Prospect for Si sensors in Korea

Y. Kwon (Yonsei Univ.)

Si sensor in general

- Mature technology
- Reliable performance
- Fine granule
- Higher energy and time resolution (than gaseous ionization detectors)
- Key burden is cost.

Microstrip silicon sensors in particle physics: a success story!



Eleuterio Spiriti

Korean Strength

• Productivity!

 – Large amount of Si sensors produced with the standard CMOS process

R&D environment





6 inch fabrication line



8 inch fabrication line

Youngil Kwon, Mann-Ho C
 Edward Kistenev, Andrey S
 John Lajoie, Physics and As
 Yongsun Yoon, BT division,
 Kwun-bum Chung, Elecropl
 Zheng Li, SDDPL, Instrum

(7) Jinsoo Kim, National Nano

I. Purpose & Scope↓

The purpose of this MOU is to the **Radiation damage and** planning to contribute their ov

studies. This MOU clarifies the areas of pa collaborate by sharing their expertise and se parties for the stated academic goal. $4^{\rm J}$



300 cm² ~ \$ 500

rties will ticipating

- II. Responsibilities Under this MOU+
 - A. Dr. E. Kistenev, and Prof. J. Lajoie, and Prof. Y. Kwon will propose silicon semiconductor detectors/devices to achieve academic goals in their field of interest in the experimental nuclear and high energy physics.⁴
 - B. Dr. Z. Li will design the proposed silicon semiconductor detectors/devices using standards... approved by industry for large area radiation hard Si devices and will advice on the radiation induced defects in Si devices. 40
 - C. Dr. A. Sukhanov will advice on the electronic design and implementation of the readout electronics for silicon semiconductor device testing.⁴
 - D. Dr. Yoon will inspect designs of the proposed detectors/devices and advise on matching design ideas to fabrication technologies. He will also perform his own radiation hardness testing of the devices he develops.4
 - E. Prof. M.-H. Cho, Prof. G. T. Park, and Prof. K. B. Chung will advise on possible defects in silicon sensors/devices and will study radiation defects in the produced sensors/devices exposed to different kinds of radiation.⁴
 - F. Mr. Kim, leader of nano patterning process team in National Nanofab Center, will assist in fabrication of the silicon sensors/devices with university discount program and consult on details of silicon detector/device fabrication process.⁴

Samsung S5K8AA

Ultra thin HD image sensor for compact mobile application

HD 1/8" 1.4um BSI Pixel Image Sensor provides;

- HD sensor integrated Image Signal Processor suitable for slim mobile phone, tablet and notebook
- High speed HD 30fps and VGA 60fps
- BSI sensors providing clear and sharp still images in low light, YSNR10 86 Lux



SK하이닉스 M8라인, 시스템반도체 전환 완료

애플을 최대 고객사로 확보



SK하이닉스가 청주 M8 라인을 거점으로 시스템반도체 생산을 본격화했다.

10월 25일 유경동 SK하이닉스 상무는 `국제반도체컨퍼런스 2012`에서 청주 소재의 자 사 M8 공장을 메모리에서 시스템반도체로의 전환 작업을 성공적으로 끝냈다고 밝혔다.

M8 공장은 CMOS 이미지 센서(CIS)와 DDI, 전력반도체(PMIC), 고주파(RF), 메모리 반 도체를 생산한다. CIS의 경우 90나노미터(mm) 공정 기반으로 터치스크린과 드라이버칩



서울시민신문 🖂



CIS (CMOS Image Sensor) SPECIALIZED FOUNDRY

Design Toolkits, 웨이퍼 가공, 패키지, 테스트 등 턴키 서비스 제공



CMOS 이미지 센서는 렌즈를 통해 들어오는 빛을 전기적 신호로 전환하는 디지털 제품의 핵심 부품으로, 저전력·초소형·저비용이라는 제품의 특성 때문에 캠코더, 디지털 카메라, PC용 카메라, 이동전화, PDA, 스캐너, 팩스 등에 널리 쓰이는 등 제품의 수요가 급증하고 있는 첨단 기술 분야입니다.

