

i3 Microsystems Inc.

Heterogeneous System-In-Package (HSIP) Technology

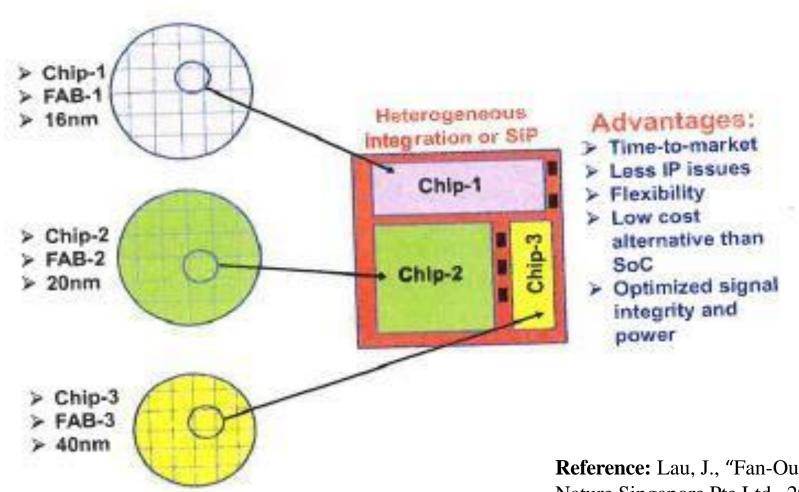
Charles Woychik, Robert Mundella, Keith Kunard, Victor Vilar, Justin Borski and Robert Nead i3 Microsystems, Inc. 9900 16th Street North St. Petersburg, FL 33716

Outline

Introduction

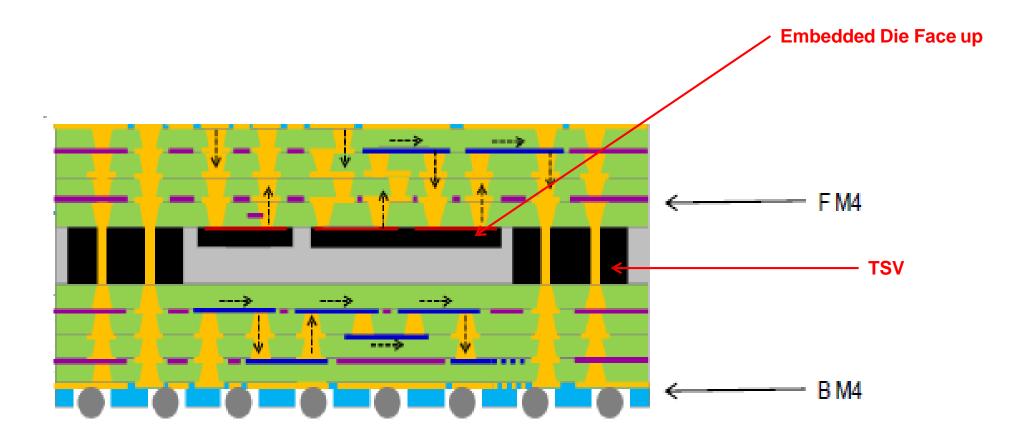
- Test Vehicle Design
- HSIP Module Build
- Results
- Conclusions
- Acknowledgements

HSIP Integration Approach



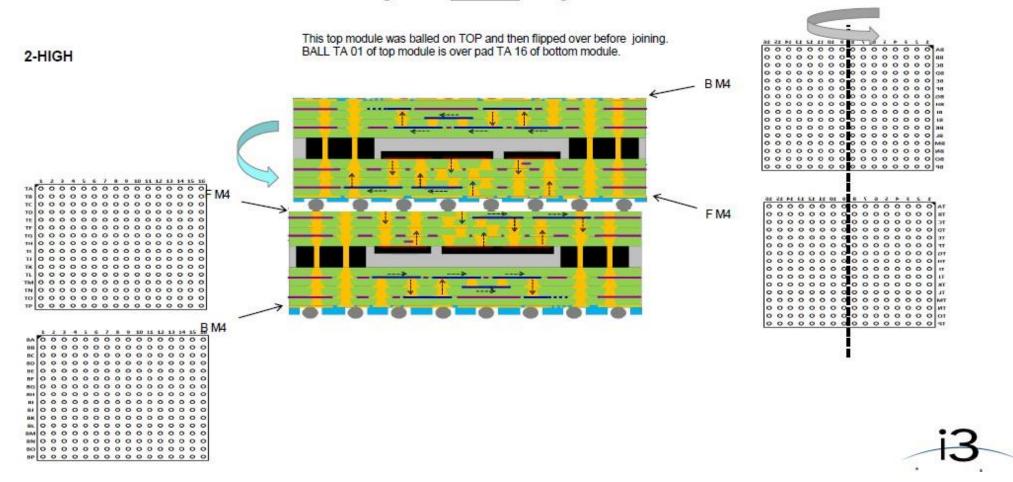
Reference: Lau, J., "Fan-Out Wafer-Level Packaging," Springer Nature Singapore Pte Ltd., 2018. Chapter 11, pp. 269-303.

