TESAT SPACECOM

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FM Qualification for Mixed Signal ASIC KNUT using the DARE Library

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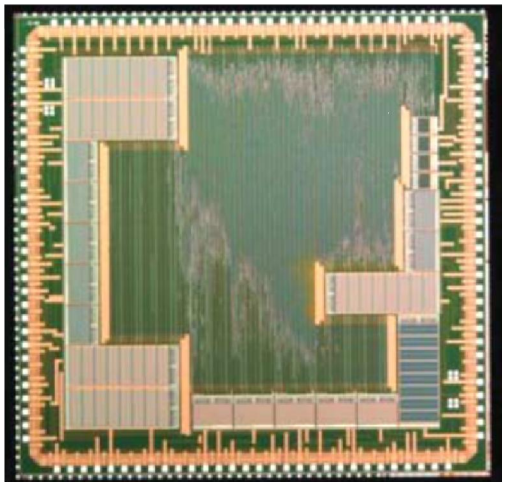
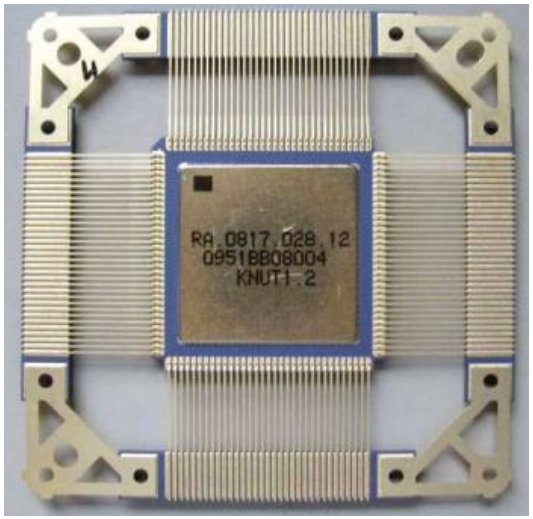
Volker Lück, Thomas Stanka , Hartwig Storm
Contact: Volker.Lueck@tesat.de