동부하이택은 국내외 Fabless 등 고객사들에게 보다 저렴한 비용과 편리한 서비스를 제공하기 위해 CIS 제품 개발에 필요한 디자인 룰킷(Design Toolkits)을 제공하고 있으며, 웨이퍼 제조공정, 패키지, 테스트 등 이미지 센서 양산에 필요한 모든 공정들을 일괄적으로 서비스하고 있습니다.

동부하이텍이 제공하는 CIS(CMOS Image Sensor)기술은 0.18, 와 0.13, 교급 기술을 기반으로 하고 있으며, CIS 공정기술의 경우 N+/PW Photo Diode와 Color Filter, Microlens 등을 제공하여 CIF, VGA, Mega-Pixel 등 다양한 형태의 CIS 칩을 양산하고 있습니다.

What is Si sensor? (Sensor on Si wafer)



Diced sensor



Introduction for student

How do we make it? (CMOS process)



Actual process sheet

The second second	and a loss	100	the second second		71.64	and been an annual and an annual and an	towner law	100	and Income	-	PH2		a port of a space of	other lives	1000	ai 1	at the l	-
THE PERCEPTION	0.1416.0	100			121	rest, success a	1400	10	499		-1/2		ori rescelence	Cashi-	-		49.0	_
PROCESS	1008	NATE:	TABLETS IN	10-DOLD	No.	10 94930	LAINS 1	STATE OF	TINCT'S IN	interes.	1 11 11 11 11 11 11 11 11 11 11 11 11 1	1 17	PECCEN	31086	Rights.	Table 1	1 100 100	1
Adde (Addec Table Addec)				-		the second second			- A		Calls.	1 1	part (start		101001	-		t
STATISTICS INCOMESTIC						18 Pingel - (6,0011,100-3)	180,000		a				Warms Tree (Trans 1991) 199-10-		1.000	2.2		Г
2 cover ear	*******	10100	we py their			Pr Plan Multiple Multiple 10	the first from the	ot. These	e Halling HEP	p.			-+180 ····	1.000	120	1.14		
loss where \$10, were	100.000	laise-	115.00			it. PHONELouillate.	THE OWNER	pie cost		111			New York Trans Street Block	(income)	0.000	2.2		
Water or a lot of the			1 1		0.0	PERMISSION CONTRACT	-	101-001		++-		*	14.000	1.1.1		1		
R Contraction (No. 71	PARIAN		1: 1. I		Prg.	the second second	100000				-		100000.000	101100	14114	1		
Name Ward of Vice Ward (1			The President Area	440.000	100		++-				1100		1.000	-	-
1000000 arthur	1 taxa march	internal li	878.08	110		23 Partney COTTONNE	140110	101.040					These shares a meda		14140	E E .		
* 1864 AL 10540			Aligner (197	110		17 PO 114 Page	1001-1001	101.000	hape size it		124		man in			1.1	-	÷
P Marriada (DRIT) IN ADD			100.000	814.10	4.04	10. Character Date: LA (1980 10)	Jamines.	-	1.1				Difference (e.c.) (inc.)	1001000		1		
· Think out shall will be a shall	*****	-	0-044644		and the second			-	8 . 44			100	star Prote Mading - Warffull A	CP. Canadi	Pro Ivan.	Phone H		1.0
B 100 to B 100 Topy 200 Top	*10.040	141410			1.0	in the ten inside	4111-001	101.044	CHERTO DOM:				(NOCorbo	Lange and	-	-	TT	Ê
a linear the	4140.001	100.04	84 41/1 http:			18 Manage Tele Plage - 19 41	10021001	111, 811	10.0				PRESL Literati	initia.	100.010	-		4
N Line Course & Hand	THE OWNER	-	1.00			In 16 Descention	Tanan	100.000	8	++-	-	4	Companyed In case	1.6310.001	38-211			Ľ
- Taxation	*****	-	-			12 TE fore Auto 100 FW		183 (181		1		*	Interfacilities manip	180-(98)	00-010			£
Anna Streement	1.1.1	111			722	18 Installer	1000.000	.000				<u>6</u>	The line of the lines		10.01	-	-	t
Dian-Dibular	State Later	Martine .	1.		**	29 Throng 1410	\$10.981	100.000	president de la companya de la compa			-	Inclusion Press of Press		10.11	Tags - 69	64	E
0 17mm 178	-	-	-00-10-10-0			The Processor Processor	(Marked)	-	1.1	++-			Massa Fin.			1.0		E
the Charles Line, and		10100	T- CHARLES			in Dealer Ter Chap. Stir (2010)	100,000	100	1 2			4	Charger + Laborat Tell Ag	1881-080		1 4		L