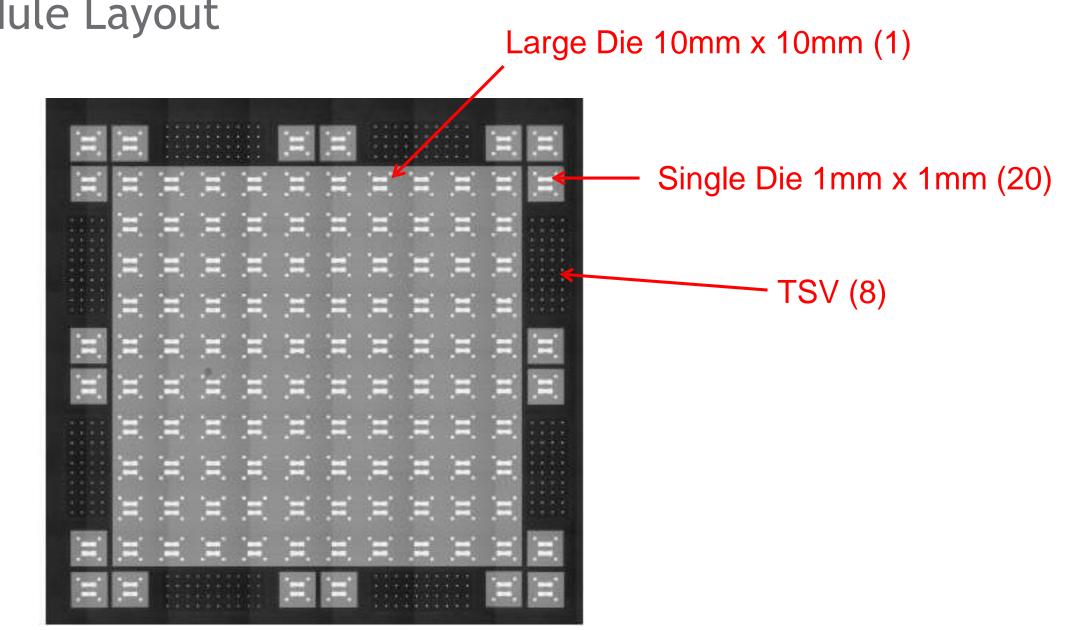
Test Vehicle Design - Single Slice



Test Vehicle Design - Double Slice

Need Fiducials and POD Notes to cover 1 high AND 2-HIGH configurations

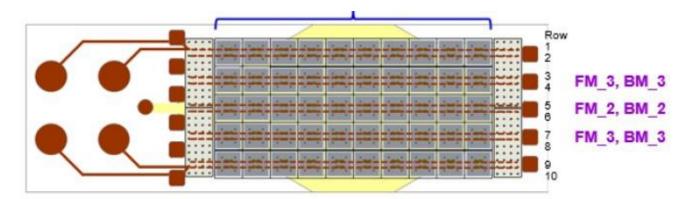




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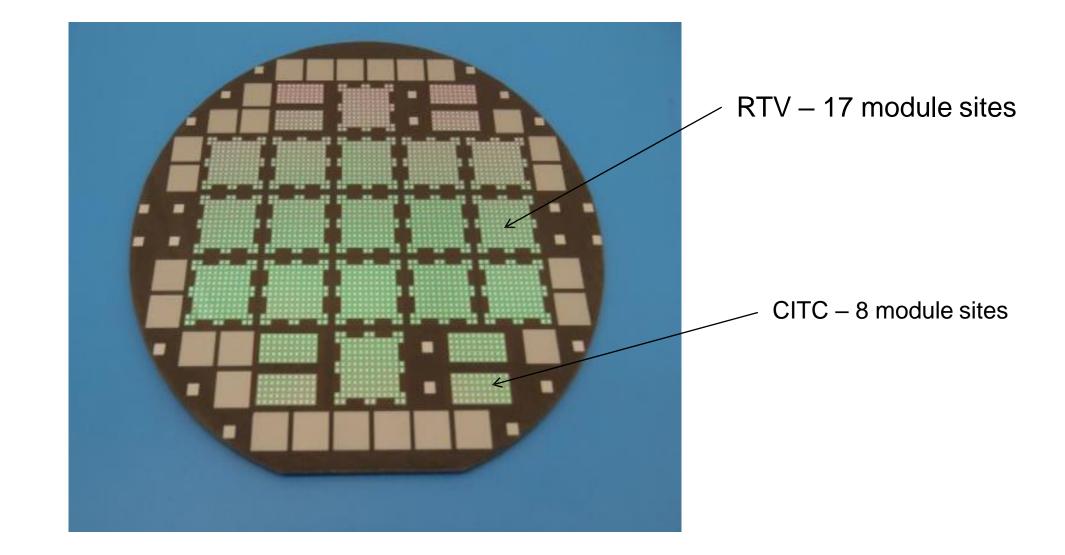
RTV Molded Module Layout

