July 1, 2013

Subject: Characterization Summary – Copper Bond Wire at ASE Taiwan

SUMMARY

Per PCN# 03A-13, Lattice is now offering alternate qualified material sets that support Copper bond wire (Cu-wire). This document will summarize the electrical characterization that supports that conversion.

The scope of this document covers products manufactured at ASE Kaohsiung, Taiwan (ASET).

METHODOLOGY

The characterization plan focused on four items:

1) Assembly Yield and Electrical Test Yield
2) Assessment of Critical Parameters
3) SSO (Simultaneous Switching Output) Characteristics
4) SERDES performance (ECP3-150 only)

Product/Package combinations were chosen to represent a cross-section of the BOM (Bill of Material) changes specified in the PCN. The product/packages and the critical BOM components are:

Product/Pkg	ASEM Copper (Control)			ASET Copper (New)		
	Mold Compound	Wire/ Diameter	Die Attach	Mold Compound	Wire/ Diameter	Die Attach
LFE3-150EA/ 1156fpBGA	EMEG750SE	0.8mil Pd Coated Cu	ABLEBOND 2100A	CEL-9750ZHF10A KL-U	0.8mil Pd Coated Cu	ABLEBOND 2100A
LFXP2-17E/ 256ftBGA	EMEG750SE	0.8mil Pd Coated Cu	ABLEBOND 2100A	KE-G1250LKDS	0.8mil Pd Coated Cu	ABLEBOND 2100A
LFXP2-5E/ 144TQFP	EMEG700Y	0.8mil Pure Cu	Yizbond 8143	EME-G631H	0.8mil Pd Coated Cu	CRM-1076WA

Multiple lots of in various product/package combinations were built as part of the qualification process for the ASET Copper BOM. Samples from the qual lots were characterized and compared to comparable lots processed with the released ASE Malaysia (ASEM) Copper BOM.

ASSEMBLY/ELECTRICAL TEST YIELDS

The first step in the characterization process is an analysis of process yields. Yield information is critical to gauge the manufacturability of a new package. As Lattice considers yield information proprietary, the yield information below is normalized with respect to the control material, which in this case is the existing ASEM Copper wire BOM.

	Assembly Yield		Electrical Yield	
	ASEM Copper (control)	**ASET Copper**	**ASEM Copper (control)**	**ASET Copper**
ASET Copper Lot Qty= 711	1.0	1.01	1.0	0.99

LFE3-150EA 1156fpBGA Yield Summary

	Assembly Yield		Electrical Yield	
	ASEM Copper (control)	**ASET Copper**	**ASEM Copper (control)**	**ASET Copper**
ASET Copper Lot Qty= 1100	1.0	1.01	1.0	1.0

LFXP2-17E 256ftBGA Yield Summary

	Assembly Yield		Electrical Yield	
	ASEM Copper (control)	**ASET Copper**	**ASEM Copper (control)**	**ASET Copper**
ASET Copper Lot Qty= 1448	1.0	1.01	1.0	1.01

LFXP2-5E 144TQFP Yield Summary

There are no discernable differences in either assembly yield or electrical final test yields between ASEM and ASET copper assembly processes.

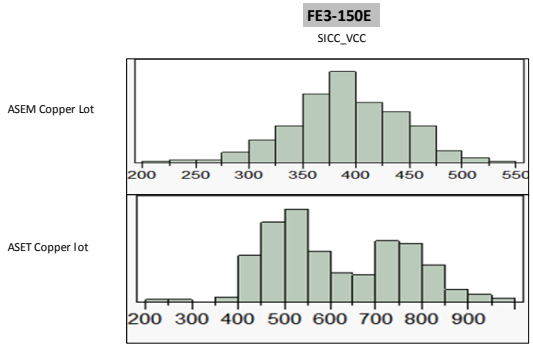
CRITICAL PARAMETERS

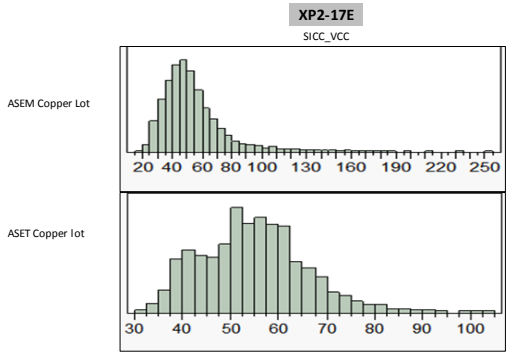
For the purposes of this characterization, critical parameters are defined as speed, power and leakage. Samples of the qualification lots from ASET were tested at the same time as comparative product from ASEM. The tabulated statistics, Cpk values and histograms of the actual distributions are shown below.

