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The Reliability of Laser Reflowed Sn-Ag Solder Joints

C.H. Raeder, D.L. Millard, and R.W. Messler
Design and Manufacturing Institute, Rensselaer Polytechnic Institute, Troy, NY 12180

This is the first quarterly report of a project aimed at determining the reliability of electronic interconnects made with Sn-3.5wt%Ag solder alloy. The reliability of solder interconnects is primarily determined by two factors; 1. the type of electronic assembly and 2. the environment to which the assembly is exposed. These two factors (each composed of several variables i.e. assembly thermal expansion coefficients, elastic moduli of assembly members, maximum operating temperature, rate of temperature change, etc.) boil down to three critical parameters; temperature, strain and strain rate (or stress). The interdependence of these variables must first be explored when addressing a creep-fatigue problem such as the case of solder joints. Specific environment (beyond temperature) and state of stress at a propagating crack, which are determined by the specific application and package geometry, are being neglected at this point in time.

Little involving the creep or fatigue properties of Sn-3.5Ag is reported in the literature. Prior studies [1,2,3] have used unique joint geometries to measure joint properties. The results are thus limited to the specific test geometry or conditions. This study, in name, centers on assessing the reliability of laser soldered SnAg solder joints but recent work from our lab [4] has shown that following aging microstructures of conventionally reflowed and laser reflowed solder joints are very similar. Given that, it is not deemed necessary at this point in time to use a laser soldering process or laser soldered joint to assess the creep and/or fatigue properties of SnAg solder joints.

This study aims at achieving results which are general in nature. A very simple test specimen is being used with only commercially pure solder alloy. We begin by determining the isothermal tensile creep properties of Sn-3.5Ag in the cast state. 20 lbs of commercially pure solder were obtained from the Indium Corporation of America. The chemical composition is given in Table 1. The solder was melted and poured into Pyrex test tubes and allowed to cool in air at room temperature. These cylindrical ingots were machined into tensile dog-bone samples with a gage diameter of 6.0 ± .02 mm and a length of 40.0 ± .5 mm. Testing is being conducted between the temperatures of 20°C and 160°C. Strain is monitored continuously during testing to record both transient and steady state components of strain. Testing is halted at the strain rate minima so that the same sample may be used for more than one test.

Table 1. Chemical analysis of Sn-3.5Ag, ppm except where noted.

Sn	96.46wt%	Ag	3.49wt%	Bi	82	Cu	11	Fe	57
In	43	Ni	65	Pb	36	Sb	157		

To date, isothermal creep data has been collected at two temperatures, 158°C and 107°C. Representative creep curves are shown in Figure 1. From these curves the steady state strain rate (the minimum strain rate) is determined and plotted vs. stress in Figure 2.

In the immediate future isothermal tensile creep data will be collected at lower temperatures to determine the activation energy and stress dependence at lower temperatures, as this appears to be a function of temperature judging from the above initial results. From the creep data constitutive relations will be developed which give the stress and temperature dependence of strain rate over a broad range of relevant conditions.

Further work will focus on the thermal fatigue behavior of joints made with Sn-3.5Ag. First it will be determined if the joints show the same stress and temperature dependence of strain rate, then lifetime predictions will be made as a function of strain range and rate. Furthermore, the constitutive relations will be used link the experimental data to various geometries and service environments not explorable in the laboratory.