CITC Module Layout



Rows	TOP/Front		BOT/Back	
1, 2, 9, and 10	Chip Side Via stitch 4 high vias like TV Net PP4-4-4		Non chip side via stitch 3 high vias like TV Net PP15-6-3	
3, 4, 7, and 8 FM_3 BM_3	Chip Side Via stitch 3 high vias like TV Net PP3-4-3		Non chip side via stitch 2 high vias like TV Net PP14-6-2	
5 and 6 FM_2 BM_2	Chip Side Via stitch 2 high vias like TV Net PP2-4-2	< < ↑	Non chip side via stitch 1 high vias like TV Net PP13-6-1	···>

Embedded Core Layout



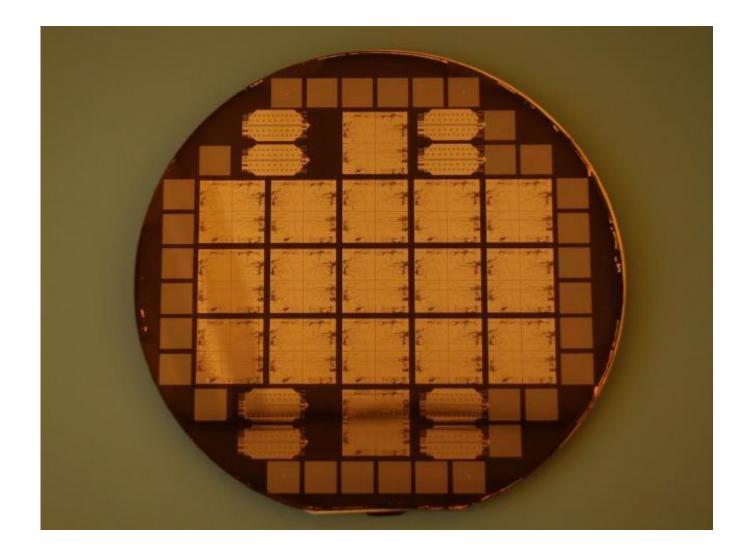
Processing Conditions

RTV-03 low cure temperatures and long bake times

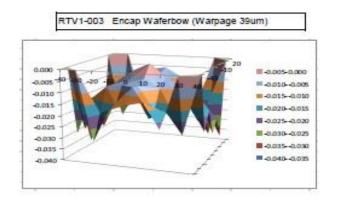
RTV-04 higher cure temperatures and shorter bake times

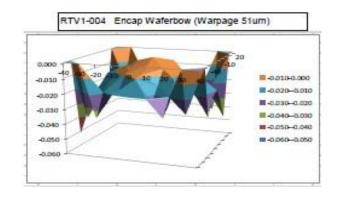
RTV-05 higher cure temperatures and shorter bake times on a new equipment set

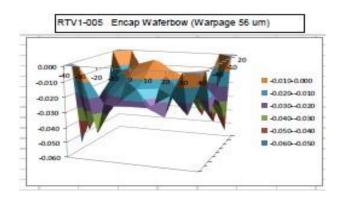
Wafer with Backside Buildup Layer (BL1)



Warpage of the Reconstituted Wafer

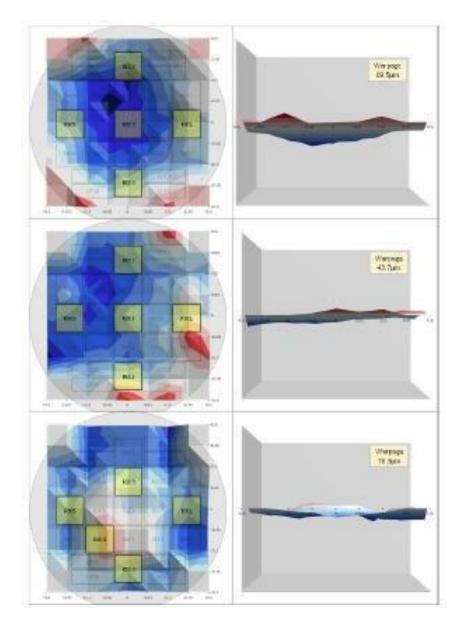






©2020 i3 Microsystems, Inc. Presented at IMAPS 2020 Warpage for RTV-03 is 38.5umWarpage for RTV-04 is 51.4umWarpage for RTV-05 is 56.9um