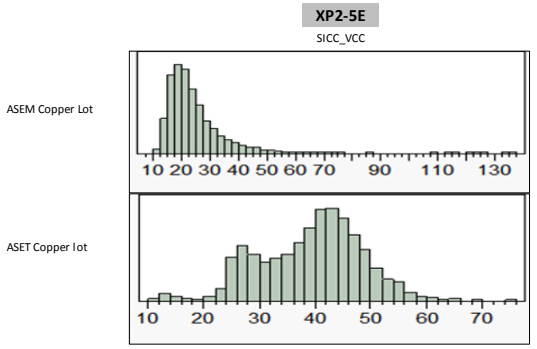
All of the critical parameters are from the device datasheet except for Tpdcounter. Tpdcounter is a Built-in Self Test (BIST) routine that is correlated to datasheet parameters. Higher counts equate to faster devices.

Note that there is no significant change in the Cpk values between the various BOMs, which indicates that there is no significant parametric difference between ASEM and ASET copper bond wire.

		Icc(mA)				
		N	Mean	Std	Spec	Cpk
LFE3-150EA	ASET Copper lot	704	391.73	49.04	2693	2.7
	ASEM Copper lot (control)	590	612.7	140.6	2693	1.5
LFXP2-17E	ASET Copper lot	1083	54.75	11.01	395	1.66
	ASEM Copper lot (control)	7349	53.1	20.71	395	0.9
LFXP2-5E	ASET Copper lot	1921	39.3	8.93	172	1.5
	ASEM Copper lot (control)	28435	23.5	8.08	172	1

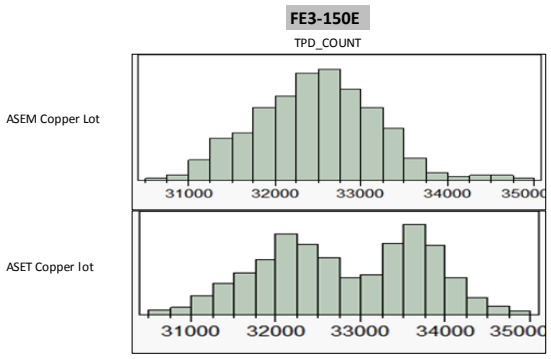


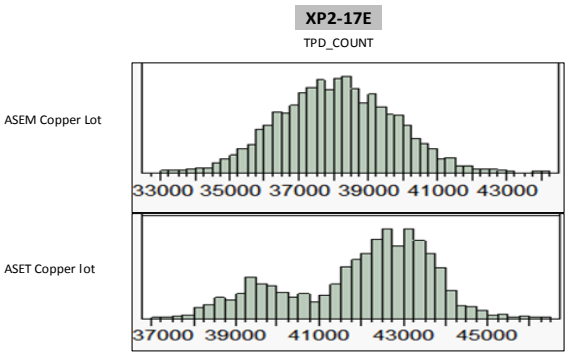


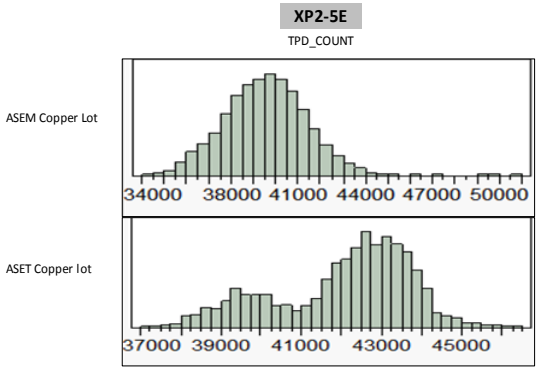


		TPDcount(counts)				
		N	Mean	Std	Spec	Cpk
LFE3-150EA	ASET Copper lot	704	32479	687.8	26561	2.868
	ASEM Copper lot (control)	590	32817	913.9	26561	2.282
LFXP2-17E	ASET Copper lot	1083	39037.61	1446.19	32000	1.622
	ASEM Copper lot (control)	7349	38086.52	1588.47	32000	1.277
LFXP2-5E	ASET Copper lot	1921	41980.36	1659.5	32000	2
	ASEM Copper lot (control)	28435	39530.12	1731.77	32000	1.45

