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CREEP BEHAVIOUR OF A Sn – Ag – Cu ALLOY NEAR ROOM TEMPERATURE

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ABSTRACT
A Pb solder joint is fast becoming a reality in electronic manufacturing due to marketing and legislative pressures because Pb-material is harmful for healthy. The reliability of SnAgCu solder joints has been a subject of major research in electronic industry and a number of researches showing SnAgCu performs better or worse than SnPb solder, depending on the components tested and test conditions employed. The temperature used in this experiment was at room temperature 30^0C until 100^0C and the stress used was 64MPa until 178MPa for different diameter.
Keywords: behaviour, temperature, manufacturing, creep.

1. INTRODUCTION
Pb solder joint is fast becoming a reality in electronic manufacturing due to marketing and legislative pressures because Pb-material is harmful for healthy. The reliability of soldier joints is one of the most important factors when selecting a package for a particular application. The stiffness mismatch between the package and the board results in thermal stresses in solder joints during temperature and power cycling. The damage caused by these stresses accumulates as the electronic assembly is subjected to multiple cycles, ultimate causing failures of solder joints. The reliability of Pb free solder joints is an important factor for selecting the proper replacement of SnPb solder. Based on various studied conducted (with different composition), the industry as a whole has converged towards SnAgCu solder alloy to replace SnPb solder from electronic assemblies.The goal of the investigations was to determine a parameter of the creep which are the activation enthalpy **Q**, the stress exponent **n** of the power law model and the parameter of the material **A**.

2. MATERIAL
The experimental composition of the solder alloy that used was:
95.5% Sn; 3.8% Ag; 0.7% Cu.
Next step we will see the microstructure of the solder alloy SnAgCu:

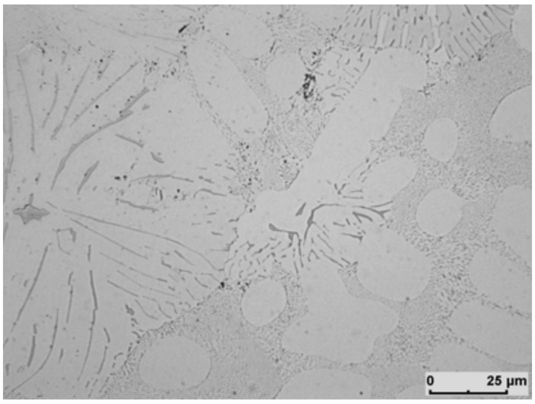

Figure 1: Show the microstructure of 95.5%Sn3.8%Ag0.7%Cu

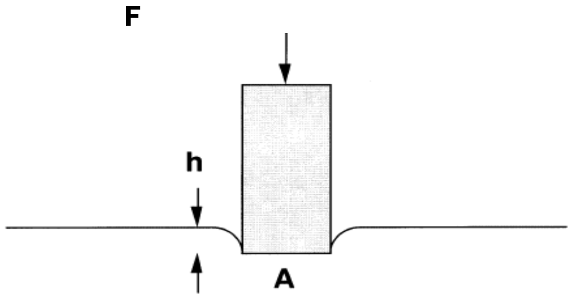

Figure 2: Schematic of the indentation creep test

3. CREEP EXPERIMENTS

Indentation creep test (impression test) schematically was illustrated in figure 2 below.

A flat bottomed cylindrical punch of diameter ‘A’ is pushed into the creep test specimen under an applied pressure F. The depth of penetration h of the punch is monitored as a function of time. Indentation creep test is derived by plotting h versus time. The punch diameter used was typically of 0.5mm smaller and larger 1mm was also employed depending on the application. They were made of stainless steel and were used for creep test at condition temperature. It was significant to find the equation for estimating plastic zone sizes for plane stress situations (impression test) can be developed from the elastic stress field equations. The method which is used to estimate the limit plastic zone is called the linear-elastic fracture mechanics (LEFM) and we found the elastic-plastic zone:

$$r = \frac{1}{2\pi}\left(\frac{K}{\sigma_y}\right)^2 \qquad ...(1)$$

Where K shows the property of material, σ_y applied stress in impression creep test and r the distance of the depth zone. To estimate the plastic deformation we used in generally two cases:

$$\varepsilon \approx h_{pl} \quad \text{and} \quad \varepsilon \approx 1.5 \cdot h_{pl} \qquad ...(2)$$

Where ε the creep strain which applied on the specimen and h_{pl} a depth of plastic zone.

Where F_i the indenter force applied on the specimen and F_{af} applied force. The experimental set-up is sketched in the Fig.3, which also shows the picture of the equipment.

