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Topic	Environmental Engineering

Environmental Impact of different Solder Alloys

Investigation of the two solder alloys Sn37Pb and Sn3.0Ag0.7Cu

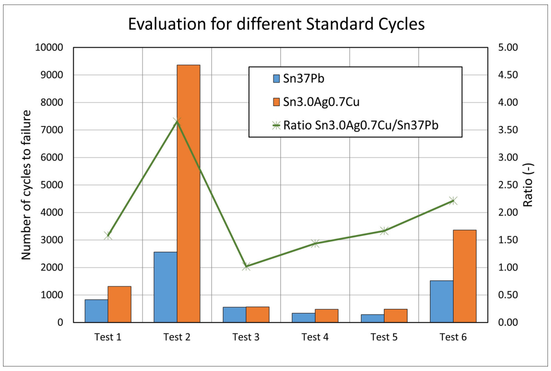

Figure 1: Number of cycles to failure for different standard temperature cycles (durability evaluation with the Coffin-Manson thermal fatigue model)

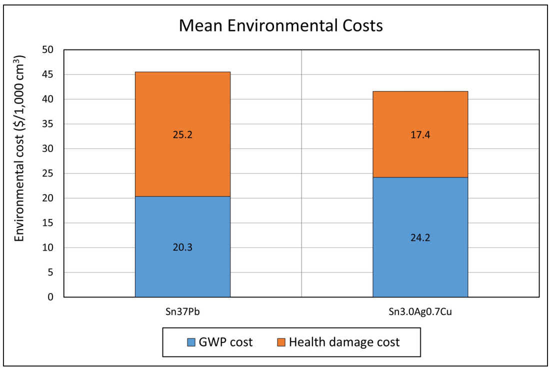

Figure 2: Environmental cost evaluation for the two solders Sn37Pb and Sn3.0Ag0.7Cu

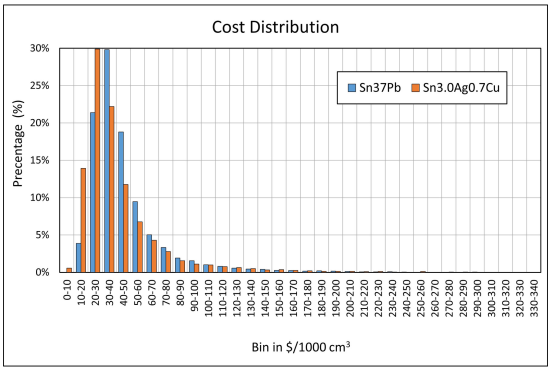

Figure 3: Distribution of the environmental costs for the two solders Sn37Pb and Sn3.0Ag0.7Cu (Monte Carlo simulation with 10,000 values)

Introduction: The durability of electronics and different solder materials can be evaluated by experimental and analytical techniques. The durability can reduce the environmental impact of electronics significantly by ensuring longer life time of the products. Longer life lowers the need for re-manufacturing and replacement of electronics, thus allowing added benefits such as lower energy consumption during the manufacture and lower environmental pollution due to recycling. Thus durability is one of the important metrics that should be evaluated for different solder materials when assessing the environmental footprint of different solders.

Objective: A literature review has shown the following main statements:

- The environmental impact of solders in different categories is known under defined boundary conditions
- No overall approach for comparing the environmental impact is given (comparability through different categories is not possible)
- A trade-off relationship between energy impact categories and human health impact categories can be detected
- The data availability for comparing different solders is low and mainly focused on the two solders Sn37Pb and Sn3.0Ag0.7Cu. Given this background, the Sn3.0Ag0.7Cu solder alloy appears to be the leading Pb-free solder candidate

Due to the represented main statements above, an approach for detecting the environmental impact of different solders should be elaborated with including the global warming potential (GWP) and the disability of adjusted life years (DALY).

Result: With the Coffin-Manson thermal fatigue model, the durability for the Sn3.0Ag0.7Cu solders is for all of the 6 defined test standard cycles higher with a Sn3.0Ag0.7Cu/Sn37Pb ratio between 1.0 and 3.7. Calculated with mean values, the total environmental cost for the Sn37Pb solder is 45.5 $/1,000 cm^3, respectively 41.6 $/1,000 cm^3 for the Sn3.0Ag0.7Cu solder. Through the lower health cost, the cost distribution for the Sn3.0Ag0.7Cu is slightly shifted to the left compared to the Sn37Pb solder alloy. The 5 and 95% percentiles for Sn37Pb are $21.0, respectively $98.5 per functional unit of 1,000 cm^3. For the Sn3.0Ag0.7Cu solder alloy, the 5 and 95% percentiles are slightly further apart with $15.4, respectively $100.8 per functional unit. In 60.6% of the 10,000 comparison, the environmental costs for the Sn37Pb solder are higher compared with the Sn3.0Ag0.7Cu solder alloy.