Impedance Analysis as a Prognostics Technique for Interconnect Degradation

1. Team

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2. Objectives

- Quantify differences in time-to-failure between change in RF impedance and increase in DC resistance during creep and fatigue tests.
- Using failure analysis and experiments on model contact geometries, determine the extent of physical degradation required to produce RF impedance changes.

3. Introduction

Operating frequencies of communication and digital equipment are increasing, while critical dimensions of PCBs and components are shrinking. At high frequencies, signal propagation is concentrated in the surface of interconnects due to the skin effect. As signal frequencies of analog and digital equipment rise, electrical performance will exhibit increased sensitivity to interconnect degradation, which will precede loss of DC continuity.

Results obtained in C07-16 demonstrate that RF impedance does respond to solder joint degradation earlier than DC resistance, showing that standard methods for monitoring solder joint reliability do not adequately detect initial stages of degradation, and may overestimate the lifetime of products used for high speed or high frequency applications.

Building on the results of the first year's research on this topic, this project will exploit high frequency metrics as a more sensitive measure of interconnect degradation, which should also provide more accurate assessments of reliability in high speed applications.

4. Approach

- Instrument test samples in creep and fatigue tests for simultaneous monitoring using a vector network analyzer and ohmmeter.
- Determine extent of differences in sensitivity to solder joint degradation for the two approaches and whether these differences are dependent on the stress condition.
- Using destructive physical analysis identify failure sites, characterize material response to the applied stresses and correlate changes in RF and DC signal with extent of physical degradation.
- Explore use of model contact geometries to further investigate sensitivity of RF impedance to interconnect degradation.

5. Deliverables

- Quantification of differences in time-to-failure between change in RF impedance and increase in DC resistance during creep and fatigue tests.
- Evaluation of dependence on nature of accelerated stress condition.

- Determination of extent of physical solder joint degradation associated with observable changes in RF impedance and DC resistance.

6. Project Status
   - A Labview test automation program was written to stop the fatigue tests when RF impedance degrades beyond a threshold value, in order to observe degradation of the solder joint before a DC open circuit is measured.
   - Fatigue tests were conducted using the degradation control program with simultaneous measurements of RF impedance and DC resistance.
   - Failure analysis on a degraded solder joint was conducted using cross-sectioning.
   - The electrical measurement setup was adapted for use at elevated temperatures to allow simultaneous measurements of RF impedance and DC resistance during creep tests.

7. Estimated Schedule

Tasks	Oct-Dec 2007	Jan-Mar 2008	Apr-June 2008	July-Sept 2008	Oct 2008
Set up creep and fatigue test platform for monitoring with VNA and ohmmeter.					
Perform stress tests on SMT component.					
Failure analysis					
Develop measurement capability with controlled contact geometries					
Perform exploratory tests using controlled contact geometries					
Report and Review					