

 AEROFLEX
GAISLER

 imec

 ThalesAlenia
Space
A Thales / Finmeccanica Company

LEON3 Fault-Tolerant Design Against Radiation Effects - ESCC Evaluation

P. Somerlinck / S. Habinc / S. Redant

Microelectronics Presentation Days 2010

Thales Alenia Space ETCA

Ref : LEONDARE-ETCA-XR-0099.

Date : 30 March 2010

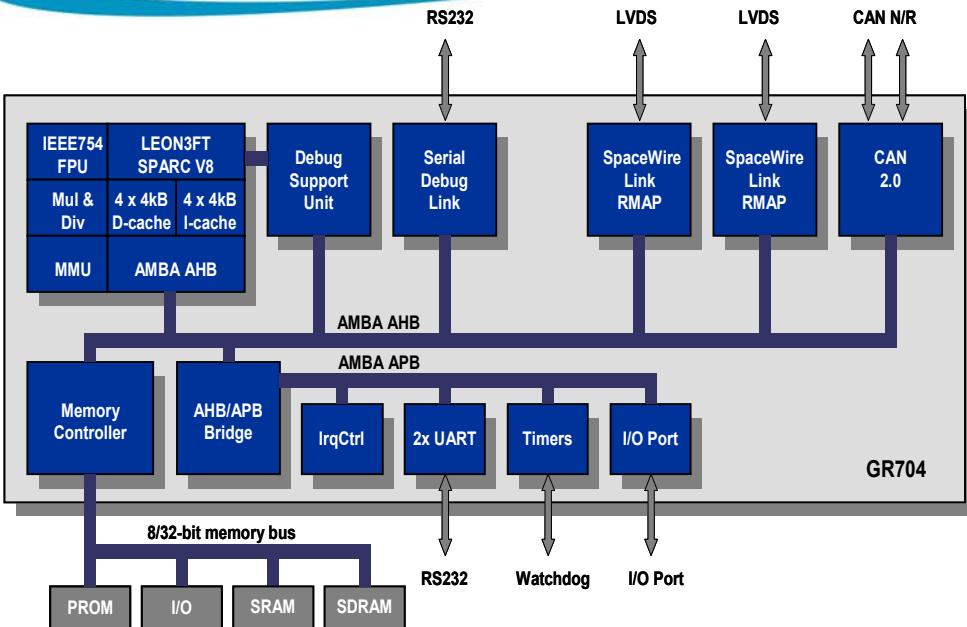
 THALES

All rights reserved 2010 © Thales Alenia Space

- **Project overview**
 - Context
 - Design
 - Test equipments
 - Status
- **Results**
 - Production yield
 - Library experience
 - Package Construction analysis
 - TID test
 - ESD test
- **Pre-Results**
- **Conclusion**

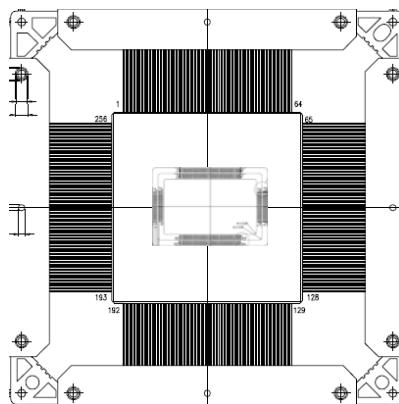
Project overview

- **Evaluation of the feasibility to develop and produce an ASIC having a proved capability for space use in a fabless approach, using a commercially available technology (UMC 0.18 µm CMOS), the Design Against Radiation Effects (DARE) library and a dedicated production and evaluation flow complying with the ESCC standards**
- **The 2 main outputs of the project will be :**
 - An evaluation plan summarizing the results of all the tests
 - An ASIC procurement & Qualification flow defining the tests to perform for guaranteeing highest space quality and reliability requirements for future DARE chips.
- **Design selected is the Aeroflex-Gaisler LEON3-FT**
- **Responsibilities:**
 - Thales Alenia Space ETCA (B) - Prime
 - Project management
 - Validation and evaluation testing
 - Aeroflex Gaisler (SE)
 - LEON3-FT processor design
 - IMEC (B)
 - Layout generation and DARE library
 - Interface with ASIC wafer fab via MPW EUROPRACTICE run



- LEON3-FT core with MMU & 2x16 KB caches
- 2 SPACEWIRE links + CAN-BUS interface
- Memory Controller with EDAC supporting SDRAM-PROM-SRAM memories
- 16 GPIO + UARTs
- Max core frequency : 120 Mhz
- Max SpaceWire rate : 250 MBPS
- Max power consumption : 3 W