		-	5			in Production St.	anti-see	100.001		11		4	Bulue.01988	8112-040	0010-0	Sept-168	1	Г
Charlen Charles State 1	1100000	-	1.0			THE SPECTRUM	610.06	100.000		++-	-		Bears for 19 Mile	-	- 104	2.2		
	-		1	1		W Annual and print of the land	a mainin	100-000					1 48 688 1	instant.	100.000	1 44		÷
						Lauran Balances	and h in					1		0.4.1	1.4	-		-
																		_
1192.5	DECOM	CTORPRE	OCENS SHEET		_		eniconatic	ton ris	XXX SHEET				108.0	MECONOC	CIDEJIN	0.125 SH	ш	
EIN.N N. GITAL COMMUNI N. GITAL (N. T N. GITAL N. S	DECOMON PART DA	CT OR P14	ar			E383 m. 107 - 1 Hauro, m. 1197 - 0 Hauro, 107, 108 - 10	ENICONDUC UNITE (INC. 1989)	ton Plat	XXXX SHEET		12/2		1100.00 6.637-13.950.000 6.99273.000.000 14.99273.000.000	Maccesoco Pager [140. Famer	422 60	90 E 55 S 58 91 [E1	
1100.0 00.0147.4 450.00100 0.01487.4 (00.017) 01. 100.017	Descorpto Parte Des Totar	CT OK THE		100000		E1043 (m. 6101-1-0-41mm-ta), (m. 44410) (m. 49 (m. 2000 B/h) (m. 1004200	2500 05000 0500 [00.0	ton Her					1100.03 6.0073-0.150.0400 6.000740.050.000 71.000040 1000010	NOLONOO NORT INC. NORT	403 60 80000	ar and same	8.54 47 2 1 1 1 1 1 1 1	100
EDDL 0 01: 0107.0 4 4 hand to 01: 0107.0 (No. 1 10: 000.0 (No.	DELOVER TOTAL	CTOR PRO		10,0048		EIRIS PRE-EIRIC - C. Hanneller PRE-EIRIC - C. Hanneller Pre-Eiric - C. Hanneller Topological - C. Hanneller Pre-Eiric - Hanneler Pre-Eiric - Hanneller Pre-Eiric - Hanneller Pr	ENICONDUC UNITS [101- 10300 FORM]			1 10 10			1118.02 4. 637.5.1.4 (Saaron 1. 9457.8.1.966.4751 1. 9457.8.1 1. 9	1000 000000000000000000000000000000000	AD3 and	0. 1.55 540 *		100
ETDE.0 00.0424 (June 14) 00.0424 (June 14) 01.0424 (June 14) 1.0424 (June 14) 1	1000 (000 (000 (000 (000 (000 (000 (000	CTOR PAG	N EMASERET	100000		E2813 Terr (2017 + 2 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	ENICONIC UNITS INC. 1999 Frida District	Total Plat	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX		12		LTBL 52 4: 43.9 - 5 - 4 Tourist 0: 40.9 - 5 - 4 Tourist 0: 40.9 - 7 10: 10: 10 10: 10 10	1000 00000 1000 000 10000 10000 10000 100000	ATT BUT	00 1005 5488 9		200
EDE. 8 10. (1974) - 1. (2004) (2014) 10. (1974) - 1. (2004) (2014) 10. (2014) (2014) (2014) (2014) 10. (2014) (20	ALL DODA TABLY TABLY TABLY TABLE TABLE TABLE TABLE	CTORPHS	A LIM SHEET	10,000	2	EXISTS THE STATE OF CONTRACTOR THE STATE OF	EMECONDUC 0.4947 100 1.5557 T-1.000 D-1.004 1 1.000 1	Total Plat	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	1.00 MR			E10 13 Force 11 Fo	100 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	CIDEPA -423 eff person person (ac.2) (ac.2) (ac.2)	0 105 540 41/	8.34 (17) (17) (17) (17) (17) (17) (17) (17)	204
EIDE.0 9. 0437 / Low, 19 1. 0437 / Low, 19 1. 0437 / Low, 19 1. 0437 / Low 19 1. 0439 / Low 19 1	THE CORE	LT DB. PBC		100000	Tax Tax	ETRIS mail (1071-01-0100) mail (1071-01-0100) 1072 (1080-010-01-01-01-01-01-01-01-01-01-01-01-0	ENEONBIC 1999 No. 1999 J. 1999 J. 1	Tom Plot	CESS-SHEET ALL STATUTA SALVALA SALV	1 000 000 5 1 000 000			LIBLO AL & & ALF J-1 & Handrein L. (1997) A. (100, 1971) M. (100, 1971) M. (100, 1971) Markov, M. (1971) Markov, M. (1971) Markov, M. (1971) Markov, M. (1971)	ALCOSOL 140 years 140 years 140 years 140 years 140 years 140 years	CIDEPRE 403 eff postal 1 00.00 (00.00 (00.00 (00.00 (00.00)	N 255 588 877 { 9 { 1 28427 814428		200