Warpage after Completion of Entire Buildup Layers

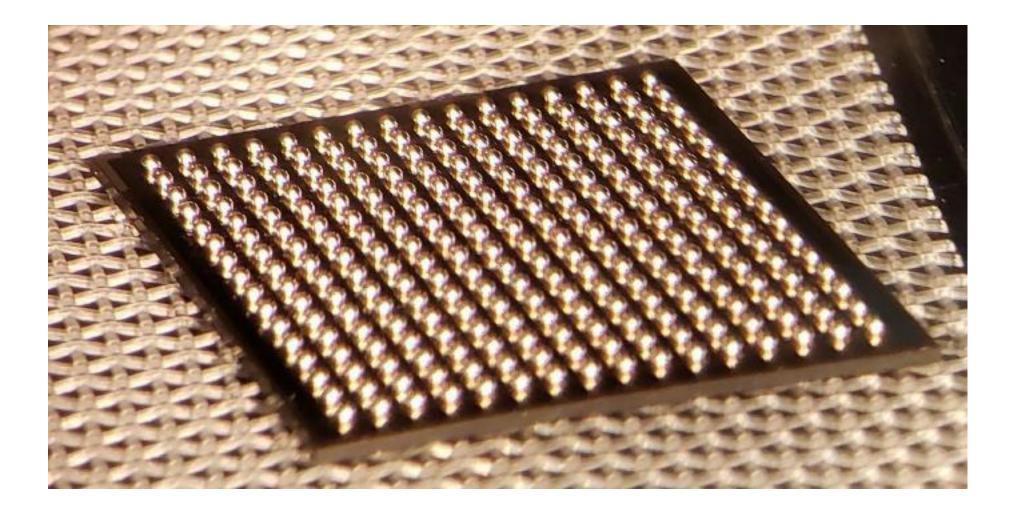


Warpage for RTV-03 is 89.5um
Warpage for RTV-04 is 43.7um
Warpage for RTV-05 is 70.9um

Warpage Measurement of Individual Modules

Fina		1-003 dule B	low	Fina			Bow	RTV1 al Moo		Bow
	R1C3	-0.4			R1C3	7.3		R2C3	7.0	
	R3C5	-2.2			R3C5	-8.9		R3C5	2.8	
	R3C3	-3.8			R3C3	-8.8		R4C4	3.1	
	R3C1	-1.7			R3C1	3.4		R3C1	2.9	
	R5C3	1.1			R5C3	7.5		R5C3	11.4	
	Avg	-1.40			Avg	0.10		Avg	5.44	
	Min	-3.8			Min	-8.9		Min	2.8	
	Max	1.1			Max	7.5		Max	11.4	
			1				1			1

