

## • Artesyn's Approach to RoHS Compliance

- RoHS summary
- Project implementation strategy
- Process development status
- Reliability test plan
- Reliability test status and results
- RoHS content testing
- Supply chain status
- Issues
- Implementation roadmap



# What is RoHS? Restriction of Hazardous Substances

- RoHS legislation bans six substances from products destined for shipment to EU countries – effective July 1, 2006
  - Cadmium (Cd)
  - Hexavalent Chromium (Cr6+)
  - Mercury (Hg)
  - Lead (Pb)
  - Polybrominated biphenyl (PBB)
  - Polybrominated diphenyl ether (PBDE)
- *The law exempts the use of lead in solder, on high end storage and telecom equipment – but most customers intend to ship lead-free products in advance of the 2006 date*

# Implementation strategy

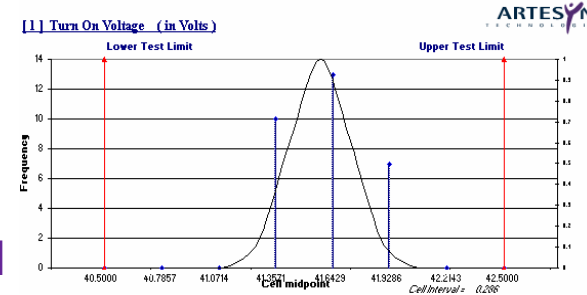
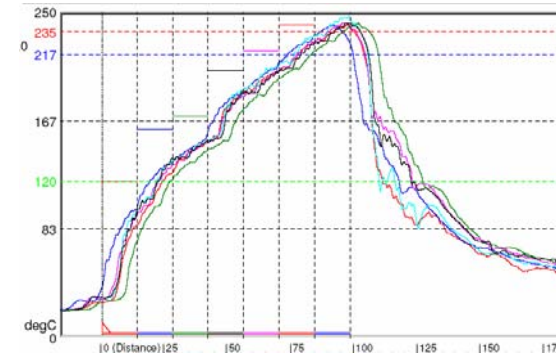


- Ensure backward/forward process compatibility
  - Components: Sn with Ni barrier or Ni-Pd-Au
  - Board: high T<sub>g</sub> laminate
  - Board finish: OSP
- Reliability testing incorporated into implementation plan
- Global control of solder paste, wave flux choice
- Early (and continuous) factory involvement
  - Process development
  - Process qualification
  - Equipment upgrades
  - Lead-free sample builds

**Minimize risk**

# Lead-free process development status

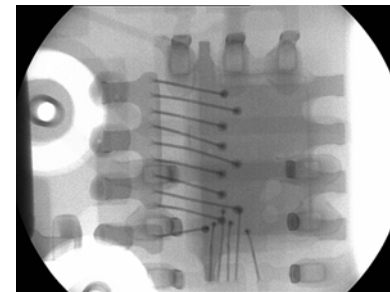
- SMT reflow
  - Processes developed in China & Hungary
  - SAC305 no-clean solder paste chosen
  - Customer evaluation samples built, 5 products
  - Average 245°C peak, 8°C  $\Delta T$
  - High temperature OSP coating performed well
  - Test yield, CpK high
- Wave solder
  - Process developed in China
  - SAC305 bar solder chosen
  - Factory standard no-clean flux
  - Little change to current production parameters
  - Customer evaluation samples built, 2 products
  - High temperature OSP PWB coating performed well
  - Test yield, CpK high



# Lead-free process development status – cont'd

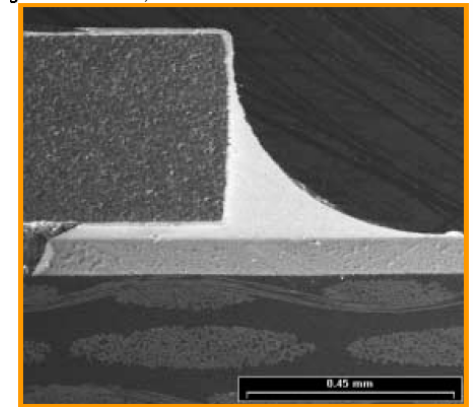
- Repair & rework
  - High temperature tip required in most cases
  - Hot plate needed for board-to-board & heatsink assembly
  - High flux content (3%) helpful

- Inspection
  - Void quantity and distribution similar
  - Wetting angles similar to SnPb
  - Surface appearance “frosty”



