were also observed in addition to the high-amplitude AE signals (Fig. 3). These results resemble those of Fang et al.[31] but the differences between these 2 experiments are that the weldment volume used by Fang et al. was big, and the range of material affected by heat was wide resulting in unequal thermal conduction. In addition, they mostly investigated artificial defects formed by soldering metals with coefficients of thermal expansion different from the parent metal. The resultant soldered crack was a visible macrocrack, which was the source of AE signals with high amplitude and high energy. On the other hand, the source of the low-amplitude AE signals was the decohesion of MnS inclusion bodies around the microcrack formed by nucleation. However, in this experiment, no visible macrocracks were seen in the soldered specimens under any conditions. Therefore, the high-amplitude AE signals produced during soldering did not result from macrocracks, but were produced by flux inclusion bodies under stress. The smaller-amplitude AE signals emitted during the isothermal and cooling periods came from different sources.

During the isothermal period, the heat-absorbing metal changed from a solid into a molten condition, called a material phase transformation. At this time, thermal stresses had not yet formed, and the AE signals produced belong to one of the continuous types. We found high-amplitude AE signals produced by the high-frequency soldering machine and flux during this period, and also found continuous found lower-amplitude, continuous-type AE signals, which may have been produced by the same material phase transformation as in the above experiment of impedance soldering of steel. When the high-frequency soldering machine stopped heating, the specimen naturally cooled down, and the melted metal began to solidify and contract. But then, the parent metal, which originally had expanded with heat, began to contract in the opposite direction, resulting in tensile stresses. When these tensile stresses appear, they meet low-melting-point extracts on the grain boundary leading to melting, and enters the liquid membrane phase, then micro cracks may appear, causing the specimen to continuously produce lower-amplitude AE signals during the cooling period.

According to the results of the tensile test, soldering temperature has no obvious effect on the ultimate tensile strength. Unfortunately, the temperatures chosen (1150 and 1200 °C) in this study were limited by the high-frequency soldering machine used, whose highest temperature is only about 1200 °C. Moreover, temperatures must stay between the melting temperatures of the solder (1100-1150 °C) and the soldered metal (1320-1350 °C) (Table 1). Approximation of the solder's soldering temperature (1180 °C), as suggested by the manufacturer to be between 1150 and 1200 °C, used in this study may also result in similar soldered metallurgical properties. However, from SEM observations, the microstructure can actually be seen to vary with temperature change (Fig. 6). The reason may be that the temperature effect is a kind of microeffect, in the same category as microcracks and microvoids. Such micro effects do not appear during the ultimate tensile test, but may be manifested by fatigue testing in a further study.

ACKNOWLEDGEMENTS

This investigation was supported by a grant (NSC 87-2314-B-038-020) from the National Science Council, Taipei, Taiwan, ROC.

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