- DARE library (1.8V / 3.3V) – UMC 0.18 CMOS technology
- Full Custom CQFP256 with tie bar. Leads pitch 0.5
- Die dimension : 10 x 5 mm
- 430k equivalent gates



- Functional tests performed in application-representative conditions on **GAISLER GR-PCI-XC2V LEON PCI development board**



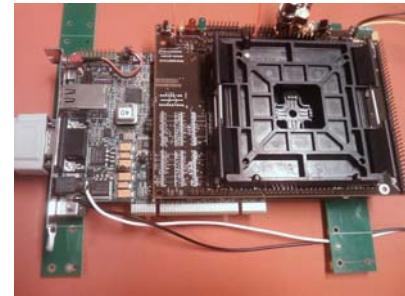
+



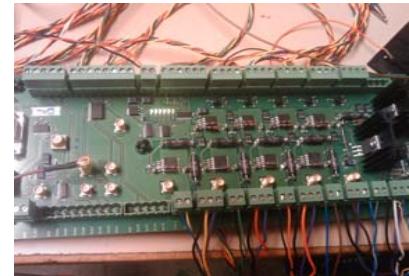
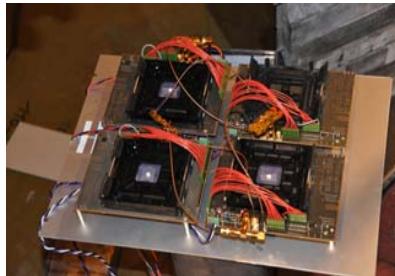
Or



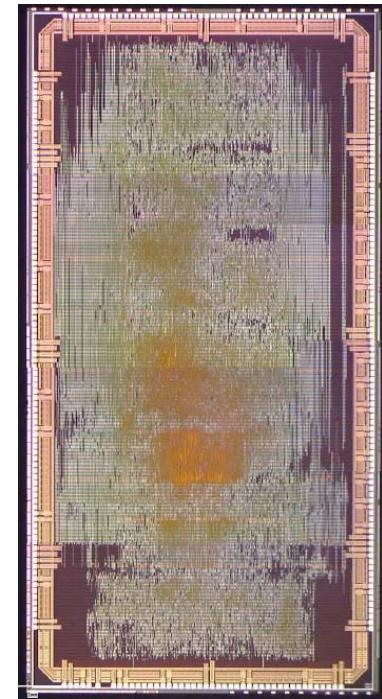
=



- Schlumberger tester at test house facilities (SERMA) for production tests.
- Dedicated ETCA test boards for evaluation and validation tests



- **Design / Layout / Manufacturing** ✓
- **ADR / PDR / CDR successful** ✓
- **Design validation**
 - Assembly & screening tests ✓
 - TID tests ✓
 - Heavy ions tests ✓
- **Evaluation tests**
 - ESD HBM test ✓
 - Package construction analysis ✓
 - Functionality verification over varying parameters (T°, Voltage,...)
 - Mechanical & thermal package tests
 - Die construction analysis
 - Thermal & power step stress tests
 - Life-test > 2000h & burn-in
- **Project end : September 2010**

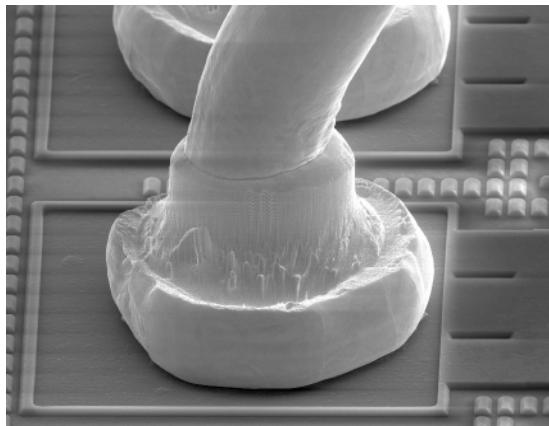
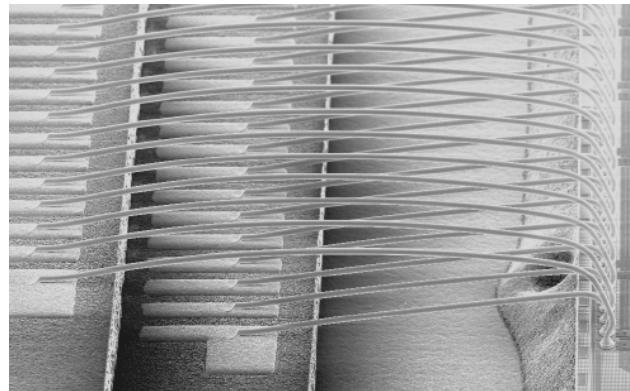