EVEL A 4 November 2 Constant 2 Constan	THE CORE	LT DB. THE LEFT. DF. Particular BBC DBC COLOR CO	CENSSEET		Tata Tata Tata	EEELS Term (2017 - 2) - Chambrid Terr, - 1-1-12 (State State) Terr T	ENEORATIC 3/997 No. 3/990 J 7/999 J 7/999 J 1/000 J	Data Plat	ACCOS SHIELD ACCOS SHIELD AC	1			EDE 21 FOR 21 FOR 21 FOR 21 FOR 21 FOR 24	ALCOSOLIAN THE OFFICE THE OFFICE THE OFFICE THE OFFICE	-403 ella martina ferrare canada cana	0. 105 580 6 1 100 100 1 100 100 1 100 100		734
1102.0 5. 557.0 (Sec. 19. 10. 552.0 (Sec. 19.) (Sec		CT UN 210 407. 01 100 00 100 00 100 1	All B.W. All B.W. B.W.			EIRIS International Control of Control International Control of Control of Control of Control International Control of Control of Control of Control International Control of Control of Control of Control of Control International Control of Contr	EMICONSIC 3/557 YOUR S. Dela Della Carrieri Galanti Carrieri Santa	1000.PM	XXXX SHEET	1 00 000	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		EDE 23 4. 617-13 (No. 499 6. 49478) (No. 499 7000000 7000000	NUCCESSION POINT SALES VIENNE	CIOLEN an Sur Constant Constan	0 105 588 60		
EDDL 1	1000 000000 1000000 1000000 1000000 1000000 1000000 1000000 1000000 1000000 10000000 10000000 100000000	CT OR PRO APPA PACE OF PACE	AT In W AT In W In W MI			E200.5 Test - 0.017 + 0.4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 -	EMICONDUC 0.1999 Dis. 3.555 T-1999 3.7643; Ebd For 1.56; Star 1.56;	000.750 000.750 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 000.00 00	KINS-SHEET IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	1 100 100 1 100 100 1 100 100 1 100 100 1 100 100			LIBCO 4. 217-13 (hours) 1. 02774 (hours) 1. 02774 1. 027744 1. 027744 1. 027744	100 0900 100 0900 1000 1000 1000 1000 10	CIDEL280 -423 #0 PROTECT	11		-
DEF A 4 Power 2 Dec 7 4 Dec 7 Dec 7 4 Dec 7 Dec 7 4 Dec 7	1000 00000 1000 000 1000 00 1000 000	CT OR PRO- appl and the pro- part score of the pro- cession of the				EEELS Terrer (2017 - 2) - Charactery, Terrer (2017 - 2) - Charac	EMECONDUC 3555 1000 1	1000.050 00		1 100 1000 1 1000 1000 1 1000 1000 1 1000 1000			LIBE OF a (27.5.3.4 Summary) 1. COLOR (No. 701) 1. COLOR (NO. 7	HELOPSON FORT ALONG WINHOUT MINUTAR THE LOOP	CIDEL230 -423 #0 9009041 000300 00030 00030 00030	11		200
1102.0 10.0127 (14.010) 10.0127 (14.010) 10.0127 (14.010) 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 10.0000 1	CARL CODEX FUELS FUEL		CENSSEET	147.2444 147.2444	12 12 13 14 14 14 14 14 14 14 14 14 14 14 14 14	EIRIS INTERNATIONAL	EMECONDEC 0.1997 DEL 3.0992 TOBE 7.000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1	DOB PEC ST TAL ST TA	XXXX SHEET	1 000 000	12 11 11 11		EDE 23 4. 617-13 (No. 701 0. 49478 (No. 701 1990) 1990) 1990) 1990) 1990) 1990) 1990) 1990) 1990) 1990) 1990) 1990) 1990)	140 0500 1400 140 1400 140 1400 140 1400 140 1400 140	CIDELPHO ADD BOOMS COLLEGE COL	10 205 588 10		
