Optimizing Reflow Profiling in Lead-free SMT Assembly

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Outline

- Reflow phases
- Max slope vs. ramp rate
- Factors affecting reflow process window
- Solder defects
- Conclusion

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Reflow Phases

- **Preheat**
  - Minimize thermal shock
  - Drive off volatiles
  - Ramp rate
- **Pre-reflow**
  - Flux activation/oxide removal
  - Void minimization
- **Reflow**
  - Intermetallic formation
  - Peak
  - TAL
- **Cooling**
  - Grain structure
  - Minimize CTE

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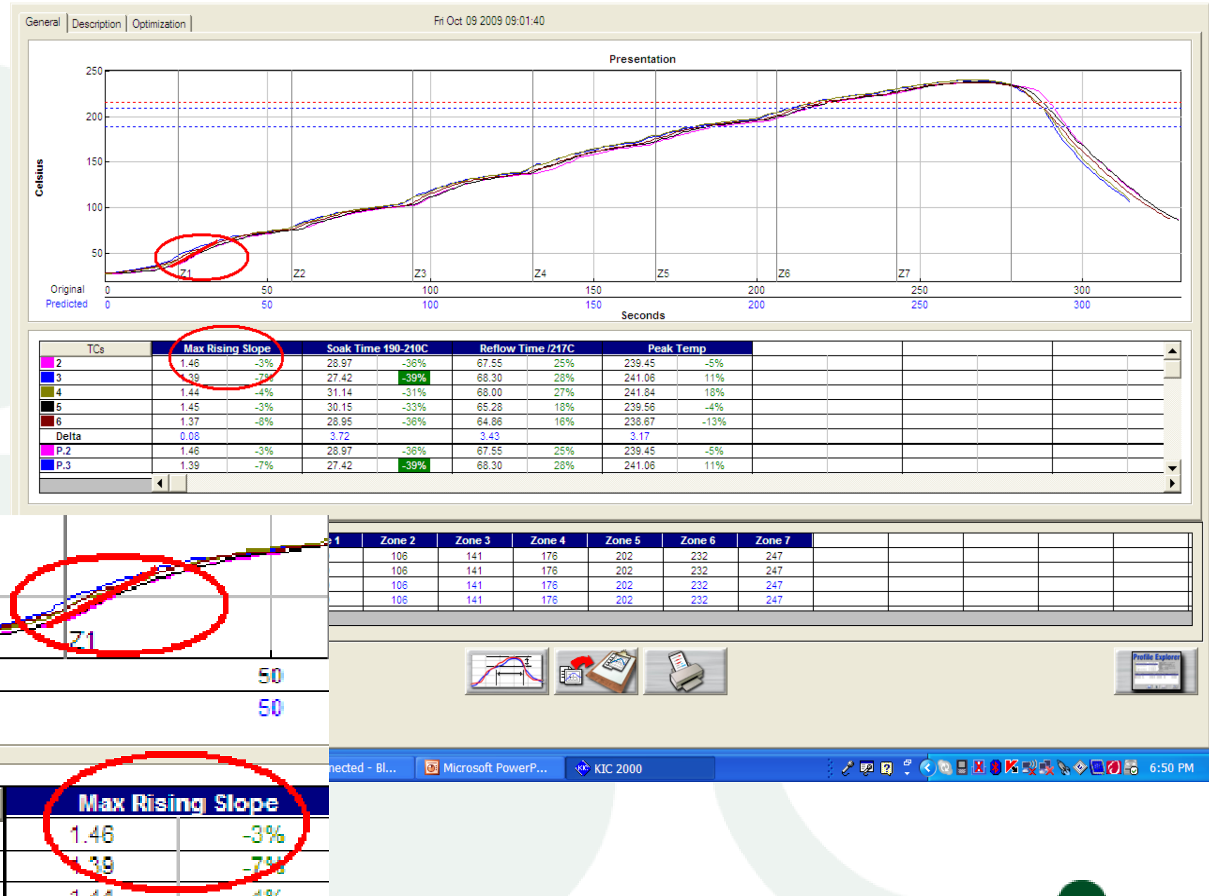
Preheat Ramp Rate

