Solder Joint Materials By Design

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Project Start: 4th Quarter FY07

This presentation does not contain any proprietary or confidential information
Purpose of Work

- Hybrid and Electric Propulsion Vehicles depend on high efficiency, lower cost, weight and volume, power electronic components and subsystems

- Future power electronic systems need to operate
  - At junction temperatures of 200°C vs current 125°C
  - Reliably for 15 years

- Increased operating temperatures require use of
  - Alternate packaging materials to withstand higher temperatures
  - Wide band-gap semiconductors devices

- Need to understand effect of higher temperatures on material microstructural evolution and property degradation
Image of an IGBT Module

Courtesy A. Wereszczak
Barriers

• High temperature exposure and thermal cycling cause microstructural changes that degrade properties of solder joints and wire bonds, and decrease lifetime and reliability

• Methods to evaluate long-term reliability for high temperature operation have not been established

• Solder composition, physical properties such as thermal expansion coefficients, and package design influence degradation and their effects need to be evaluated

• Methods to select best suitable solder composition for lifetime and reliability are not available
• Simple packages will be fabricated
• Effect of steady-state exposure to 200°C on microstructure, strengths of solder joints and wire bonds will be measured as a function of time
• Effect of thermal cycling on packages will be evaluated by thermally cycling from -65°C to 150°C (or 200°C) and characterizing degradation
• Joints will be fabricated with alternate solders and tested to develop database relating degradation to solder composition and microstructure
• Database will be used to design/select appropriate solder joint composition based on composition-property evaluations
Plans for FY08

- Preliminary work showed higher void content in eutectic Au80-Sn20 (melting point 280°C) processed with solder paste in inert atmosphere

- Processing of solder joints with Au-Sn preforms in vacuum will be performed both in-house and at external processing facility

- Joint strength will be characterized using die-shear tests, and microstructure will be characterized using microscopy and radiography

- Package will be subjected to steady state exposure and thermal cycling at the thermal cycling and failures will be evaluated in this solder (Milestone to be delivered by 9/08)
Summary

- Advanced Power Electronics components and systems in hybrid and electric vehicles have to operate at higher junction temperatures (200°C vs. 125°C) with a lifetime of 15 years.

- Effect of high temperatures and thermal cycling on solder joints and wire bonds are expected to influence the lifetime and reliability of these components and systems.

- The proposed work will characterize the effect of steady state exposure to temperature and thermal cycling on degradation in properties of solder joints.

- This knowledge will assist in optimizing component life through a better selection of solder compositions and will be communicated to components and system manufacturers.