BGA Attach



Resistance Measurements of Modules

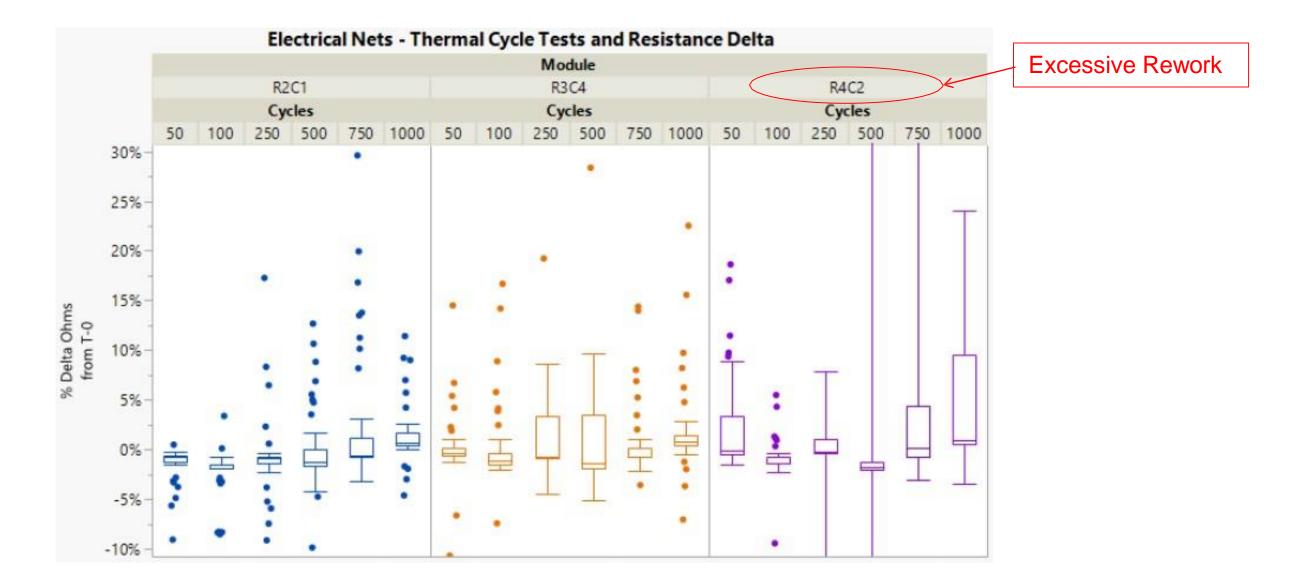
RTV-03

								•		<u> </u>										•															_
								1	RTV-03						14				RTV-04									R	TV-05						_
- 6		-													- 6	2								into Mue						Car	familing Mode				_
•	Name of Carolin	803	830			ы ж	50 E		40 K	22 BK		G 18	a 43	•	80	ESC#	RDC3	842	623 G	-	2 89	-	2C1 520	7 812		a a	204 80	a .		CA 83	a m		KA 1945		82
1	BIA Net 1	4	14993	3.5836	2,8472	2.6%	2.6429	1108	2.500	2.8117	18921	2,8028	2,4139	23.267	180	2,8542	18875	3.7972	8.75 P	18867	2.6583	2.843	- 23827	1860	2.818	84776	1.8354	2.664	1.170	2,7581	180	2.6512	1.781	2.9822	
1	BILA Net 3 Top Left AL HA	1	1.1488	L2187	1.2000	1.001	1.840	1340	1.1704	5.3728	1.2998	1,29(1	1.2723	1100	1.01	1.8790	1476	1.8008	1.010	1,25%	3,2004	1418	1344	1.6009	1.4421	LAND	1.000	1.807	1,170	1.881	LMR	1.2004	1,2714	LANO	
	BIA Net 2 Aut Rate 19/28			Lines	1.4818	1.014	1.580	13188	1,000	Later	LANK	1.000	1.8179	2.8 054		1.8188	1170	1.4228	1.034	1,000	1.1007	1.423	53287	1.079	1 4734	LADO	LIM	1.4079	1.0.00	1490	180	1.0140	1.666.6	LAIMA	
	BOA Net 3		1.608.7	0.0199	54265	LMB.C	0.4242	2,4518	C.468.8	3.4208	1.000	8.4512	C.0999	14381	LED	0.5088		0.4808	4.5539	1.4244	2.4366	0.668	25211	LMD	and so	CAME	1.600	1.001	0.413	2.488.6	2.89.54	C.8420	23054	0.8258	
	858.6 el 2 Top Right A15-818	St. 10	1,2174	8.3157	11023	0.2645	0.3238	2244	0.3624	8.35%	0.2744	8.2565	0.3981	1381	0.218	0.8091	2,2200	0.3387	6.40%	02294	1.195	6.988	5358	1.684.*	0.0120	6.190	0.4023	128	0.306	8.965	D.RJ.W	0.3480	0.0004	0.8188	
-	BER Ref 2 Kirk Left C1-92		1.000	0.3001	4,000	0.2012	0.3038	8,30170	0.2004	6.2008	11,2007	8.2067	1.007	1.187	0.305	0.3028	2,1126	0.3028	2,208	0,2058	6.2012	0,202	6.1136		1,004	0.1134	0.2005	1.27.18	6,3028	1.2028	6281	0.3038	1 2083	0.3000	
1	BOA Net 8		-	LIND	LIMT	1.803	LMAT	13920	1.4090	1,80%	1.6001	1.8078	1,941	1100	1.000	1,88.89	14100	LATER	3,2999	LINEL	1305	1.000	1100	1.607		LABO	1.54590	1.7810	1.0100	1.000	1410	10000	1.001	1.195.6	
	BOA Net If fue Left 21-68		CARD .	0.9463	2.8599	2.163.8	GATE?	DAX26	0.8427	231.00	0.0000	5.4045	E-ADEI	2,5480	2.606	0.9934	2494	0.666.6	1.8767	DADe	83662	192	8.8700	D. ALMA		CASTR	8.7975	23708	CA1m	E MARK	CHH	OALSS	1.0628	0.848.8	
•	WIA Net 3 Son Hight NDS-F28		17287	6.9612	1820	2.7684	0.7967	LINK	0.7682	0.7940	1.7968	8.7778	0.7080	2.706	2.766	0.7925	1,040	0.7859	2.0849	0.7461	17617	6.773	0.1299	1.7709	100	Crests	0.160	1,128	6.728	8.7723	1.7657	0.3507	1.600	0.8047	
	BOA Inel A		19028	1.9983	7336	1.0018	Lasor	1838	1.8658	1.0418	2.5 189	2,4099	1.49.79	3.4639	1.817	1.9839	and the second second second	LADAR	2.00%	14452	1.862	1538	13905	1760	****	14429	Lane	2,3440	1.5487	24644	1.854	1.5422	1.0007	3.1279	
	804 hei 4 hai 47 AN		1.869.2	6.8171	1170	E 8340	0.3735	2103	0.860	23188	-	1.801	C.018F	1336	2.630	0.8888		0.940	0.32.00	0.8428	23015	0.885	23834	1.000	6.120	C160	0.420	LINK	CATH!	21/90	0.00	0.308	E.MIN	C.S.M.M	