- **Max (+) Slope 1.46°C/s**
- **Ambient to peak 4min 40s (280s)**
- **1.46°C/s x 280s = 408.8°C increase from ambient to peak**
- **25°C (ambient) + 408.8°C = 433.8°C peak**



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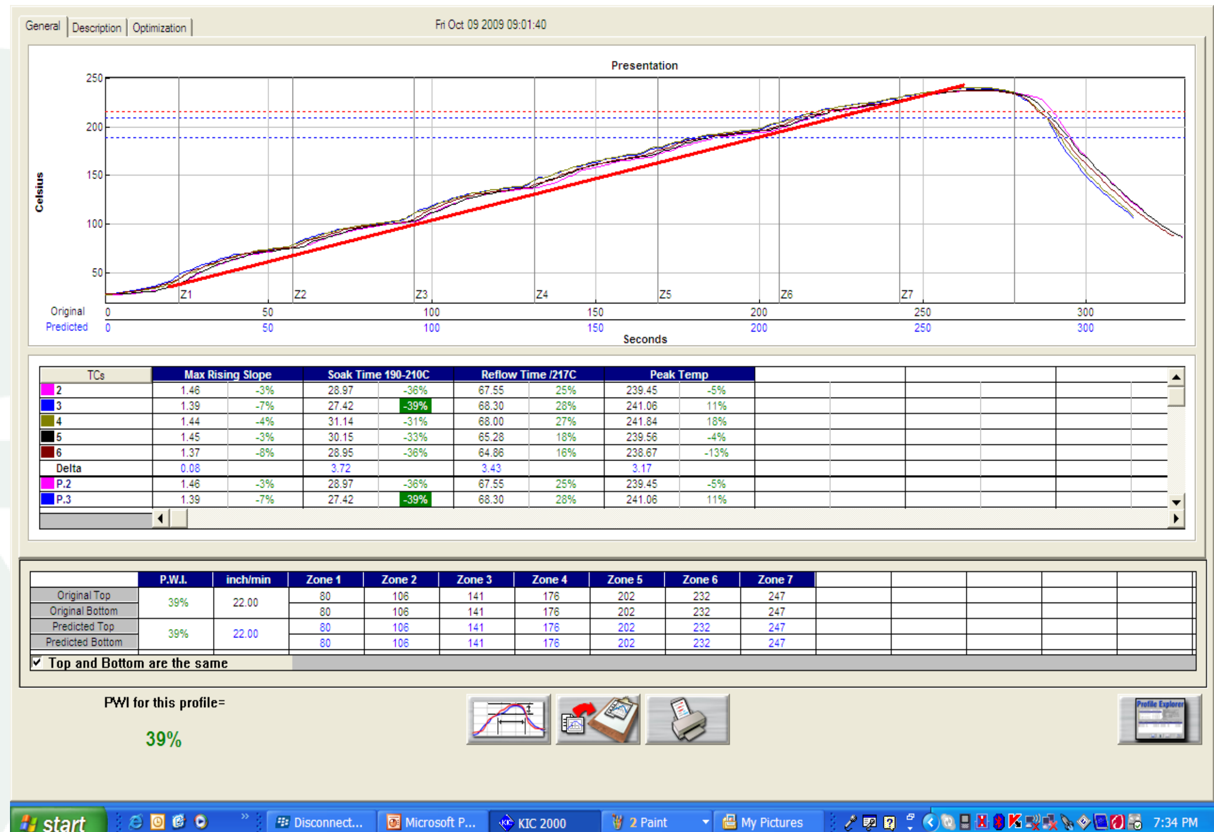
Preheat Ramp Rate

- True ramp rate or slope is from ambient to peak (RTP profile)
- Ramp rate considerations for soak profile
- Ramp rate = ΔTemp/ Δtime
- 214°C/280s = 0.76°C/s



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Factors Affecting Reflow Process Window

- **Water soluble vs. RMA/no-clean**
- **Powder type**
- **Board size**
- **Component density/diversity**