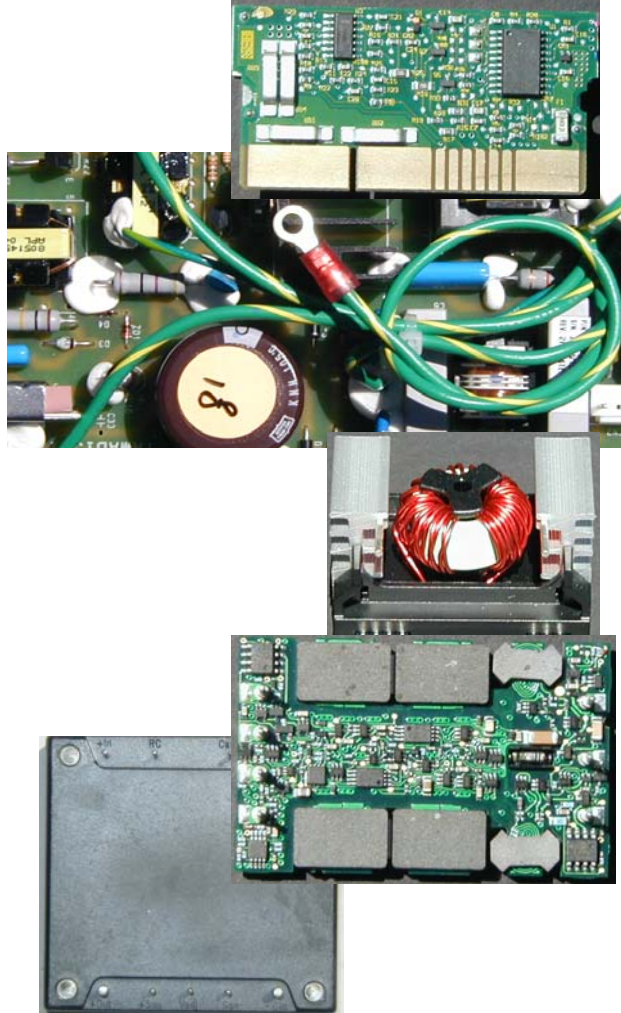
# Reliability test plan

- Product reliability testing as required by customer
  - Repeat initial product qualification (HALT) for lead-free samples
- Process reliability testing:
  - Samples of SnPb and lead-free tested side by side
  - 1000 cycles thermal shock
    - -10°C to 100°C, 30 minute dwell at each extreme
    - Acceleration factors unknown, but survival rates compared for SnPb and lead-free
  - HASS screening
    - Thermal cycles, -40°C to 125°C
    - Vibration at 5 GRMS, 10 GRMS, 20 GRMS
  - Repeat product functional test
  - Failure analysis
  - Cross sectioning & metallurgical analysis



# Reliability test status

cornerstone models



Zhongshan factory	
Processes represented	Status
Two-sided reflow followed by limited hand soldering for T0220 and heatsink, VRM style.	Thermal shock, HASS screening, final testing completed. Passed.
Through-hole, wave soldered single board power supply.	Thermal shock and HASS screening completed. Final test in progress.
Very high volume, simple SMT, mechanical assembly.	Lead-free samples built in late August.
Dense SMT assembly, chipscale packages, heavy copper PWB, core bonding.	Lead-free samples built in late August.
Fairly dense SMT assembly, T clad, two board potted assembly.	Lead-free samples built in late August.

# RoHS Compliance testing



- Proposed method for RoHS compliance verification
  - Product will be ground, aqua regia leached
  - Presence and concentration of Cd, Cr+6, Hg, Pb identified by ICP-AES or ICP-SFMS and reported as a percentage of product weight
  - Presence of PBB and PBDE identified by solvent extraction and measurement by GC-MS



