Presented at the COMSOL Conference 2009 Milan

COMSOL CONFERENCE 2009

csem centre suisse d'électronique et de microtechnique
info@csem.ch www.csem.ch

Simulation of Daisy Chain Flip-Chip interconnections

M. Fretz[1], G. Spinola Durante*[1]
[1]CSEM SA, Central Switzerland Center, Untere Gründlistrasse 1, CH-6055 Alpnach, Switzerland
Corresponding author:* gsd@csem.ch

Introduction

Flip-Chip technologies are selected among Au bump thermocompression with and without NCA underfiller, anisotropic conductive adhesive bonding, and AuSn20 eutectic solder. Within Comsol framework the daisy chain simulations and a method for comparing single-bump resistance are implemented.

Challenges:

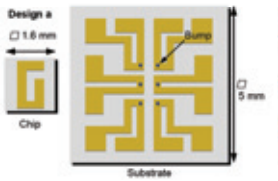
- estimate more accurately the single-bump resistance
- model current crowding effect
- model high aspect-ratio 3D model

Solution:

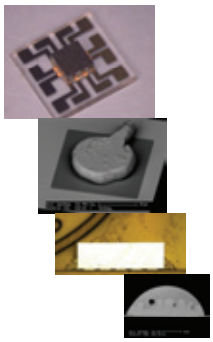
- simplified FEM model solved using AC/DC Comsol Multiphysics feature
- normalize experimental data with numerical correction factors calculated through FEM results post-processing

Experimental results & Comsol Model

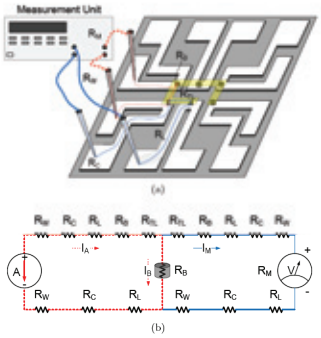
• Daisy chain chip



Measured sites: 1, 2, 3, 4



• Experimental setup



Setup: 4-probe resistance measurement

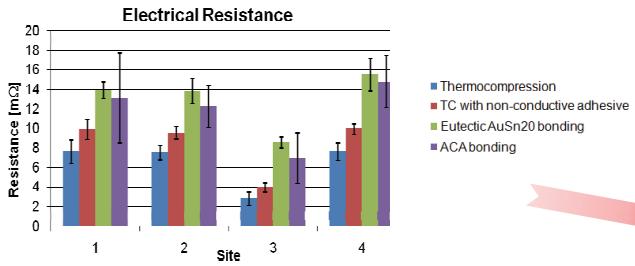
Equipment: Keithley 2750 DMM

Typical resistance values:

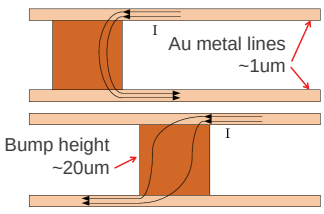
- R_W: Connection wires 1Ω
- R_C: Probe-to-metal-line contact 1 Ω
- R_L: Bottom substrate metal line 100 mΩ
- R_{TL}: Top die metal line 20 mΩ
- R_B: Interconnect bump 10 mΩ
- R_M: Measurement unit 10 MΩ

$R_B \sim R_{Measure} \cdot (1 + 4 \cdot 10^{-7})$

• Experimental bump resistances

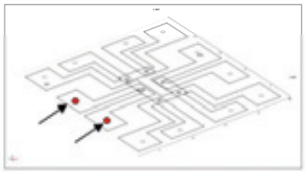


• Current crowding effect



- Site 3 appears to have ~2 factor less resistance than other sites
- This effect depends on the daisy chain layout geometrical features
- Effect is known as current crowding effect
- This effect is enhanced with high aspect ratio geometries.

• FEM calibrated model

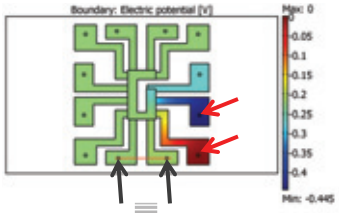


Calibration of Au line conductivity

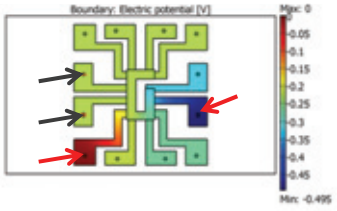
Comsol results

• Resistance extraction method

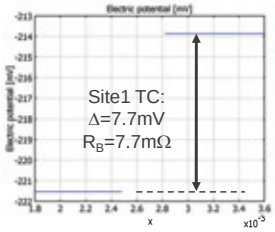
Site 1 simulation



Site 4 simulation

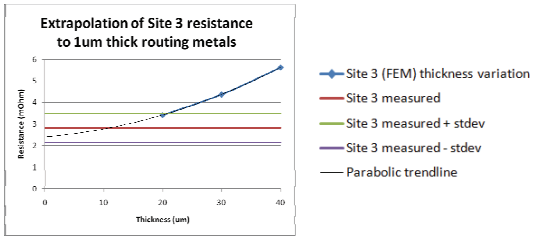


- Forcing current = 1A
- Voltage measurement ÷ R_B

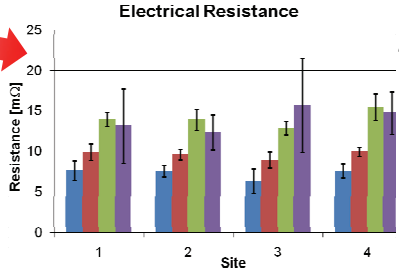


- For thermocompression bonding (TC) site 1, 2 and 4 give similar simulation results
- Site 1 (TC) simulation gives accurate resistance value of 7.7mΩ against an experimental average value of 7.6mΩ

• High aspect-ratio simplified FEM model



• Normalized experimental results



$$Site(1)_{norm} = \left(\frac{Site(1)}{Site(X)}\right)_{FEM} * Site(X)_{exp.}$$

Conclusions

- Simulation of simplified high aspect-ratio 3D model with Comsol Multiphysics matches experimental results for thermocompression
- The prediction of FEM helps to quantify the measured current crowding effect and to normalize the single-bump resistance measured values.
- The impact is to improve the design of interconnects and to allow more accurate bump comparison for future reliability assessment.