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Solder Defects

- Tombstoning
- Solder Balling/Beading
- Voiding
- Graping
- Head-in-Pillow (HIP)

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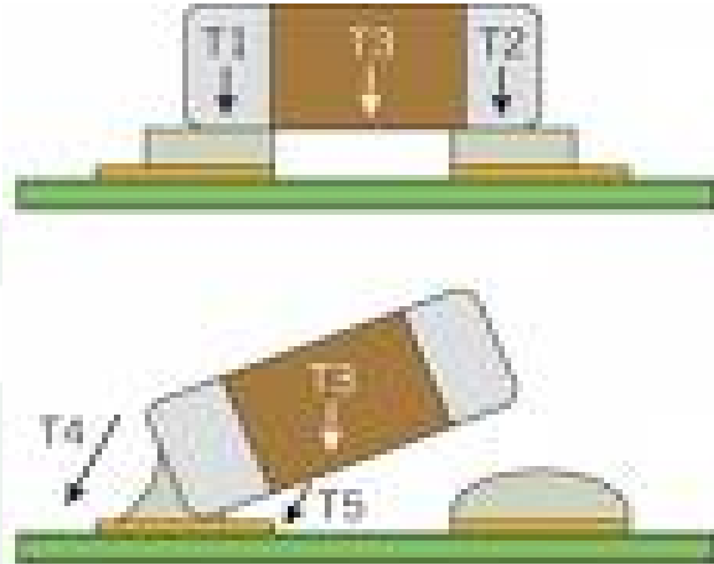
Tombstoning

- **Unbalanced wetting forces – leadless component**
  - Weight of chip
  - Surface tension under chip
  - Surface tension side of chip



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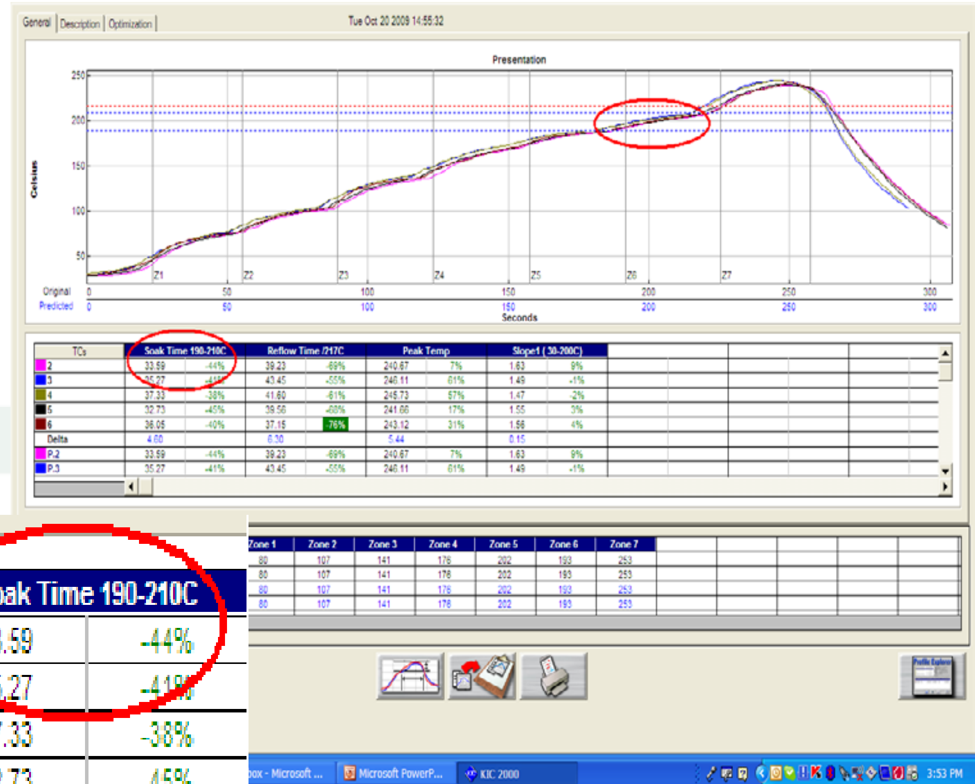
Tombstoning