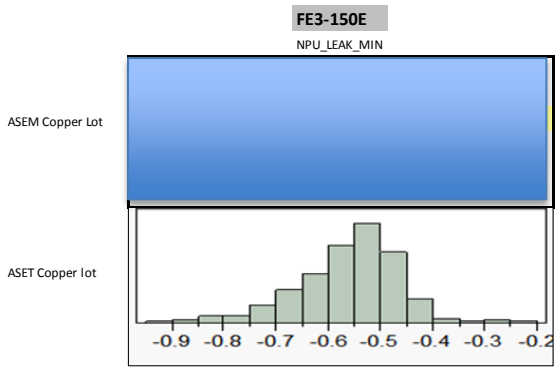
**Slowest speed grade*

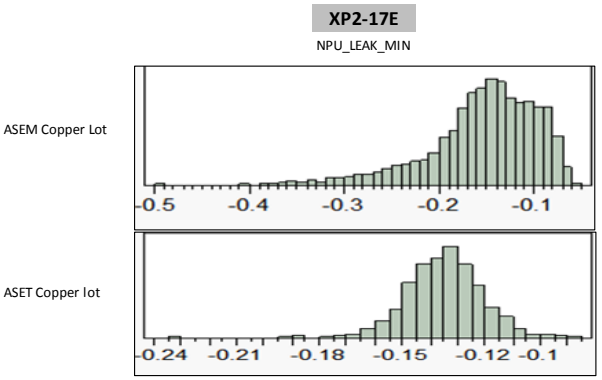


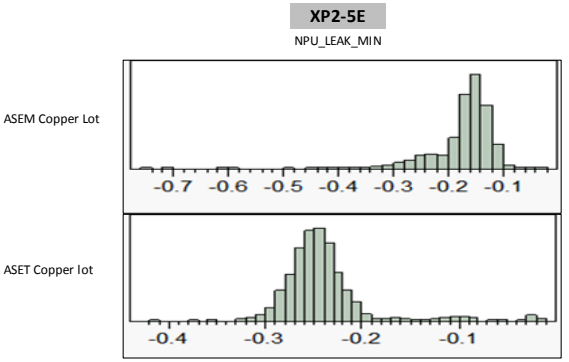




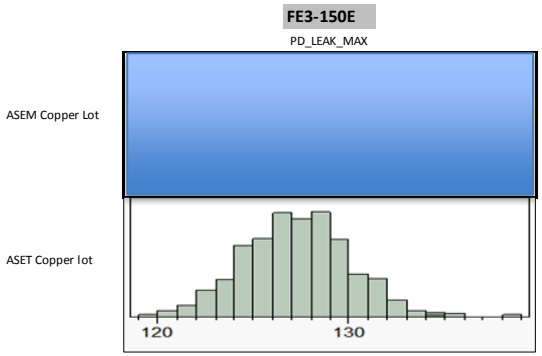
		IO Leakage(uA)				
		N	Mean	Std	Spec	Cpk
LFE3-150EA	ASET Copper lot	704	-0.56	0.092	10	7.025
	ASEM Copper lot (control)					
LFXP2-17E	ASET Copper lot	1083	-0.14	0.01	10	195.8
	ASEM Copper lot (control)	7349	-0.15	0.06	10	47.4
LFXP2-5E	ASET Copper lot	1921	-0.24	0.04	10	62.2
	ASEM Copper lot (control)	28435	-0.17	0.04	10	60.4

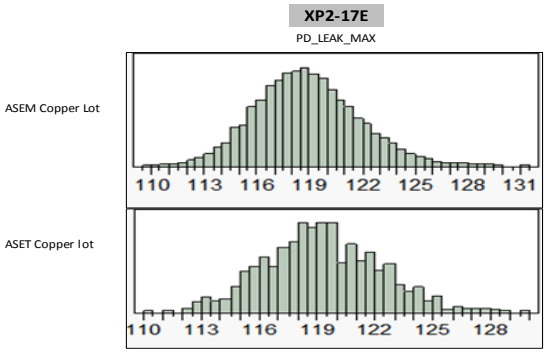


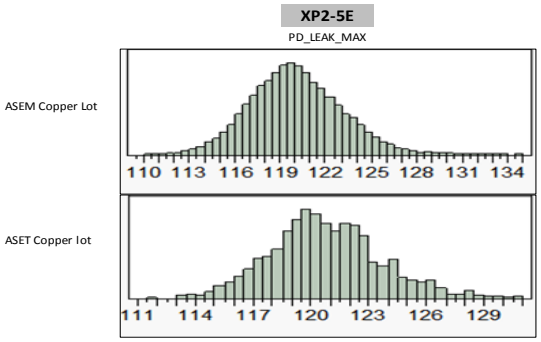




		PullDown Leakage(uA)				
		N	Mean	Std	Spec	Cpk
LFE3-150EA	ASET Copper lot	704	127.26	2.68	210	10.3
	ASEM Copper lot (control)					
LFXP2-17E	ASET Copper lot	1083	119.2	2.96	210	9.7
	ASEM Copper lot (control)	7349	118.82	2.88	210	10
LFXP2-5E	ASET Copper lot	1921	120.7	2.8	210	10
	ASEM Copper lot (control)	28435	120	2.9	210	9.65







SIMULTANEOUS OUTPUT SWITCHING PERFORMANCE

To qualify a copper wire bond for the second source assembly site, it is important to quantify the Simultaneous Switching Output (SSO) performance. This characteristic is also referred to as Ground Bounce although it can affect both power and ground supply rails.