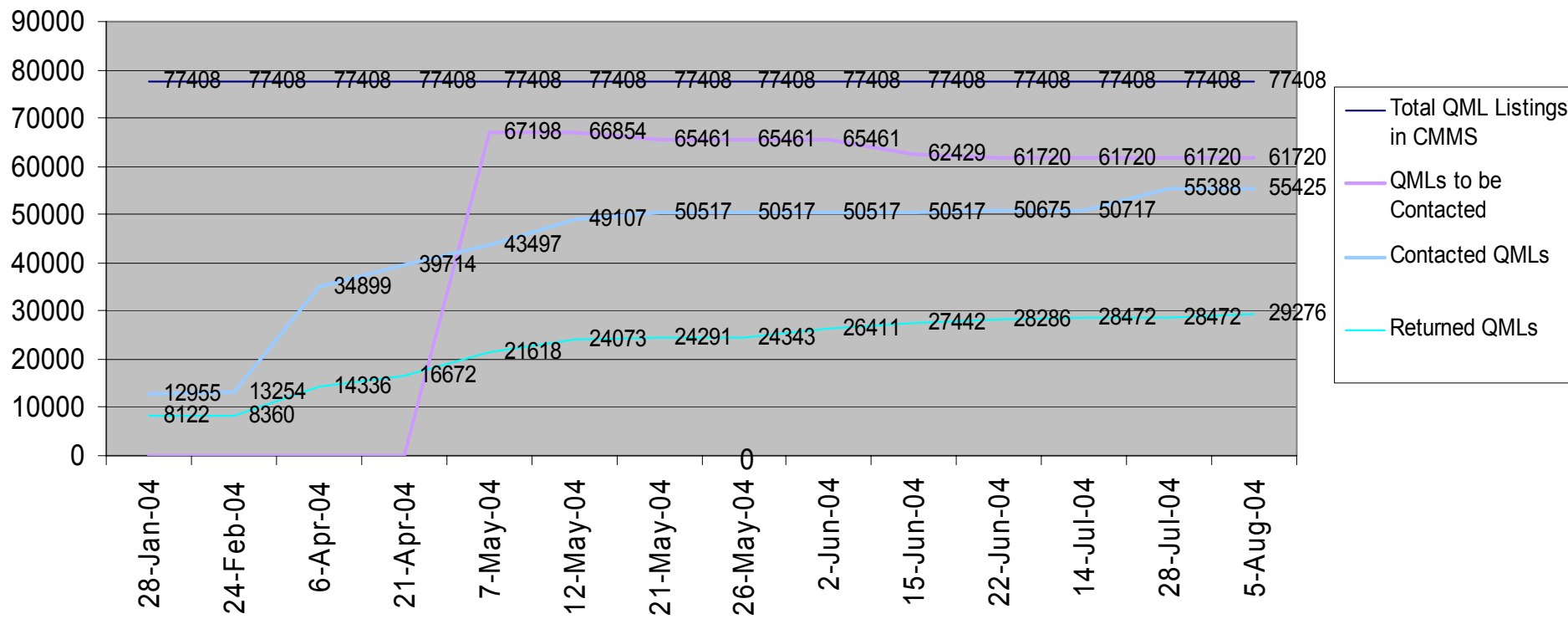
- *Valid only for RoHS-free definition “by product”*
- *RoHS-free “by homogenous material” will rely on vendor declarations*



# Supply Chain Status



Summary by Component



# Issues

- Control of supply chain
  - Purchasing from distribution
  - Ensure parts are RoHS-free at incoming
  - Inventory management – minimize scrap but ensure compliance
  - Poor response time & incomplete data from some suppliers
  - Continuous database updates

ARTESYN <sup>®</sup> TECHNOLOGIES													
RoHS Compliance Tracking Report													
General Information					Pb-, Hg-, Cr6+-, Cd-, PBB-, PBDE- free Development							When Pb, Hg, Cr6+, Cd, PBB, PBDE-free mass production	Tg fil (M Br g fl)
Component	Description	Vendor	Vendor Material	Pb-free Part Number	Component Pb-Free?	Component Hg-Free?	Component Cr6+-Free?	Component Cd-Free?	Component PBB-Free?	Component PBDE-Free?			
1070003	SIGDIO,SW,1,25A,75V,SOT23	ON SEMICONDUCTO	BAS16LT1	BAS16LT1G	Yes	Y	Y	Y	Y	Y	3/31/2004 12:0	matte	
1070003	SIGDIO,SW,1,25A,75V,SOT23	PHILIPS SEMICONDU	BAS16TRL		Yes	Yes	Yes	Yes	Yes	Yes	2003/Q3-Q4	Ni Pc	
1070005	PWRDIO,FR,1,2A,200V,SMB,I	ON SEMICONDUCTO	MURS120T3	MURS120T3G	Yes	Y	Y	Y	Y	Y	3/31/2004 12:0	matte	
1070006	PWRDIO,FR,1,2A,600V,SMB,I	ON SEMICONDUCTO	MURS160T3	MURS160T3G	Yes	Y	Y	Y	Y	Y	3/31/2004 12:0	matte	
1070103-0000	SIGDIO,HF,1,2A,75V,SOD323	ON SEMICONDUCTO	BAS16HT1	BAS16HT1G	Yes	Y	Y	Y	Y	Y	3/31/2004 12:0	matte	
1070103-0000	SIGDIO,HF,1,2A,75V,SOD323	PHILIPS SEMICONDU	BAS316		No	Yes	Yes	Yes	Yes	Yes	2003/Q3-Q4	Ni Pc	
1080267-0000	DI,SKY,2,2A,30V,SOT323,BA	PHILIPS SEMICONDU	BAT54Cw		Yes	Yes	Yes	Yes	Yes	Yes	2003/Q3-Q4	Ni Pc	
1080267-0000	DI,SKY,2,2A,30V,SOT323,BA	ST MICROELECTRON	BAT54CwFILM	same PN	No	Yes	Yes	Yes	Yes	Yes	tdb	Matt	
1100001-5.1	DI,ZEN,5.1V,5%,23W,SOT23,B	ON SEMICONDUCTO	BZX84C5VILT1	BZX84C5VILT	Yes	Y	Y	Y	Y	Y	3/31/2004 12:0	matte	
1100001-5.1	DI,ZEN,5.1V,5%,23W,SOT23,B	PHILIPS SEMICONDU	9331373 90215 - BZX84-C5V1		Yes	Yes	Yes	Yes	Yes	Yes	2003/Q3-Q4	Ni Pc	
1100001-5.1	DI,ZEN,5.1V,5%,23W,SOT23,B	ZETEX	BZX84C5VITA										