1	Bibh Net & Right HCle (18	2 1 2		6.00M	2436	C MAG	0.37%0	2,8579	0.8980	1384	1374	2.694	0.8722	2.1 000	10.22	0.3738	E JANE	0.860	0.0020	0.8868	8.8825	LINE	23679	LOWIE	0.42.00	Case	1.039	1.8678	C.FHCB	2.8864	0.0078	0.0140	1.654	0.4225	
	RMARE CRIE CO.M			0.88.82	1190	2.965	GANE	13952	0.6948	0.0684	0,0100	2.4940	0.4044	0.000	2.944	UACA	D.9528	0.860	1.600	2,558	2.8674	2340	2,210	LINK	0.400	CASH	0.1429	0.8880	0.3140	1.1016	CHH	CALER	1.0414	0.4476	
4	855 Net 4 Left (1-81	-	1.49679	0.4971	15049	2.090	0.3078	1313	U.SHOR	0.8288	U.erc.r	0.4880	0.8366	24787	C MR	0.4733	- Contraction of the local division of the l	0.4847	1.407	0.8228	2.0078	0.01	23662	CARE	0.8400	(1866	0.660	2.9586	0.3088	2.001	E-M003	ONTHA	ENDED	0.000	
	THE Bel 1		19400	1.7100	8.7839	1.0013	3.7922	84348	8.7724	1311	8.8.2ME	2.0012	1244	3.5187	8.947	3.8454	1.199.8	1.8324	8.4829	8.7342	8.622.9	3,738	5.0400	3.9953	4.694	8.8388	4,004	8.7780	3,000	6,003.6	6.02349	A.DER.M.	4.0770	6.1760	
-	700/Bel 2		1283.8	1.1689	14834	8,8208	1.4181	8,2064	8,800	8,2838	1342	8.8390	1210	0.2000	1.03	E SARP	40797	6.0947	1.0758	8.87%	1.005	6.25.7	13085	LMC	8.2710	1.1304	1.400	LEN	1.000	14029	8.0127	8.4901	1.6008	8.4888	
	TO Bei I		1.1104	1.200	8,8288	8.1915	1.8122	82794	8.3662	8,0795	8.5899	8.2205	8.5864	2.8619	3.589	3,3639	1.0409	8.3158	8.2258	6,2108	\$1777	1.00	R3466	1.000	13400	1.000	8.455	3.6240	1,000	8.8817	8.0408	8.4238	8.8708	8,867	
	TEN INel 4	- 3	1.007	6.8842	6707	4.6347	4.3797	ASSE	6.004	8.8942	6.6329	4.5494	6,080	4340	4,000	4,7166	4.18.80	8.7128	4.1028	63967	A.KUR2	2.636	68878	ARCIN	1.120	4,8428	1.8559	6.7828	4,7801.	4.000	4.6726	1.76.64	8.000	8.7908	
-	733 541.8	1000	10079	\$2828	6,2546	8.5387	8.3832	8.008	8.060	6.0040	6.0240	5.2000	83085	4.8.807	8.276	8.3758	1010	8,0046	8.1221	6.0KU	8.0875	8.202	82706	6.008	8.8238	8,2002	4,000	8.1284	9,209	1.296	8.1040	8.3467	8.000	8.3862	
-	TYN Ref. 6	1.1	14294	8.2788	1.8799	8.7880	R.TTWL	1000	8,8218	RATES	8,600	8.778.8	1.000	1.5415	8.798	2.9038	RATE	2.9482	8.8216	1,000	8.7875	8.863	8,7996	4.000	6.2607	3.9486	4,003	1.0100	41386	1.080	1.01.04	4.0941	6.5825	8.0408	
-	Tix Bes 2		12768	4.8128	4,9734	4,2949	4,3642	6.9128	6.000	6.0678	8.1.927	6.8234	6.0346	ALCON.	4.08	6.6102	1000	4.4957	4.6615	6.6368	8.2828	4.347	63086	4.9807	1.0044	4.6790	4.0070	LEDG	6.6708	6.6823	AATTI	4,4074	6.822.0	4.0007	
-	TO Bei 4		LACIA	8.5268	BACTT	1.000	1.6286	LANC	8.8824	LOUIS.	1.1101	1.1018	8.50m	0.170	8.828	2251	4.3.810	8.7583	6.8742	6.8475	8.9875	1.600	42134	4.2129	1.1796	4,000	1.3638	6.2578	1340	-	1.010	4.8730	8.888	6.000	
1	Chip-side time 1 plas 1 High			7.3430	2,4818	1.0123	73294		2.8297	7.0288	7.568	7.4812	7.2118		7,294	7.3.648	8.208	7.524	7.1828	P.ACUE:	7.1588	1,28.9	73582	7.8455	7,8868	LADA	7.6500	7.90.69	Tanki	2,008	7.6181	7.8797	1,7179	7.8012	