Figure 3: Construction of the indentation equipment

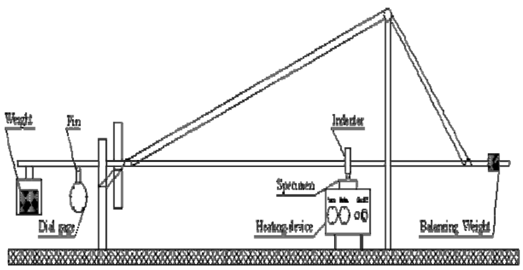

Figure 3.1: Schematic view of the construction equipment

The specimen is held at each end by a plain stainless steel indenter inserted through each loading stirrup. The moment due to the specimen stirrup and indenter is balanced by that of the weight hunger stirrup. The indenters are close fit to the holes at the end of the specimen.

Figure 4: Show stainless steel indenter on the specimen

Figure 5: Dial gauge measures

Loads are applied by hanging weight on the end of the lever arm. A rest pin is provided to support the weight of the lever arm when loading the specimen prior to test. A dial gauge measures the elongation in the specimen which will show in the Figure 5.

Table 1: Experimental used for the different temperature and stress

Nr	T (ºC)	σ (MPa)	D (mm)
1	30	64	1
2	30	77	1
3	30	102	0.5 , 1
4	30	153	0.5
5	30	178	0.5
6	50	64	1
7	50	77	1
8	50	102	0.5 , 1
9	50	153	0.5
10	50	178	0.5
11	80	64	1
12	80	77	1
13	80	102	0.5 , 1
14	80	153	0.5
15	80	178	0.5
16	100	64	1
17	100	77	1
18	100	102	0.5 , 1
19	100	153	0.5
20	100	178	0.5

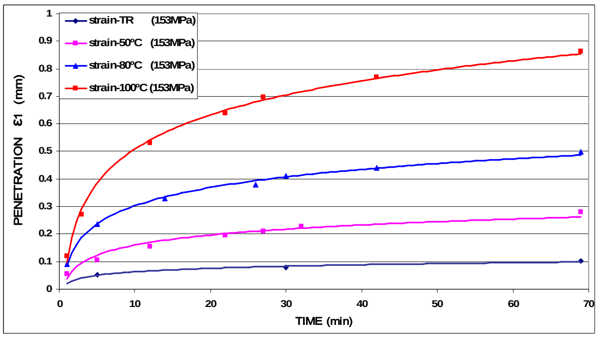

Figure 6.1: Impression depth versus time for

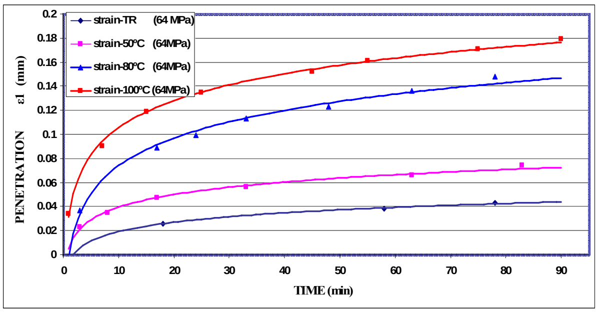

Figure 6.2: Impression depth versus time different temperature (0.5mm) for different

4. RESULTS AND DISCUSSION

In crystalline materials, such as metals, creep mechanism is linked to diffusion flow of vacancies and dislocation movement.

However the equation of Norton power law for creep behavior can be expressed as:

$$\dot{\varepsilon} = A\sigma^{n} \exp\left(-\frac{Q}{RT}\right) \qquad ..(3)$$

Where & is the creep rate, A is the constant parameter of material, n is the stress exponent, σ is the applied stress; Q is the activation enthalpy, R is the universal gas constant and T is the absolute temperature in Kelvin.

5. CONCLUSION

The impression creep test is not only viable but also versatile test method. It offers several advantages over conventional creep testing such as small amount of testing material, stress and temperature effects tested on the same crystal, stable deformation without tertiary stage, constant stress at constant load, separation of creep mechanisms by punch size effects in additions to stress and temperature effects.

The creep strain rate becomes larger with the increasing of the stress level (increasing diameter size), and the effect of the stress level becomes larger with the temperature increasing.

The Norton exponent n strongly depends on the metal and on the creep mechanism. In the case of diffusion creeps, the value of n equal 1. In the case of dislocation creep at homologues temperatures, n has a value between 3 and 10 and increases with stress. At lower temperatures core diffusion become dominant. The Norton exponent at RT exceeds this exponent at high temperatures – by 2. The value of n that we have found is between. We see that at room temperatures we are in dislocation mechanisms, while with increasing of the temperature we have diffusion mechanism.

The activation energy simply describes the change in (steady-state) creep-rate for a given substructure (strength), at a fixed applied ''stress'' with the temperature. From our experiments we have found that Q-activation energy increase with the decrease of the temperature, with the increase of the applied stress and with the increase of the indenter diameter. The values that we have found are nearly the theoretical values, but they involve also the experiment errors.

A-material constant increase with the increase of the diameter, with the decrease of the Q-activation energy and with the decrease of the exponent creep stress (n).

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