EDEL 1. SERVIC A Supervise State of the service of the service THE SERVICE OF THE SERVICE OF THE SERVICE THE SERVICE OF THE SERVICE OF THE SERVICE THE SERVICE OF THE SERVICE OF THE SERVICE OF THE SERVICE THE SERVICE OF THE SERVICE O	000.0000 10	CT OR THE 401 01 000 000 000 000 000 000 000	0 EDS SEEET			E200.3 Terr - 0.017 + 0.01 - 0.000 + 0.01 Terr - 0.017 + 0.000 + 0.01 Terr - 0.000 + 0.010 + 0.01 Terr - 0.000 + 0.000 + 0.010 - 0.0000 + 0.000 + 0.000 - 0.0000 + 0.0000 - 0.0000 - 0.0000 + 0.0000 - 0	EMELOSALC 1997 Balance 1999 Balance 1990	100 Per 112 11 11 110 10 110 10 100 0 100 0 1	KINS SHEET MILL MINE AND	1 000 0000 1 00000 1 000 0000 1 00000 1 0000 1 00000 1 0000 1 0000 1 0000 1 0000 1 0000 1 0000 1 0			LIBE.21 4. 417.1-3. (No. 471) 7. (No. 471) 7	100 UPOD 100 100 100 100 100 100 100 100 100 100	-403 e0 -803 -9048619000000000000000000000000000000000000	00 1005 5880 00 1000 00 00 000000 00 000000 00 00000000	E3	100
EVEL 1	1000 00000 1000 000 1000 00 1000 000	LEAST OF LEAST LEAST OF LEAST WARRING WARRINO	CLINSSELET ALT	10,000		Image: 1000 + 01 + Hausers, mr. 1000 + 01 + Hausers, mr. 1000 + 01 + Hausers, mr. 1000 + 01 + 01 + 01 + 01 + 01 + 01 + 0	EMECONDIC 0/489 [80: 3000 FURE 5, Fort, Rod IV 40: 000 0/00	DOB./Hot 210 30.00			21 11 11 11 11 11 11 11 11 11 11 11 11 1		EDE 21 4. 672-51 (Pace 470 (a) 69473. (Pace 470 (b) 69473. (Pace 470 (b) 709310 (b) 709310 (b) 70931 (b) 70931 (b) 70931 (b) 7093 (b) 7093 (b) 7093 (b) 709 (b	HELOPOLI 1000 141 1000 1100 1000 1000 1000 1000	CIUGLING 4073 001 1997 1997 1993 1997 1997 1993 1997 1997 1997 1997 1997 1997 1997	0. 205 SBR		200
1102.0 9: 557.0 (4 500000) 10: 552.0 (10: 50000) 10: 50000 10: 5000 10: 500 10: 500	CHEA LONDAX FORM FORM FORM TOTAL STATE	CTORESS 44.4.4.00 000 000 000 000 000 000 000 0	CLOADELET Art	110/0098	12 Jan 1	EXELS 1000 (10000 (10	EMICONSIGC 3.552 1.100 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0	Don Pba 		1 (10) (11) 5 (10	ZZ 22 22 22 22		LIBES 4.25211 - 14 Postality Personal Perso	10000 1000 100000 10000 10000 10000 10000 10000 10000 100	420 mm	100 540 107		
EDEL TOTAL 1 Support 1 Control (Control (Contro) (Control (Contr	CALL COND. 1997 2 241 2 400 2 1997	CTOR.PEC 4441 Original Control Particular Control Cont	CLIN SELLT A1	117,000	THE STREET	EEEE 2 THE STORE OF CONTRACTOR THE STORE OF	EMECONDUC 1997 No. 1 1997 No. 1 1998 No	1000 /Per 900 /			22 1 22 22 22 22		LUBLO 4. 4/2 3.5. 4/baarton 1. 4/4/17. (Dc. 4/2) TOTOLO TO	102 01000 10000 0100 10000 100000 1000000 1000000 1000000	40 m	81		
EVEL A Comment of the second	COLLOGIC 1007 DA 1007 1009	CT UN-FBE	AT			Image: 1000 + 01 + 100000000 mm: 1000 + 01 + 100000000 mm: 1000 + 01 + 100000000 mm: 1000 + 1000000000 mm: 1000 + 10000000000 mm: 1000 + 100000000000 mm: 1000 + 10000000000 mm: 1000 + 1000000000000000 mm: 1000 + 1000000000000000000000000000000	EMECONSISC 3099 100- 3099 100- 3099 100- 10-	1000 - FSC 1000 -	XXXX5-MEET All		12 12 12 12 12 12 12 12 12 12 12 12 12 1		LDB.01 4. 672-51 (Poc. 470 (Poc. 470 Poc. 50 Poc. 50	HE COSC 1997 ML 1998 1708 1708 1708 170 1708 170 170 170 170 170 170 170 170 170 170	40 fr	10 105 548 117		
EDELS 1. 043 A.S. 4 Soundary 1. 0447 A.S. 4	Distriction Field (44) Field (44)	444. 000 1444. 0000 1444. 0000 1444. 0000 1444. 0000 1444. 0000 1444. 0		1 2 244 1 2 2 244 1	12 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	EIRIS 1000 (1000 + 0.0 + formation) (1000 + 0.0 + formation) (1000 + 0.0 + formation) (1000 + formation) (10	ENECONDEC 10/19/0 2011 2005/2 2005/2 2005/2 2005/2 400.0000 400.000 400.0000 400.0000 400.0000 400.0000 40	Don PSC 1215 121					LIBES 4.22214 1-1 Photoster (No. 10) 100000 100000 100000 100000 100000 10000	Industrial Party (MA) Party Pa	LTORIPHI ACO III IIII IIIII IIIII IIIIII IIIIII IIIIII			7294