- **Profile recommendations**
  - Minimize thermal gradient before reflow
    - Slow ramp rate (belt speed)
    - “Shoulder” soak
  - Effect of nitrogen



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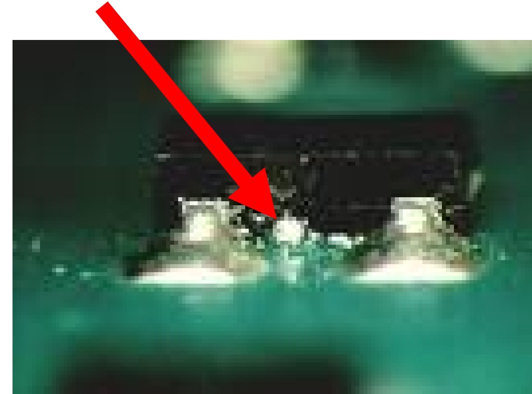
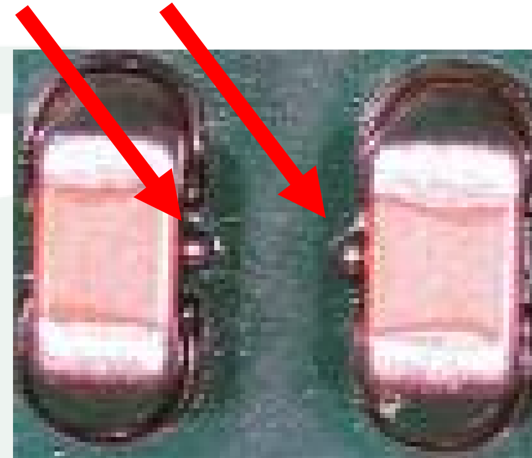
Solder Beading

- Isolated paste aggregates
- Low stand-off components
- Pad design





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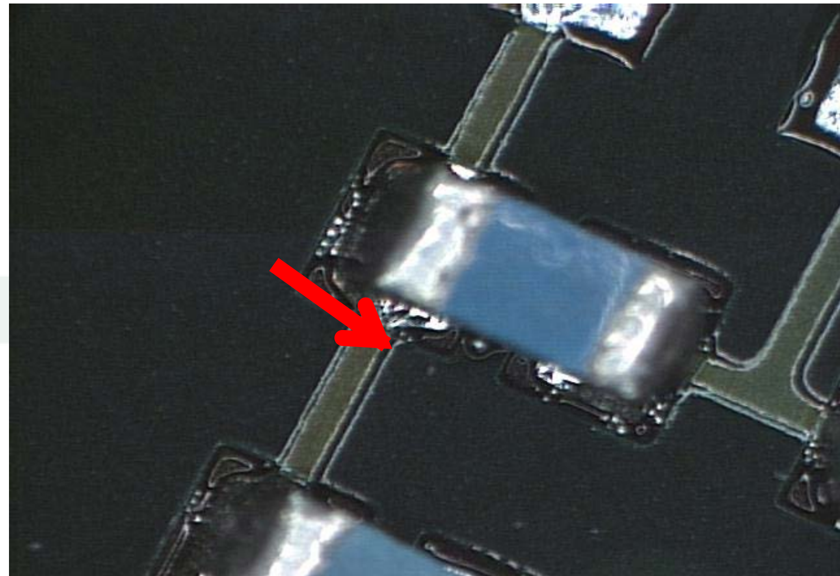
Solder Balling

- **Small particles isolated from solder joint**
  - Origin
  - Flux spattering
  - Flux slump
  - Solder mask
  - Oxidation



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Solder Beading/Balling

- **Profile recommendations**
  - Ramp to peak profile
  - Ramp rate (ambient to peak) 1-1.5C/s