Results

- **149 parts produced and packaged into CQFP 256**
 - 7 parts rejected during assembly after visual inspection
 - 4 parts used for package constructions analysis & assembly trial
 - **138 parts electrically tested at 3 temperature (-55°C / +25°C / 125 °C)**
 - IO continuity tests.
 - Supply currents measurement (Iccsb, Iccop)
 - Static and dynamic parameters measurement (Vol/Voh/Vil/Vih,tplh,tphl)
 - Scan and functional tests
 - 124 passed the tests but after cache disabling (cache problem detected during electrical testing)
 - 14 failed the test
- ✓ **Excellent production yield (Manufacturing + Assembly + Production tests)**
⇒ +/- 85%

- **Risk on functionality of larger RAMs known at project start**
 - Large RAMs for caches on LEONDARE did not work correctly.
Smaller ones did.
 - Simulations of full RAMs showed problem. Solution identified.
 - Problem will be corrected in upcoming compiler version.
 - Workaround by not enabling the caches by software
- **Power consumption estimate complied with measurements after LVDS buffer consumption was taken into account.**

- Following **ESCC2269000**
- Performed on 3 parts, ball bonding
25 µm diameter gold wires.

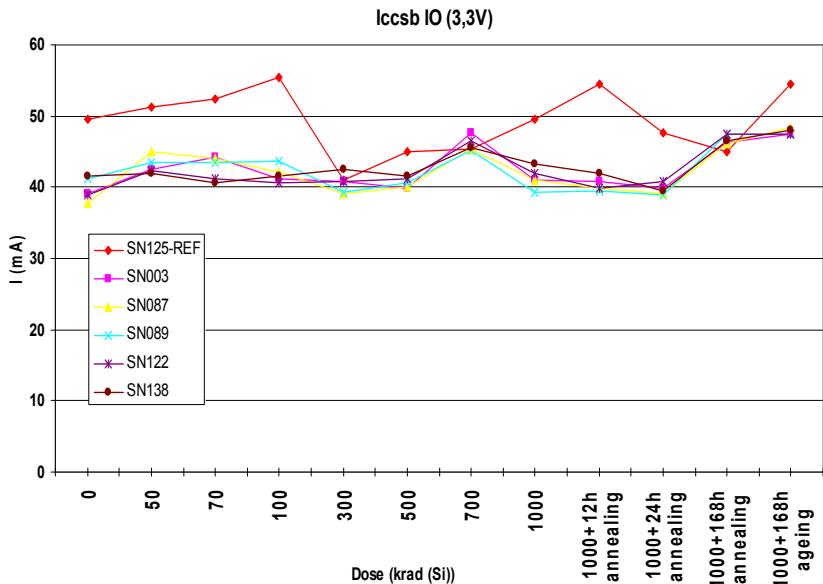


- **Results :**
 - No assembly defect was revealed
 - Internal connection were good
 - Wire pull & die shear test were correct

- Following ESCC22900

- Icc stand-by of the core :

- Stable until 100 krad(Si)
- Increase until 500 krad (Si)
- To decrease until 1 Mrad (Si)
- Fully recovery & functional after accelerated ageing at 100 °C

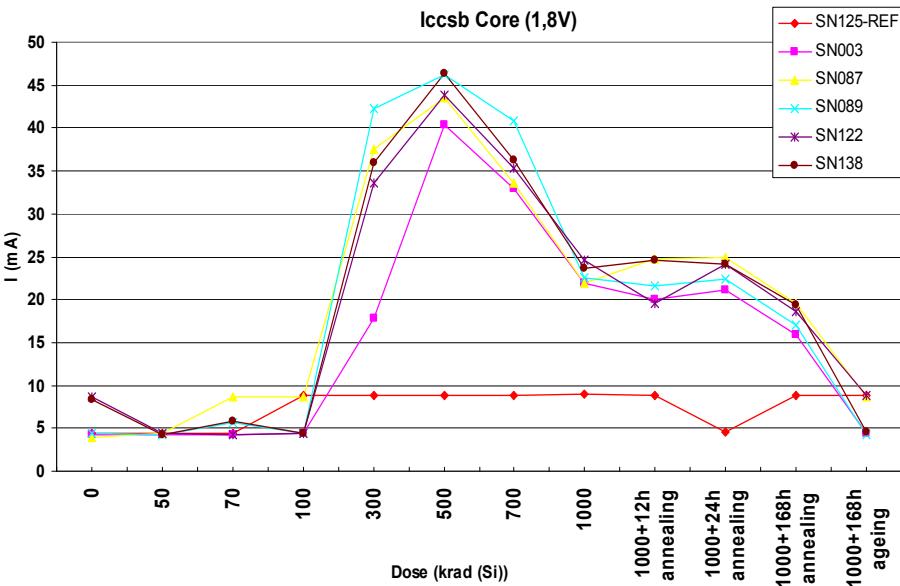


Thales Alenia Space ETCA

Ref : LEONDARE-ETCA-XR-0099

Date : 30 March 2010

Page 12



- Icc stand-by of the IO :