LUSE.0 TOP 1.1 4 Second 1 TOP 1.2 4 Sec	CONCLEMENT 1997	CTUR-ME 4444 Professional Profe				EERIS THE ISSNER OF A Floatester, THE ISSNER OF A Floatester, THE ISSNER OF A Floatester, THE Float Head Head Head Head The Head Head Head Head Head Head The Head Head Head Head Head Head The Head Head Head Head Head Head Head The Head Head Head Head Head Head Head The Head Head Head Head Head Head Head Hea	EMECONDUC 3/98/00 3/98/00 1	1000-FBS 900					LUBLO a. d.(2.1.5. 4%aarts) 1. et al. (2.4. 2%a resultions) 1. et al.	HECOSOC Page [44, 2007] Vinite	400 (100)	100 Selles Selles	8.39 67 67 11 11 11 11 11 11 11 11 11 11 11 11 11	790
EVEL 8 Total 1 Total 1 Total 1 Total	CONTRACT	CTUREDE 4441 04 1444 04 144	AT Image: Second s	1		EEEE 2 Term 1.000 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0	EMECONDEC 0.01979 100.1 0.0002 TOTAL 0.0002 TOTAL 0.0002 0.00	DUBL/HS 121 121 121 121 121 121 121 12	XXXX5-MEET ALL				EDB. 01 4. 0(74.1) [No. 470 (No. 470 (N	INCOMOUNT INCOME	423 (0.000) (0.000) (0.000) (0.000) (0.000) (0.000) (0.000) (0.000)	N 105 541		
EURI. 1	CONCUMENT	CTORPHS 4000 00000 000				EURA THE STATE OF A Constraint, THE STATE OF A CONSTRAINT, THE STATE OF A CONSTRAINT, THE STATE OF A CONSTRAINT, THE STATE OF A CONSTRAINT, CO	EMEDISALIC 0.49.04 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0	LUGLAGE 410 410 411 411 411 411 411 411			121 121 121 121 121 121 121 121 121 121		LIBCO 4. 417-13 (hoc 491 1. 49742 (hoc 491 1. 49	1800000 1800 1800 1800 1800 1800 1800 1	423 et al.			739
LUR. 1	CIEL LOCAL 1412 - 1413 1413 -	444. 444. 445. 445. 445. 445. 445. 445.	Alt Intervention Alt Intervention Intervention Intervention Interventintereeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee			EEEE Territoria Constantia Territoria Const	ENCONSIL 2017 100 100 100 100 100 100 100 100	Don Jigs arm star works wor	XXXXX				100.01 a. 6(7.5.1.4%aars) (140. OPSCO 1400 1400 1400 1400 1400 1400 1400 140	400 400 400 400 400 400 400 400 400 400			200
	DECOMPOSI- 1017-101 1017-101 1017-00	11 COL 125	ALLIAS SELECT AT			EEEE	ENE UNSELCE 101-05 000 101-05 000 101-05 1	DOU PES 101 101 101 101 101 101 101 10	XXXXX-SHEET ALL				LUE 3 4.2571 - 1 Postal Person Tennis Person Tennis Person Service Person Service Person Service Person	380.0500 1979 - 84 1978 1979-84 1970-84 1970-84 1970-84 1970-84 1970-84 1970-84 1970-84 1970-84 1970-84 1970-8	C108.138	14 EISS SHE 467		
	COLUMN	TURNER ALL OF ALL OF AL				EERAS Free - 0.000 + 0.000 - 0.000 - 0.000 rate - 0.000 - 0.000 - 0.000 - 0.000 rate - 0.000 - 0.000 - 0.000 - 0.000 rate - 0.000 - 0.000 - 0.000 - 0.000 - 0.000 rate - 0.000 -	EXECUSATE 1974 1 100 1974 1 100 1074 1 100 1000 1000 1000 1	Loss / Sol all b all					LIBES 4.22714 Phates 1997 A. 1997 A.	100 USGU 2007 340 71040 71040 71140 71140 71140	420 (0) (0) (0) (0) (0) (0) (0) (0) (0) (0	14 EISS SHE 467		
LUK.1 Total A.4 South State	Construction C	LICENTER ALL CONTRACTOR ALL CONTRACT	X LINS SEELET ALT			EEEE 2 THE STORE	ENEUSOILE 1997 1000 1997 10000 1997 1000 1997 10000 1997 1000 1997 1000 1997 1000	Loss / So 					LIBCO A 4(2)	100 USGC 000 100 100 100 100 100 100 100 100 10	400 mm			