FM Qualification for Mixed Signal Dare Library ASIC

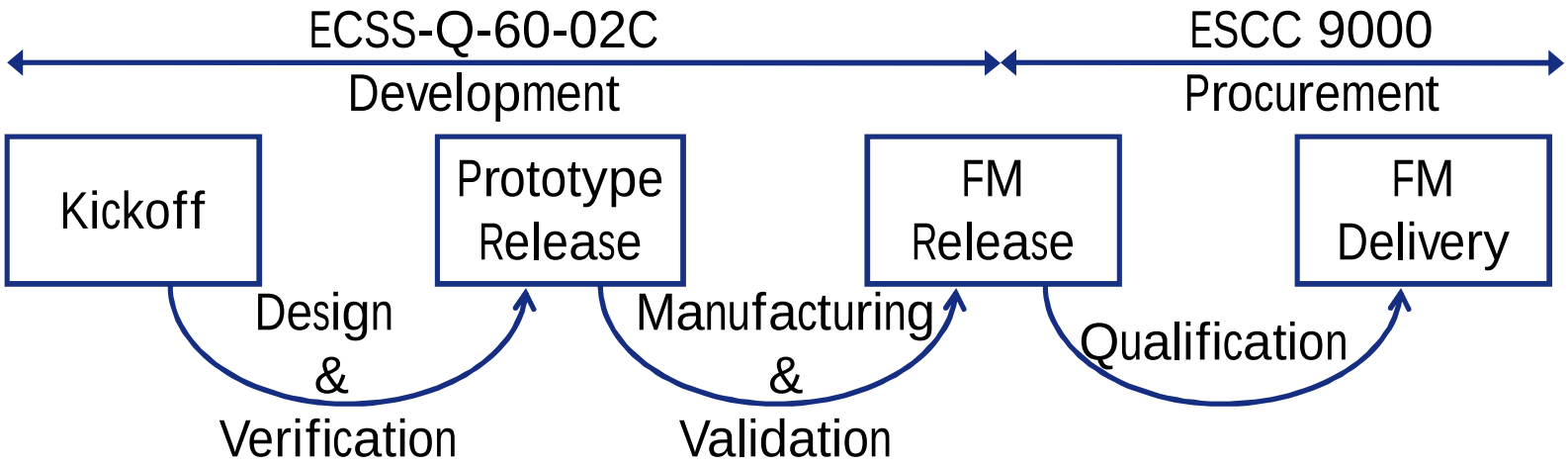
Agenda

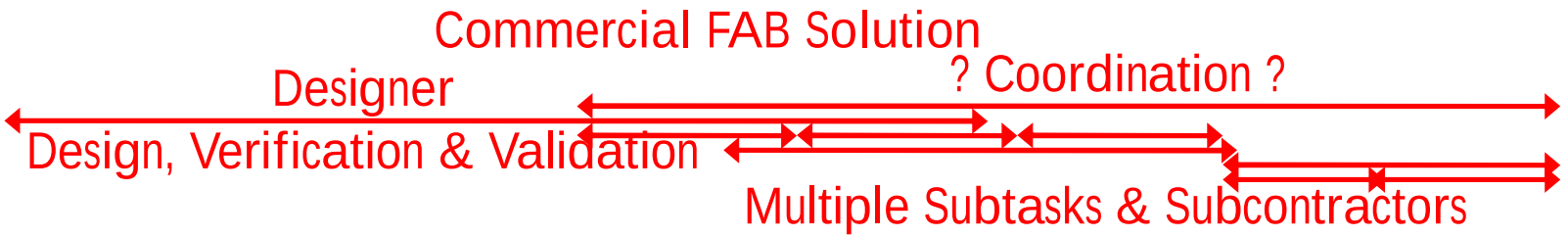
- Design & Qualification
- FM Qualification Flow
- The KNUT Solution & KNUT Decisions
- Knut Status and Results
- Comparison with qualified vendor flow
- Conclusions
- Acknowledgements



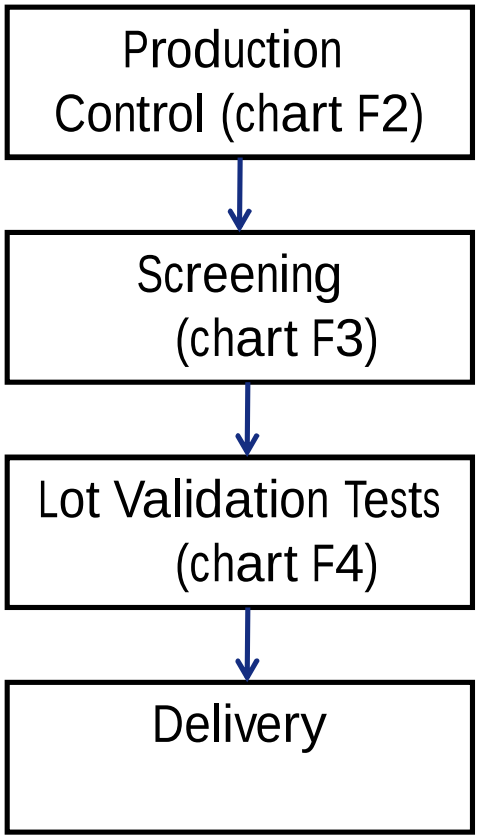


Design & Qualification





FM Qualification Flow



- Wafer Lot Acceptance
  Special In-Process Control

- Serialisation, Temp Cycling, Initial Measurements, Burn In, Final Measurements, Visual Inspections, Seal

- Environmental Subgroup Tests
- Endurance Tests (Lifetest)
- Assembly Subgroup Tests

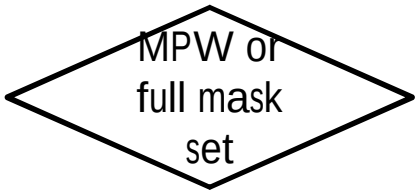
The KNUT Qualification Solution

Tasks to be performed

- Package and Socket design
- Device Assembly & Inspection
- Bond Pull tests and die share tests
- Waver testing
- Electrical test environment development
- Electrical measurements for characterization
- Electrical measurements for device selection
- ESD measurements
- Burn In board development
- Execution of burn in (screening)
- Preparation of radiation test measurement environment
- Preparation, execution and analysis of TID radiation tests
- Preparation, execution and analysis of SEE radiation tests
- Preparation, execution and analysis of life tests

These tasks were performed using 8 subcontractors

KNUT Decisions



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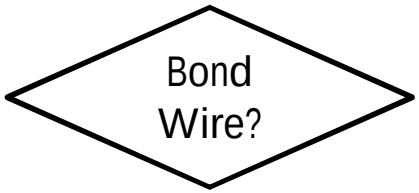
- # of devices, cost, schedule, regularity, yield, testability