	Child State new Zycles 2-frage	1000	LINES	18,6787	18,8579	18.7658	20.29.36	11110	38.8990	38,2898	18289	18,9775	1.000	17.728	24.600	21,0705	and a second sec	21008	20.4617	71.8677	21.1766	21.058	14357	20.000	30.8082	20.6342	28.5589	22.2846	20.8727	20.5148	20.00.00	20.8532	20.0010	38.3428	
	Chip side vier 8 vier 8-bigh	1.000	LINKIN	21.0949	32.6.00	21.8884	12.5462	114879	31.1460	22.4825	22,8905	21,260	nee	12.000	22.003	22.1685	22,4128	22.805	25,0827	22.6458	72.125.6	21.218	114407	72.0037	32.7980	22.5396	21.001	22.8812	25,9463	22.6794	21.825.2	21.004	39.0125	22.0274	
	Chile sales some & rives & rives	10 K	LOBAR	100	24000	1,2014	2.8588	6330	7.0429	7.1542	12879	7,0002	1.000	8.7539	1.012	7.3308	8.8000	7.3858	2.06.62	2479	8.8768	1.00	72896	1,023	1,3805	1 Lines	Y.1128	1.0624	1,000	7.8878	6.812	P.ALAT	1.4128	7.0187	
1	City tile om Vein 241gt			1.1m	71.402	2.84	ILEN	158.607	20.8045	30.8011	20404	21.4883	2.00	183124	21.838	20. Kim 4	and a	25,9802	2.60	1104	25.475	2.52	22.500	21,004	31.41.47	n.44m	21.0071	11.390	TIPEL	C. MIL	2.67		TLARTS	20,8899	19
	Chinada condicto 2 fast		LANK	2.6% 2.88	25.7629	22.8384	2.60	24.442	22,0080	21,263	23.7979	2.857	200	11175	21.620	25.1287	10000000000	36.0114 26.071	2.00	26.8140	26.2645	26.540	14.1327	20.000	38.48-55	31716	24.000	214500	51.5000 20.0120	31.500	23.4958	5.014	21.760	25.6728	
100	Citizatile new Avies 4-fragil	21 24	1.0447	4.8121	-	4.170	C.BIAT	6,0118	4.2085		6,238	4,200	41817	-	4.265	1.5488	4185	6.8012	4.7586	62758	4.1497	4.000	41964			1410	A.4654	A NOTIFIC	4.8179	A.8528	1.000	1.0010	6.8716	6.8727	
	Chip ship the Parley 2 digit	1.0	13025	17,4110	17.4486	18.019	17.0034	18.2808	17.1788	10.000	17.1804		10.000		17.61	1A.MOR	to most	17,2992	18.3047	tran	16.000	18.810	18.847	11.000	TERTAN	17,2318	17.1811	17.2788	TRACK	11.0010	18.8212	11.19.28	17.000	36.8630	
	Division new 30 year 2 high	1.1.1.2		18,6271	18,7189	17.6763	18.4188	171000	17.8000	IN IN THE	-	1000	-		18.808	-	MATE	18.8814	14.0807	-	10.0042		18.0100	18.5768	10.2040	18.07%	18.8828	18.1818	-	18,0560	18,2174	19.44.79	10.044	38.8399	
	Dispute row 12 des hitsto		LOWID	22.0000	12.476	21.894.0		11410	21.8315	12.8216		29.1819	21.8115	12.8.20	23.344	in said	Read and the second sec	A STREET	75.424		22.0848	21.013	21.0000	28.3115	12.85.10	Di Ota	22.0848	22.581.7	-	12.1075	21.8584			21.500	
1	Chip state your 12 year 6 high		ADER	1201	7.285	6.622.9	1.11.75		7.08/1	1.000	7.170	7.3873	1000000000	8.576	7.540	7.0756	0.0004	1.3872	6.7839		8.828.8	1.01	Pages 1		2.4478	LAND	Larna	1 mart	0.00	7.8128	1.4734	Contra Co	Tatte	7.5294	
20	Real side new 1 star 1-bath		Louis	19,8781	18,7500	18,4202	18.00.75	18.000	19.6004	18,2900	1A.tem	18,2015	19.407	17.880	18,880	and the lot of the lot	20.0100		20.0012	22,010	23.0012	21,914	18.1488	19 AURIL	10.00.00	10.000	14.000	18.00.00	10.000	-	-	10.0007	-	30.0922	