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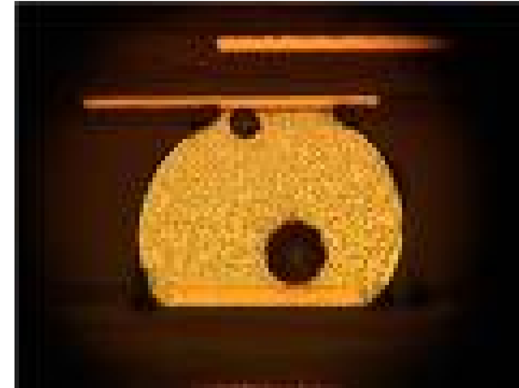
Voiding

- Components such as BGA, LGA, SGA, QFN, flip-chip
- Out-gassing entrapped flux
- Wetting
- Particle size/ powder type



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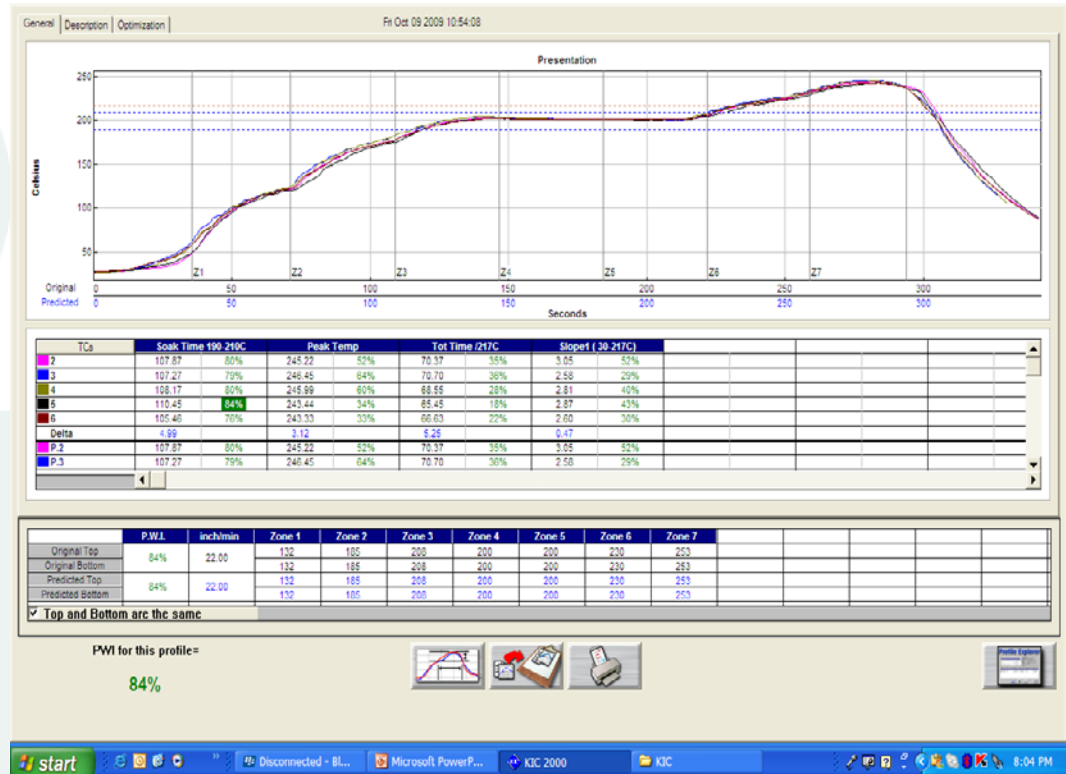
Voiding

- **Profile recommendations**
  - Raising peak temperature
  - Lowering peak temperature
  - Soak
  - Mixed alloy



TCs	Soak Time 190-210C		Peak Temp		Tot Time /217C		Slope1 (30-217C)	
2	107.87	80%	245.22	52%	70.37	35%	3.05	52%
3	107.27	79%	246.45	64%	70.70	36%	2.58	29%
4	108.17	80%	245.99	60%	68.55	28%	2.81	40%
5	110.45	84%	243.44	34%	65.45	18%	2.87	43%
6	105.46	76%	243.33	33%	66.63	22%	2.60	30%
Delta	4.99		3.12		5.25		0.47	
P.2	107.87	80%	245.22	52%	70.37	35%	3.05	52%
P.3	107.27	79%	246.45	64%	70.70	36%	2.58	29%