How does it operate?





Cosmic muon test



KPS, Fall 2010

Applications

• Calorimeter :

– Active layer (Old) – PHENIX MPC-EX

• Tracker :

– ALICE ITS Upgrade

PAST

FOCAL - schematic view (y-z view)





Large amount of Si sensors needed!



Schematics



PHENIX MPC-EX

MPC-EX for PHENIX

 Application as a pre-shower for EMCal (Electromagnetic calorimeter)





J.S. Chai⁵, K.I. Hahn², S.Y. Han², H.S. Hong⁴, K.S. Joo⁴, D.S. Kim⁴, E.J. Kim¹, Y.K. Kim³, Y. Kwon⁶, J.H. Lee¹, K.S. Lim⁴, H.J. Moon⁴, H.M. Park⁴, J.M. Park¹, S.Y. Park, D.G. Sue⁶

Chonbuk National University. ¹ ETRI. ²Ewha Womans University. ³Hanyang University, RISP. ⁴Myongji University. ⁵Sungkyunkwan University. ⁶Yonsei University.



PHENIX MPC-Ex detector



Si-W sandwich preshower detector



Fine structure



Segmentation as a pre-shower



Sensor Design



2013 IEEE NSS/MIC/RTSD, COEX, Seoul, Korea, October 27-November 2, 2013

Novel guard ring system design and implementation for punch-through protection toward the detector dicing edge with improved radiation tolerance and reduced dead area

Zheng Li, Wei Chen, Edward Kistenev, and Andrei Sukhanov Brookhaven National Laboratory, Bldg. 535B, Upton, NY 11973-5000, USA Youngil Kwon, Dong gon Sue Department of Physics, Yonsei Univ., 50 Yonsei-ro, Seoul, 120-749, Korea Kunsik Park, Jongmoon Park Electronics and Telecommunications Research Institute, 218 Gajeong-ro, Daejeon, 305-700, Korea John Lajoie Iowa State University, 2229 Lincoln Way Ames, IA 50011, USA

*This research was supported by the U.S. Department of Energy: Contract No. DE-AC02 -98CH10886

Improvements (Details by K.S. Lim)



Submission for main production

- Main production started and new submission will be made in every 3 weeks.
 - 1st submission(executed), the last week of Sep.
 - 2nd submission(executed), the 3rd week of Oct.
 - 3rd submission(planned), the 2nd week of Nov.

