Solder Joint Materials By Design

G. Muralidharan (PI), Andrew Kircher
Materials Science and Technology Division
Oak Ridge National Laboratory, Oak Ridge, TN

Burak Ozpineci
Engineering Science and Technology Division
Oak Ridge National Laboratory

Project Start: 4th Quarter FY07

This presentation does not contain any proprietary or confidential information

Purpose of Work

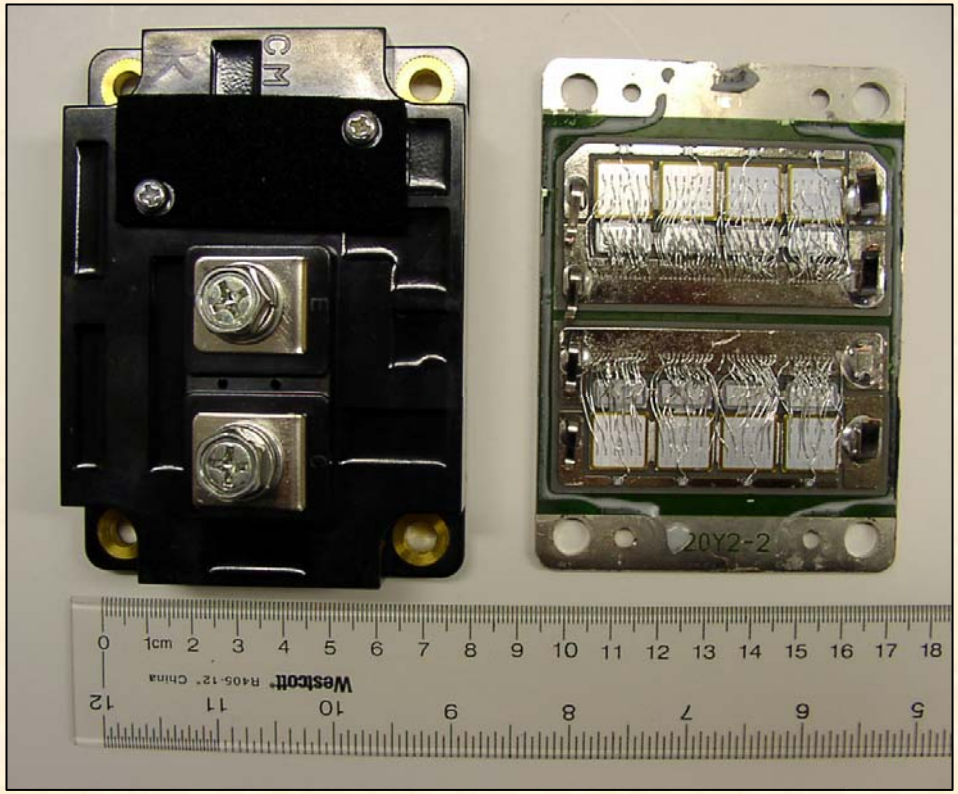
- Hybrid and Electric Propulsion Vehicles depend on high efficiency, lower cost, weight and volume, power electronic components and subsystems

- Future power electronic systems need to operate
  - At junction temperatures of 200^{o}C vs current 125^{o}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

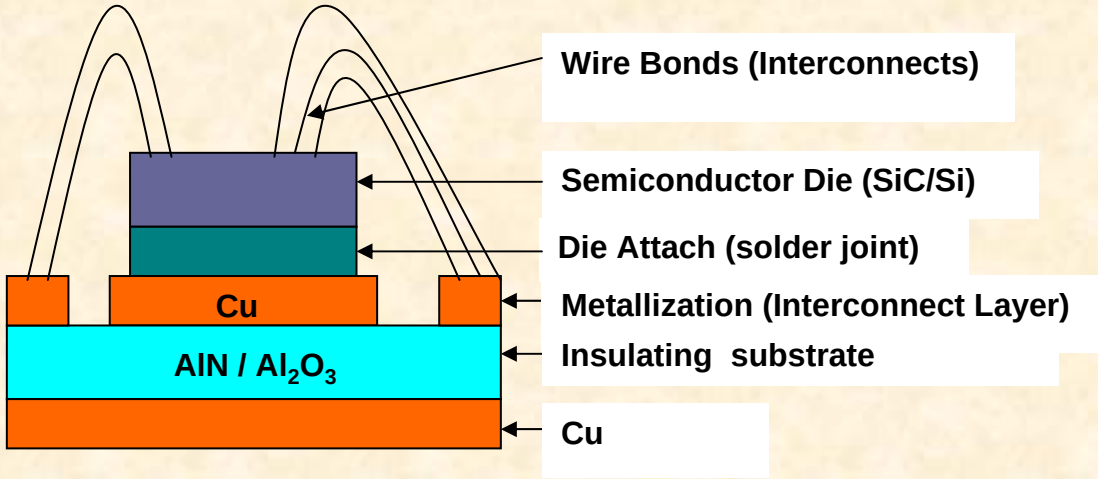


Courtesy A. Wereszczak

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

Approach



- 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^{o}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^{o}C vs. 125^{o}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.