	P.W.I.	inch/min	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Original Top	84%	22.00	132	185	208	200	200	230	253
Original Bottom			132	185	208	200	200	230	253
Predicted Top	84%	22.00	132	185	208	200	200	230	253
Predicted Bottom			132	185	208	200	200	230	253

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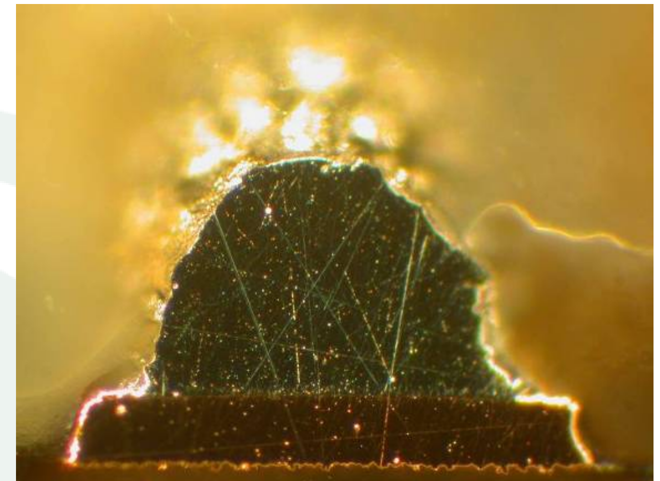
Graping

- Small print deposits translate to large surface-area-to flux ratio
- Fluxing capacity diminished
- Flux "run-away"
- Oxidized solder particles
- Mask defined vs. non-solder mask defined
- Resistors more prone than capacitors



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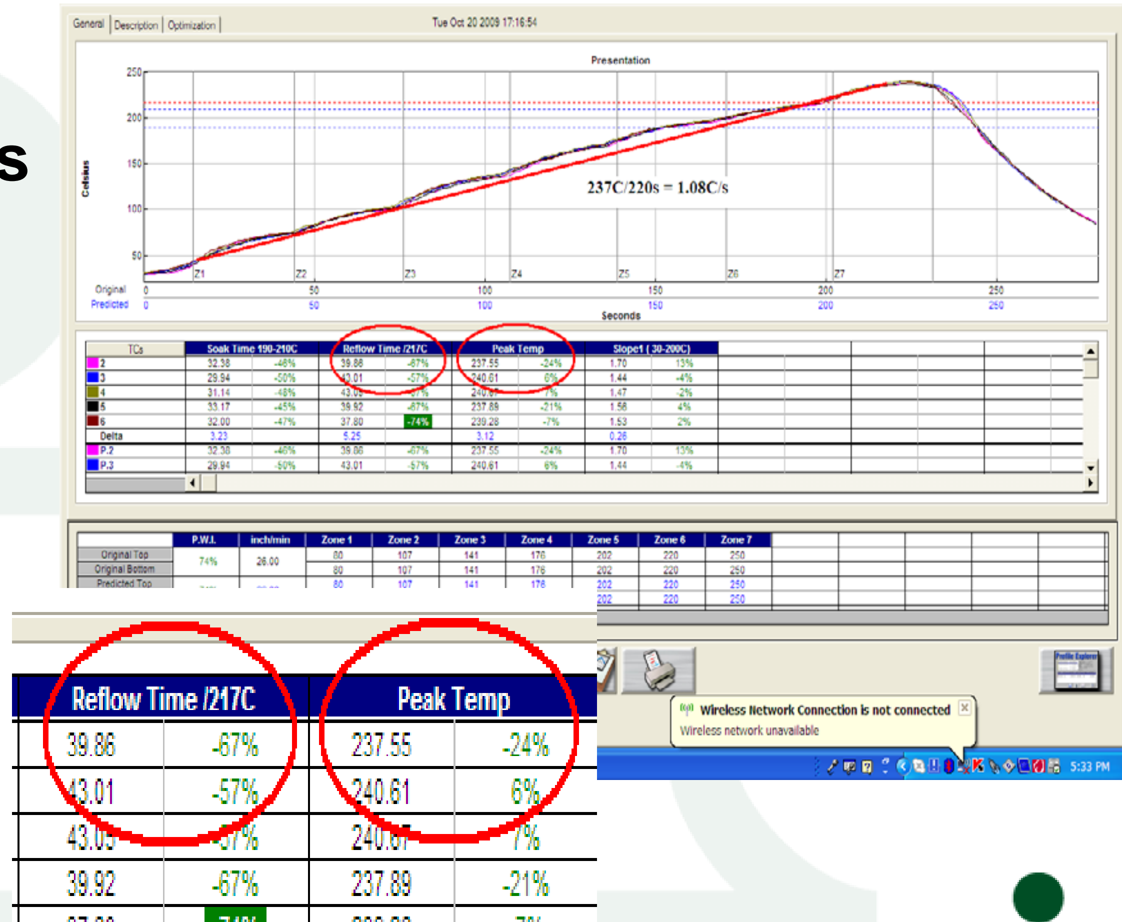
Graping

