influence by temperature change of surroundings whether product is endured.
Softening temperature	Temperature that material becomes soft.
Wetability	The glass infiltrates the space between conductive particles and it becomes attached to them.

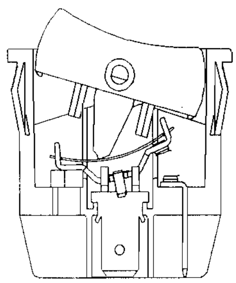
Brief Summary of the Technical Fiche

Relevant to TF−12

Substance／Usage

Sort of Substance	Related Usage	Reduction difficulty level
Cadmium contained in electric contacts	Switches, Relays, Thermal fuses, Thermal cutoff and other electric contacts	B (uncertain to be substituted till 2008)

Reason of usage

Portion of usage(Sketch)	Reason of usage
	To promote the contact resistance stability which had passed the durability test in a high electrical current range regarding power switch. Also, concerning the safety standards adopted in the other countries, fail to achieve the contact resistance stability might not allow the temperature rise level to satisfy the safety standard.

Substitution Difficulties

The electrical contact for the substitute which may share the same characteristics as Cadmium temper has not be successfully achieved, yet.

Kinds of Temper are listed as follows

1)Temper Other Than Cadmium

When the insulater(SnO_2) is generally used, Ark, which is produced during the durability test, will transform the temper into Oxide, and this Oxide will cohere on the contact surface.

This is why, this type of substance may not guarantee the contact resistance level stability.

2)Cadmium as Temper

As Ark may let the Temper evaporate, Oxide will not cohere on the contact surface.

Therefore, this will guarantee the contact resistance stability.

Explanation of technical items

Technical items	Explanation
contact resistance	Electrical resistance between closed contacts of the switch. Contact resistance will increase, if an insulating substance is on the surface of the contacts.
arc (discharge)	Electrical discharge under high voltage or high current. Contacts of the switch will be damaged by heat, which generated by arc discharge.
temperature rise of contact	The allowable temperature rise on the contacts of the switch when the rated current is applied. Temperature rise will increase when the contact resistance is increased.
evaporate	Contact material (metal) turn into a gas directly, by excessive heat generated by arc discharge.

	temparature rise limit after the test
IEC standard	max.55℃ after 10,000cycle on-off
UL/CSA standard	max.30℃ after 10,000cycle on-off

Brief Summary of the Technical Fiche

Relevant to TF－13

Substance／Usage

Sort of Substance	Related Usage	Reduction difficulty level
Hexavalent chromium in chromate treatment and chromium plating anti-corrosion	Loudspeaker, Loudspeaker system, Sounder, Bolts, Nuts, Screws, Shafts, Steel sheets, other metal parts, etc.	B (uncertain to be substituted till 2008)

Reason of usage

Portion of usage(Sketch)	Reason of usage
hexavalent chromium layer zinc plating layer steel sheet	Chromate treatment is used for the various parts of the electric electronic equipment, and the important function which keeps the life of the equipment by preventing the corrosion of each parts is fulfilled. The anti-corrosion of a chromate treatment layer has two functions. 1.Chromate treatment layer protects a metal from air as non-reactivity barrier. 2.Dried chromate layer contains small quantity chromate liquid inside. Therefore when layer is destroyed, chromate liquid ooze out and regenerate layer on the surface again due to property of self-repair. Above stated 1. shows function of coating, other 2. means excellent corrosion resistance by property of self-repair. Therefore corrosion resistance of the non-chromate treatment galvanize decrease sharply.

Substitution Difficulties

There is anti-corrosion by trivalent chromium treatment as the substitutive of hexavalent chromium treatment.

But a substitution is difficult because that anti-rust function is very poor and has the possibility that the hexavalent chromium of a small quantity exists.

The data that the time untill the white rust of the zinc occurred by the salt-water spray test are as follows.

Zinc plating	2 hours
Chromium treatment by trivalent chromium	48 hours
Chromium treatment by hexavalent chromium	120 hours

Explanation of technical items

Technical items	Explanation
Salt-water spray test	The test of the anti-corrosion for coating. An test to confirm change which is same as in long time use by short time. About 5% of the salt water(＊The salt concentration of the seawater is about 3-4%) is sprayed on specimen and check up time until rust occurs, or degree of rust on the constant time.

Brief Summary of the Technical Fiche

Relevant to TF-16

Substance / Usage

Sort of Substance	Related Usage	Reduction Difficulty level
Alloys containing a small amount of Lead.	Mechanical parts because of their special characteristics.	C(Very highly possible to be substituted by 2008) Wish to change the lead content values in alloys

Reason of usage

Portion of usage (Sketch)	Reason of usage
Mechanical parts in wide fields of manufacturing world	High speed machining ;cutting, shaving and drilling

Substitution Difficulties

The Annex Ⅱ of the 4th Draft accepts lead for alloys up to certain content as below.

Alloy	Specified lead content
Steel alloy	up to 0.3wt%
Aluminum alloy	up to 0.4wt%
Copper alloy	up to 4wt%

However , these values do not match to what specified in ISO or EN as below.
These values have to be matched each other.

Alloy	Specified lead content	International Specification
Steel alloy	0.1 to 0.35wt%	ISO683-9
Aluminum alloy	0.2 to 0.6wt%	ISO209-1 , EN573-3
Copper alloy	3.4 to 4.5wt%	ISO430

We have to check the long term reliability and durability for the substitutes.
However we have no information for the substitutes from manufacturing world of these alloys.
No substitute is available due to reason mentioned above.

Explanation of technical terms

Technical terms	Explanation