	Back side mm I star 2 figt:			19,4041	11.000	10.000	18.01.74	14,990	28.3424	14.65.18	14.7587	25.4624	D.UM	18.8812	16.100	TR. HIRS	15,2816		18.9025	14.1428	18.7604	18.000	18100	19.0011	THE	-	-	18.6110	-	-	Z.atha	mast		20.9191	
-	Band shin tree 2 alas 54 (git)	10000		11.0012	115258	11.0419	11.8894	11102	11.8278	LINK	-	11.3808	11.00.00	123270	21.54	11.808.7	12.001	12.0002	12.2288	12,808	12.0798	11.64.7		12.0015	12.71.10		11	12.9939	UAN	10.000	-	12.8811	Section 1	18.0904	
		1.1		1.1.1.1	16.4700	IN CASE	18.41.12	TAURUS	14.200			18.1303	18.210		10.741	1 10 10	10.218	11.0011	17.00.00	STATES.	15.883.0			18.0073	De et ret	10.000	14.4141	18.18.20	18.4228	17 141	2.01	10.00.00	11100	16 75 67	
T	Rank side new Kinter Scholt Rank side new 12 year 24 year	1 2		1148	17,8182	DA.DEFS	100000	18,0111	17.1848	18.0872	TRAILE.	18,1000	A DRIVEN W	18.4277	10.745	16.7342	No. of Concession, Name	18.4297	17.0024		17,1223	10.010	11170	THE DESCRIPTION OF	12.4210	10.010	22.000	27.0010	IL STATE	25.000	11708	TR. SHIT		22.0488	
	Rade state row 12 vias 2 right	0.0	2014						327	1000	-		12,211	10.000	1 C 22	10.7342	100			totality	Cis Line					1.1.1.1.1.1	1000			1917	100	and an and	Sec. 1	1000	
	Sale side rose 12 cite Prints Second in Line, 7 Series		1.0070	N.MINI NT-MINI	10.1209	NAME OF	8,755	10.000	1000	1.14.79	73858	8,8092	8,7544	1127	****	12.0.90	and a	12.4290	No. or other	SLOPER .	10.2007	AL INC.	148417	26.0905	87.1217	15.8250	87.384	ICHCHA	17.1107	18.772.6	ULAIN:	10.0100	19,360	87,5475	
		100			164 12			10000	0.10		1151000		1.11	C. C. C.			0000000000	a state of the second	10000	All the Party of the		1.1.1.1	1000			1.17.20.00	0000	10000							
-	Strikution Leger 2	1	1.13(18)	0.2974	81809	0.5963	0.1408	21562	0.3877	3.0618	122009	0.1164	0.5584	1108	0.000	-	03528	1101	0.1576	3.5408	C INC	0.048	a terr	E 2909	0.1828	0.1525	0.160	3.1683	0.5827	8.1879	0.2814	0.13494	8.3946	0.162	
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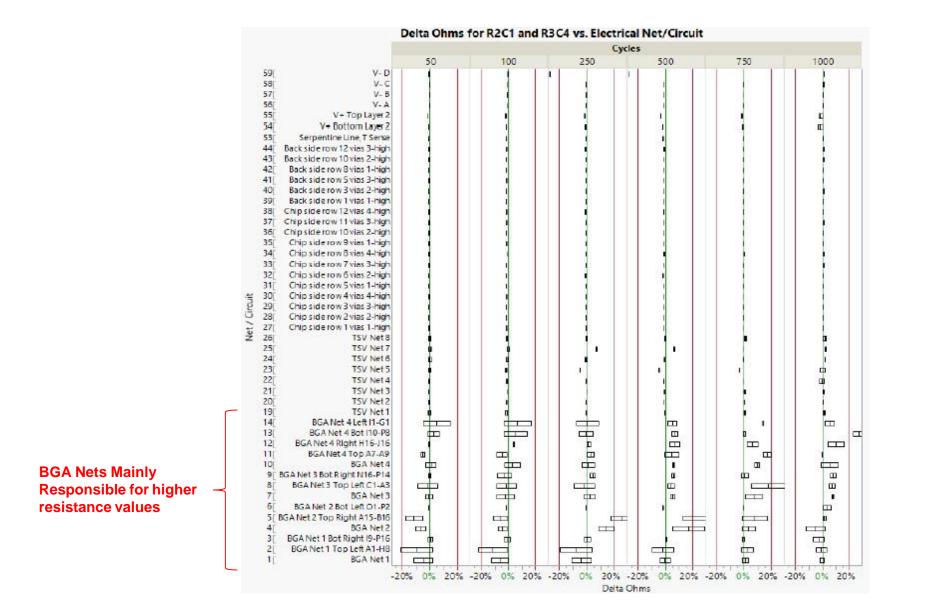
RTV-04

RTV-05

DTC Test results to 1000 cycles



DTC Testing of Modules R2C1 and R3C4 (No BGA rework)



Conclusions

- HSIP technology offers tremendous flexibility to accommodate different die types, sizes to produce a high performance high density multi-chip package using FOWLP.
- Process capable to produce a flat HSIP with good electrical circuit when using RTV-03 conditions (low bake, longer times).
- Early DTC sniff testing shows that modules subjected to a qualified BGA attach process are showing good reliability up to 1000 cycles. Testing will continue to 1000 cycles and beyond.
- □ Future work will concentrate on stacking modules and further testing under standard JEDEC conditions (T/C 0 t0100C, -40 to 125C).

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Thank You!

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