- **Profile recommendations**
  - Increase ramp rate (≥1°C/s)
  - Lower peak temperature
  - Shorter time above liquidus



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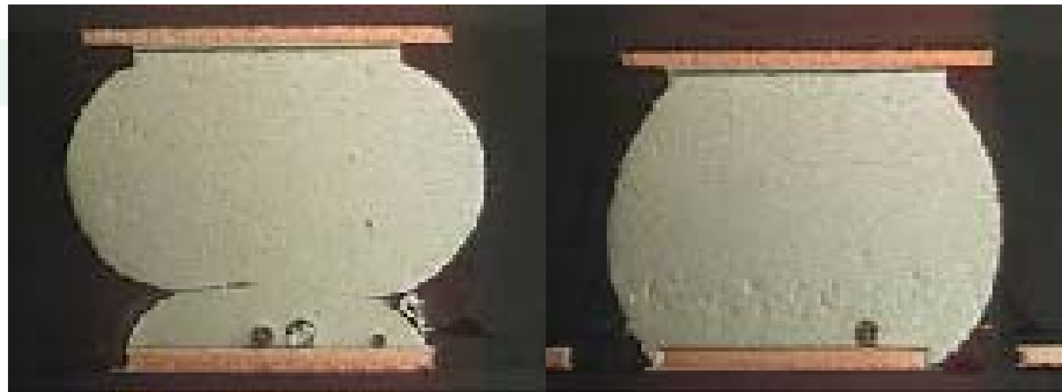
Head-in-Pillow

- Component warpage
- Co-planarity
- Poor transfer efficiency/registration
- Placement



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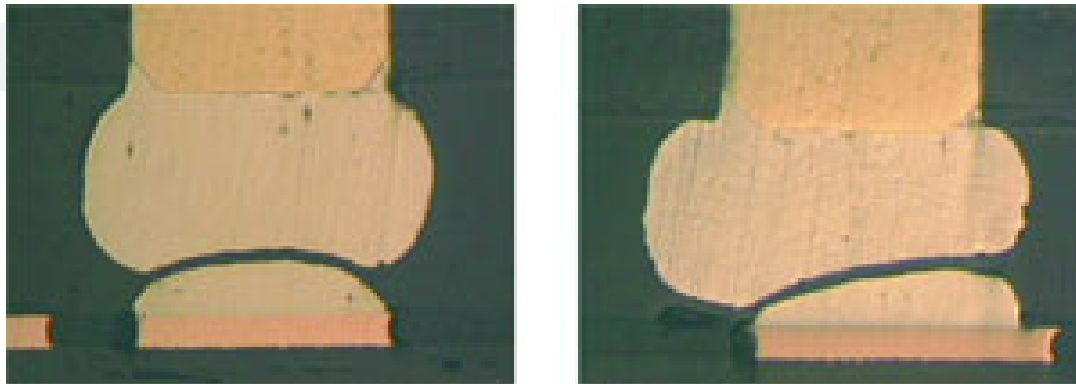
Head-in-Pillow