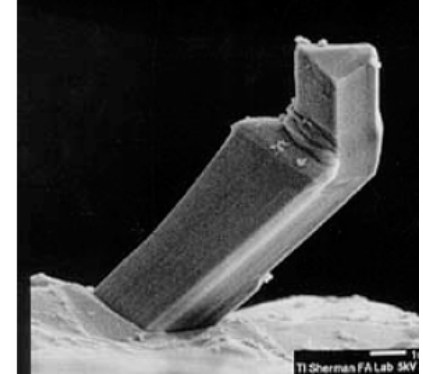
# Issues

- Control of supply chain - continued
  - Termination plating details required

General Information				Additional Information Required				
Component	Description	Vendor	Vendor Material	Type of finish (Matte, Bright, gold flash, others {specify})	For Matte Tin list annealing process	Type of metal the finish plating is over, i.e. Cu or Ni	Thickness of the Ni barrier	Ratio of materials used (%): Pd vs Ni: Sn vs Bi: Sn vs Ag
1070003	SIGDIO,SW,1,,25A,75V,SOT23,BA	ON SEMICONDUCTOR	BAS16LT1	matte	* 150 degree C Anneal currently	N/A		100% tin
1070003	SIGDIO,SW,1,,25A,75V,SOT23,BA	PHILIPS SEMICONDUCTOR	BAS16TRL	Ni Pd Au				
1070005	PWRDIO,FR,1,2A,200V,SMB,MUR	ON SEMICONDUCTOR	MURS120T3	matte	* 150 degree C Anneal currently	N/A		100% tin
1070006	PWRDIO,FR,1,2A,600V,SMB,MUR	ON SEMICONDUCTOR	MURS160T3	matte	* 150 degree C Anneal currently	N/A		100% tin
1070103-0000	SIGDIO,HF,1,,2A,75V,SOD323,BA	ON SEMICONDUCTOR	BAS16HT1	matte	* 150 degree C Anneal currently	N/A		100% tin
1070103-0000	SIGDIO,HF,1,,2A,75V,SOD323,BA	PHILIPS SEMICONDUCTOR	BAS316	Ni Pd Au				
1080267-0000	DI,SKY,2,,2A,30V,SOT323,BAT54	PHILIPS SEMICONDUCTOR	BAT54CW	Ni Pd Au				
1080267-0000	DI,SKY,2,,2A,30V,SOT323,BAT54	ST MICROELECTRONICS	BAT54CWFILM	Matte	1 hr 150°C back	Cu	NA	NA
1100001-5.1	DI,ZEN,5.1V,5%,,23W,SOT23,BZX	ON SEMICONDUCTOR	BZX84C5V1LT1	matte	* 150 degree C Anneal currently	N/A		100% tin
1100001-5.1	DI,ZEN,5.1V,5%,,23W,SOT23,BZX	PHILIPS SEMICONDUCTOR	9331 373 90215 - BZX84-	Ni Pd Au				
1100001-5.1	DI,ZEN,5.1V,5%,,23W,SOT23,BZX	ZETEX	BZX84C5V1TA					
1100253-0015	DI,ZEN,15V,5%,,2W,SOD323,15V	ON SEMICONDUCTOR	MM3Z15VT1	matte	* 150 degree C Anneal currently	N/A		100% tin
1100253-0015	DI,ZEN,15V,5%,,2W,SOD323,15V	PHILIPS SEMICONDUCTOR	PDZ15B					
1100253-0015	DI,ZEN,15V,5%,,2W,SOD323,15V	ROHM	UDZTE-1715B	Sn3Ag0.5Cu		Alloy 42		
1300001	XSTR,NPN,SM SIG,40V,,2A,SOT2	FAIRCHILD SEMICONDUCTOR	MMBT3904					

# Issues

- Tin whiskers
  - Assembly level testing not practical
  - Sufficient test data available from suppliers?
- Moisture sensitive level (MSL)
  - Expected to increase with Jedec-Std-020C
  - SMT board mounted power
    - What testing is valid for moisture sensitivity of PWB based assemblies?
- Substance reporting requirements vary
  - Compliance reporting criteria do not exist
  - Historic, current and anticipated substance bans bundled into confusing reporting requirements
  - RoHS bans six substances, reporting on >fifty sometimes required



# Roadmap