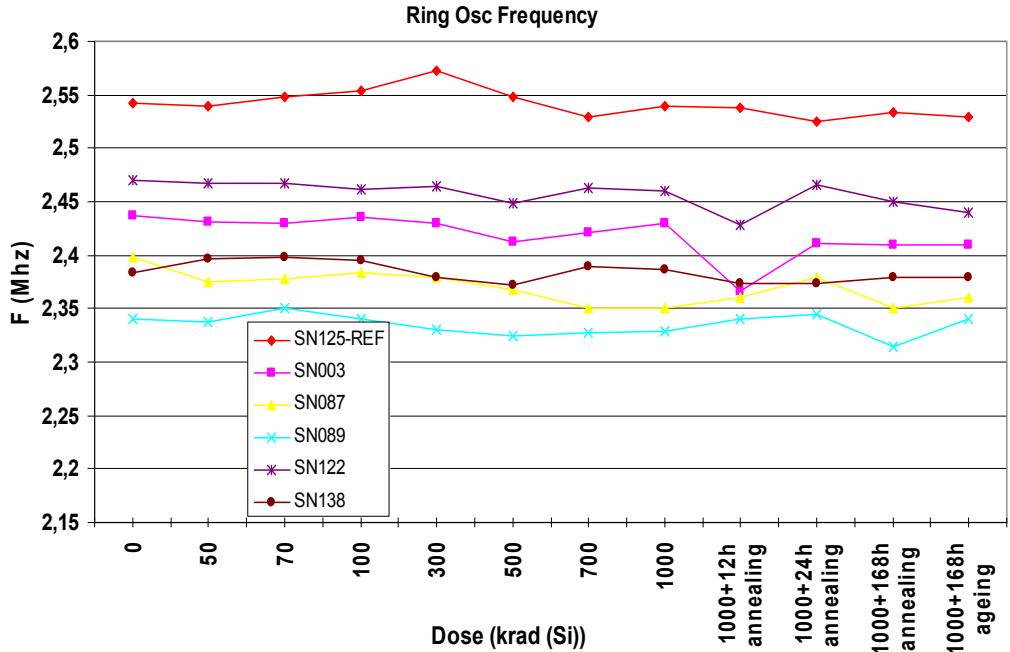
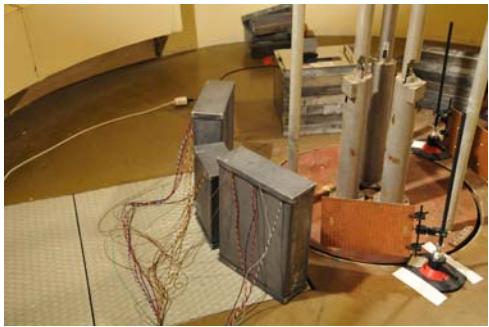
- Dominated by the LVDS buffers consumptions
- No significant evolution during the irradiation

THALES

All rights reserved 2010 © Thales Alenia Space

- **Timing drift :**

- Measure of an embedded ring oscillator
- No significant variations during and after irradiation



- Following ESCC23800 (MIL-STD883H Method 3015)
- DARE IO ESD protection embedded
- Human Body Model passed at 1 KV 2KV & 4 KV
- Post electrical tests passed after 1 KV 2KV & 4 KV

#SN82_hbm_4kv, Failure criterion is +/-20%															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
38	11	125	13	20	21	22	23	24	25	26	27	28	29	30	31
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196
196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211
211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226
226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256

Dev SN82: HBM Test Result at 4kV

⇒ ESD Class 3A (>4kV) device !

Pre-Results

- **Thermal step-stress test combined with a power step-stress test:**
 - First step at 150 °C and power max
- **First heavy ion test on December 2009:**
 - SEU hardening results seem good (LET th > 55Mev.mg/cm²)
 - Connector problem during the test campaign invalid the results
 - New test in May 2010

- The first results shows that DARE library using the commercial UMC 0.18 technology keeps one's promises as expected.
- The LEONDARE project confirms the possibility to take advantage of commercial technologies for the design of rad-hard ASICs.

Thales Alenia Space in Belgium



Charleroi

Tel. : + 32 (0)71 44 22 11

Fax : + 32 (0)71 44 22 00

etca.info@thalesaleniaspace.com

www.thalesaleniaspace.com