- Sphere oxidation
- Contaminants
- Flux exhaustion



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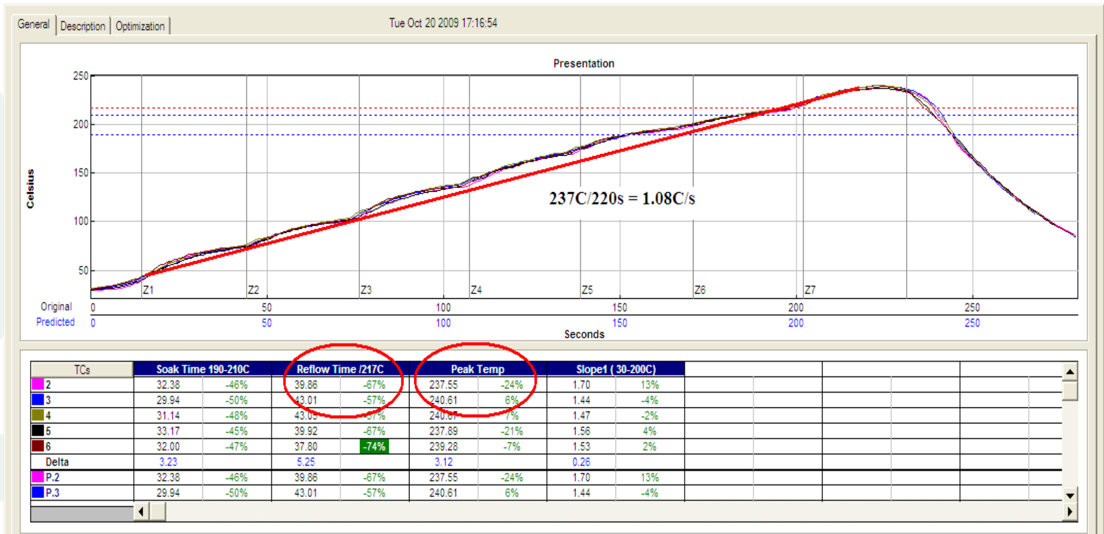
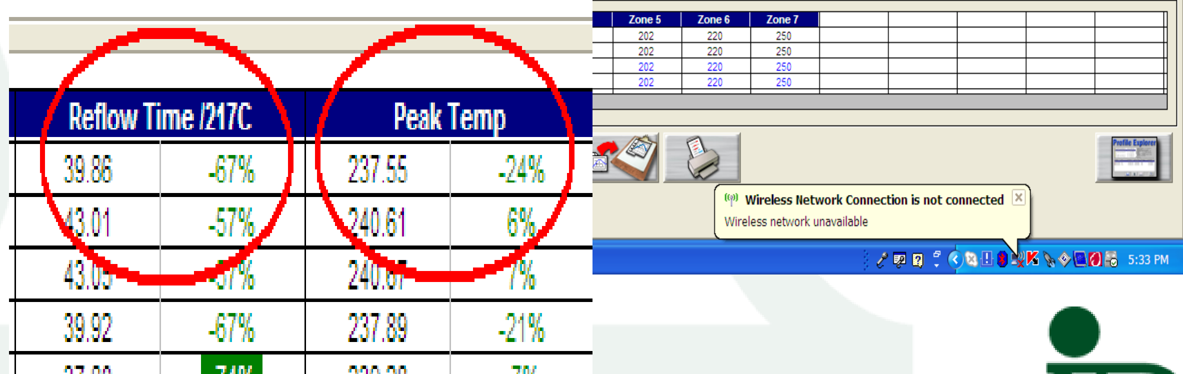
Head-in-Pillow

- **Avoid excessive heat exposure**
  - Total time in oven (increase ramp rate)
  - RTP vs. Soak
  - Lower peak temperature
  - Shorter TAL
  - Inert atmosphere





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Conclusion

- Lead-free challenges on solder paste
- Understanding reflow profile
- Optimizing the reflow process

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