Sensor Certification log (Details by S. Y. Hahn)

- CV test
- Before dicing
 - Short test

- Guard ring & pattern leakage current test

- After dicing
 - Guard ring & pattern leakage current test
 - Stability : x3 of full depletion voltage (90V)
 & 2 hours

Test system



Test electronics



Process monitoring



Summary

- Korea has a good potential in silicon sensor.
- A sequence of R&D for the silicon minipad sensor has been performed.
- Main production has started.
- Sensor log has been defined.

ALICE ITS UPGRADE

ALICE ITS Upgrade



ALICE Inner Tracking System at present



ITS upgrade

Design Objectives

- record collisions:
 - Pb-Pb at 50 kHz
 - pp at 1MHz
- improve impact parameter resolution by a factor 3
- improve standalone tracking efficiency and p_T resolution
- fast insertion/removal for yearly maintenance
- installation 2017-2018

er tirt bean pipe

- New layout
- 7 layers (3 inner, 4 middle+outer)
- reduce:
 - X/X0 per layer from 1.14 to 0.3 %
 - pixel size from 400x50 to O(30x30) μm^2
 - first layer radius from 39 to 22 mm
- beam pipe outer radius: 19.8 mm

The MIMOSA (Minimum Ionizing MOnolithic Active pixel Sensors) idea Working principle: Use of the epitaxial layer of STANDARD CMOS microelectronic processes as detecting sensitive volume.



Eleuterio Spiriti

⁽SIF 2010) September 20th, 2010

Technology : MAPS

- Gate oxide < 4 nm
 → better radiation tolerance
- 6 metal layers
- Epitaxial layer between 1 and 5 kΩcm, 15-18 µm
- Deep Pwell shields Nwell with PMOS transistors from the epitaxial layer and allows full C



epitaxial layer and allows full CMOS within the pixel without efficiency loss

- Difficult to deplete epitaxial layer under Pwell far from Nwell collection electrode, but radiation tolerance sufficient
- Stitching possible up to 200mm wafer scale

Explorer-0 : Test beam



- 4 layers of explorer-0
- 6 GeV/c pions
- Reverse substrate bias gives extra margin
- Penalized by too large input capacitance, corrected for Explorer-1.

Charge collection efficiency, Explorer-1(April 2013 submission)



 With/without irradiation, with the larger or the smaller back bias voltage, for a chosen n-well electrode

TCAD field simulation



TCAD simulations, the different settings of total diode reverse bias and epitaxial layer doping.

More detail on the collection electrodes

Sector	Туре	Diameter [µm]	Spacing [µm]	
1	0	2	0	smallest diode, lower collection eff.
2	\bigcirc	3	0	intermediate performance, S/N lower
3	\bigcirc	4	0	larger diode, no spacing, more noise
4		3	0	performance similar to sector 2
5	\bigcirc	3	0.6	small spacing, lower efficiency
6	\bigcirc	3	1.04	better S/N increasing spacing
7	\bigcirc	2	1.54	better collection eff., better S/N, TW
8	\bigcirc	3	0	triple well
9	\bigcirc	3	1.04	triple well

IV. Full analog – Our study for ITS upgrade - Specification - Front End Schematic



Summary

- 1. Scientific scope for the ALICE ITS upgrade and the needed specification was laid out.
- 2. Chosen technology is the **M**onolithic **A**ctive **P**ixel **S**ensors.
- 3. A sequence of R&D is in progress on a pixel chip named explorer for the ALICE ITS upgrade.
- 4. The R&D up to now showed, for a given pixel, how to improve the collection electrode and optimize the operation condition.
- 5. Korean groups, PNU, Inha Univ., and Yonsei Univ., are preparing the test system of the chips under development.
- 6. We joined the design R&D recently and will take part in the design improvement.