Different assembly site may have different process or tooling which can affect SSO performance. Since copper build in ASE Malaysia and ASE Taiwan have the same bond wire geometry (length and diameter), SSO results are expected to be comparable. A delta greater than 10% is considered significant.

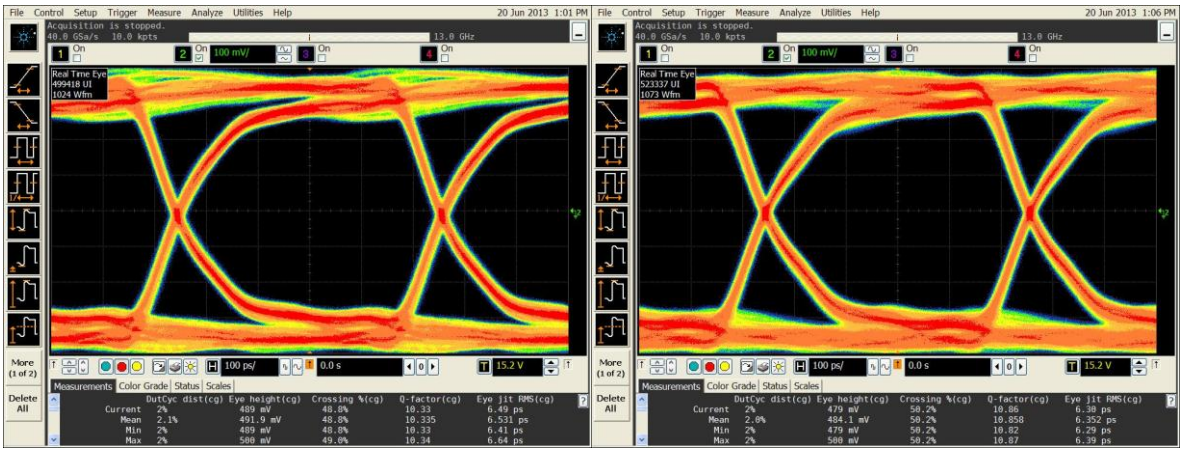
Device-Pkg	# Output Switching	Wire	Ground Bounce		Supply Bounce	
			Overshoot	Undershoot	Overshoot	Undershoot
		mil	mV	mV	V	V
LFE3-150EA/ 1156fpBGA	60	0.8Cu(ASEM)	39.12	-28.88	1.932	1.576
	60	0.8Cu(ASET)	39.6	-31.28	1.94	1.58
	Delta		-0.48	2.4	-0.008	-0.004
	% Delta		-1.23%	-8.31%	-0.41%	-0.25%
LFXP2-17E/ 256ftBGA	10	0.8Cu(ASEM)	25.92	-31.04	0.039	-0.022
	10	0.8Cu(ASET)	24.32	-33.44	0.041	-0.023
	Delta		1.6	2.4	-0.002	0.0005
	% Delta		6.17%	-7.73%	-4.91%	-2.15%
LFXP2-5E/ 144TQFP	18	0.8Cu(ASEM)	290	-190	1.812	0.94
	18	0.8Cu(ASET)	272	-176	1.772	0.936
	Delta		18	-14	0.04	0.004
	% Delta		6.21%	7.37%	2.21%	0.43%

SERDES PERFORMANCE

Similar to SSO performance, increased inductance due to reduced wire diameter could affect high-speed operation. The LFE3-150EA was chosen as a characterization vehicle so that SERDES performance could be quantified.

Three units of LFE3-150EA were programmed with a BIST pattern that generates a PN7 pattern that was then transmitted over the SERDES channel. Eye diagrams and jitter measurements were collected at nominal temperature and voltage to compare relative performance.

LFE3-150EA 1156fpBGA Eye Diagrams (3.126Gbps)



ASEM ASET

	DutyCycle Distortion (%)	Eye Height (mV)	Crossing(%)	Qfactor	RMS Eye Jitter (ps)
ASEM	2.30	478.8	49.1	10.4	7.10
ASEK	2.27	483.6	49.3	10.9	7.11

SERDES Jitter Statistics

As can be seen by the eye diagrams above, SERDES performance has not been measurably affected by the BOM change.

SUMMARY

There are no significant electrical performance issues related to the addition of the alternate qualified material from ASET.