References

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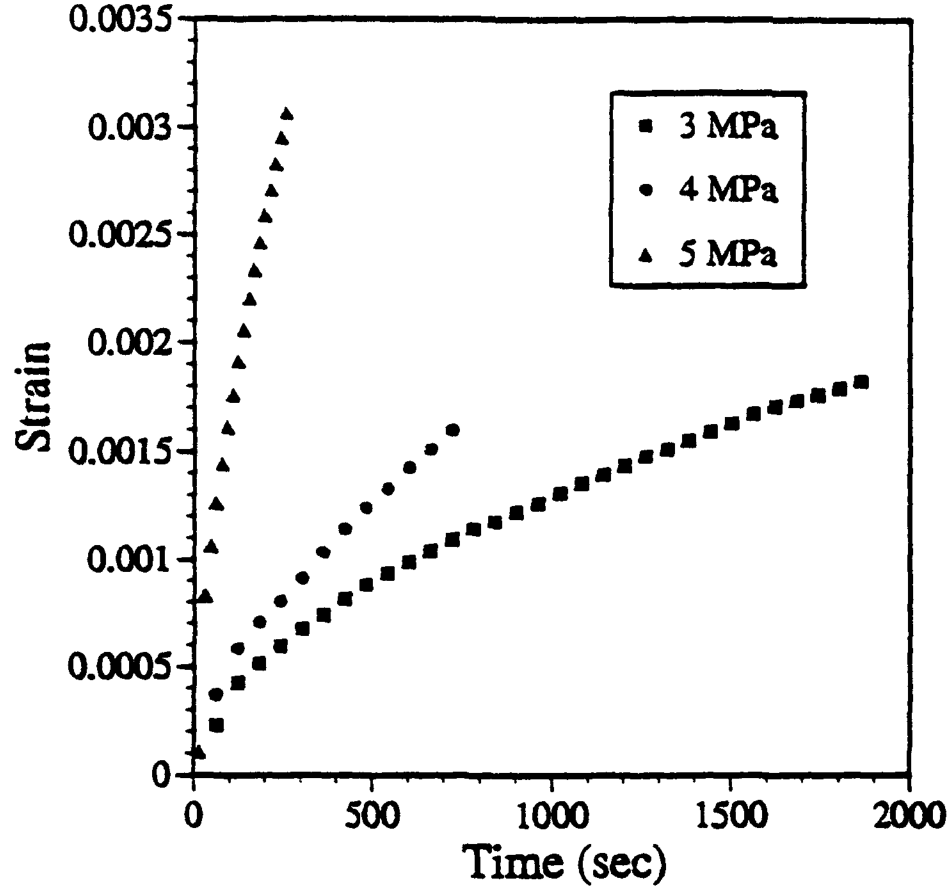

Figure 1. Representative isothermal tensile creep curves, Sn-3.5Ag, air-cooled, cast ingot.

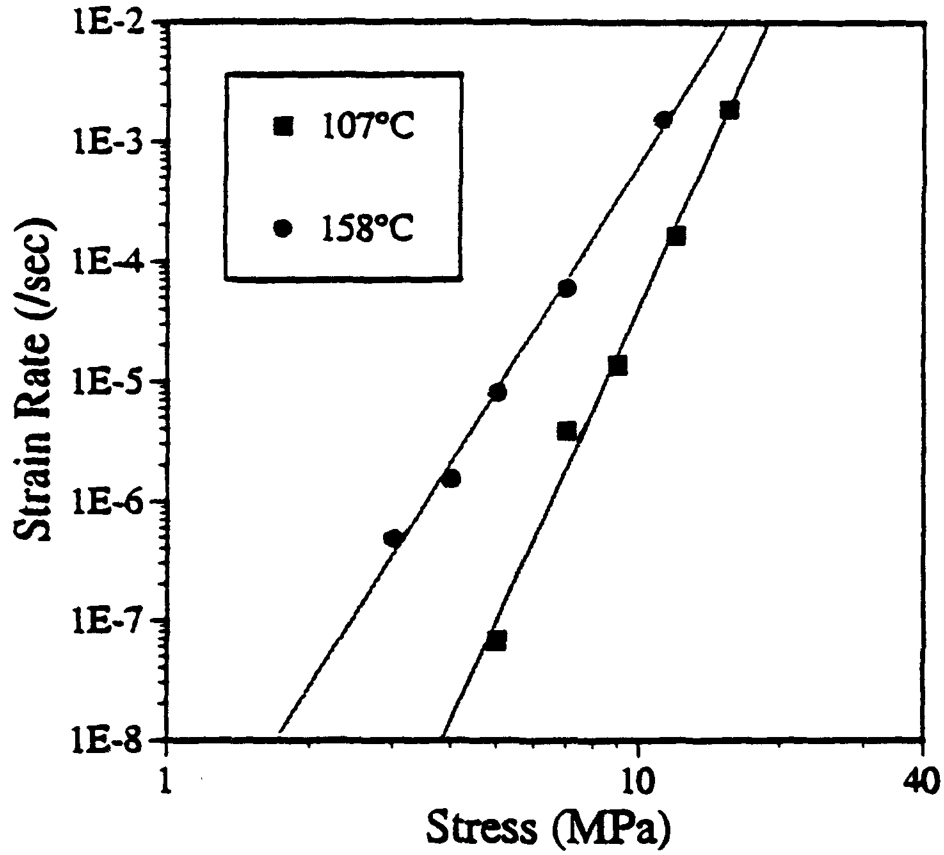

Figure 2. Isothermal tensile creep, Sn-3.5Ag, air-cooled, cast ingot.