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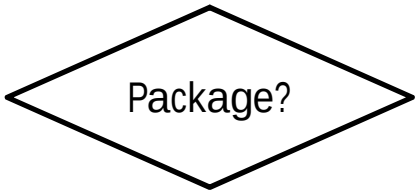
- Bond Material, Bond Wire Diameter, Bond Pad Size



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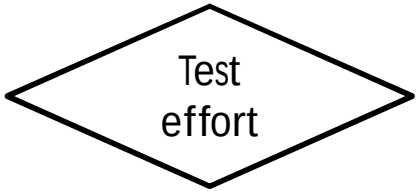
- COTS vs custom specific FM package, appropriate sockets, cost, schedule



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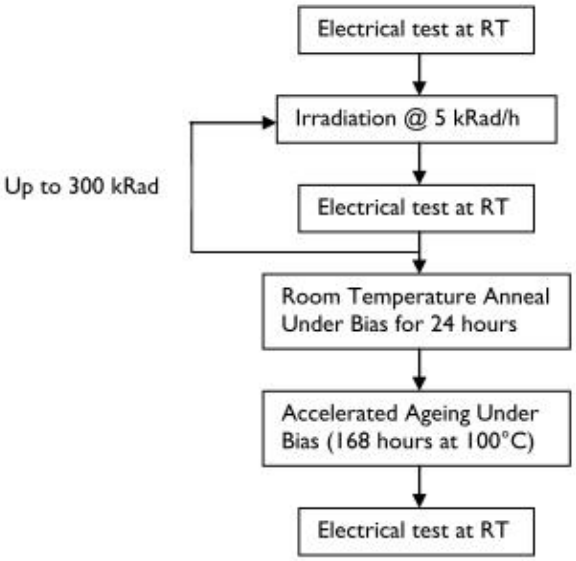
- Selection of test hardware, Test effort optimization, test hardware optimization

Design Decisions have strong impact on qualification effort!

KNUT Schedule

	2006	2007				2008				2009				2010			
	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Feasibility Study																	
Design & Manufacturing																	
Test																	
Rad. Tests																	
Knut 1																	
Design & Manufacturing																	
Test preparation																	
Test																	
Knut 2 (Redesign)																	
Design & Manufacturing																	
Test Preparation																	
Test																	
Screening																	
Lifetests																	
Rad.Tests																	

KNUT Qualification Results (Radiation TID)



- 10 devices irradiated
- Measurements for
  - static and dynamic power consumption
  - logical input and output levels
  - input leakage currents
  - DAC characteristics (INL, DNL, max/min current)
  - DAC characteristics (INL, DNL)

KNUT Qualification Results (Radiation TID)

- 1 devices showed increased core power consumption at 250 krad
- Input leakage showed no remarkable drift
- Input threshold voltage drift range of about 160 mV without monotonic behavior measured
- Few devices showed increase of DAC INL at either maximum or minimum reference current

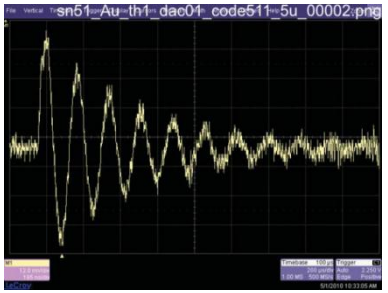
Digital as well as analog part can be used without any remarkable drift behaviour up to at least 200 krad

KNUT Qualification Results (Radiation SEE)

Ion	LET (MeV/mg/cm²)	Range in component (µm)	Inclination (°)
^{20}Ne	2.4	215	0
^{40}Ar	10.2	101	0
^{84}Kr	33.1	68	0
^{197}Au	110.3	35	0
^{129}Xe	55.7	68.7	0
^{129}Xe	70.1	44	30

- SEL tests performed at room temperature, 85 °C and 125 °C
- SET tests for DACs in 4 operation modes and 3 trigger levels
- SEU test performed using the scan chains of the digital section
- SET tests for ADCs combined with SEU tests due to readout functionality for digital results via scan chain

KNUT Qualification Results (Radiation SEE)



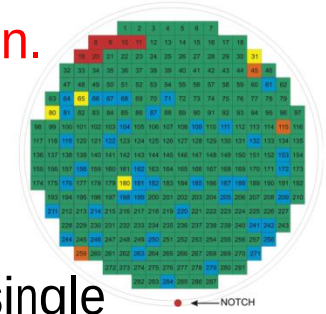
- No SEL detected up to 100 MeV/mg/cm²
- SETs on DACs with lowest trigger threshold starting at 70 MeV/mg/cm²
- SET on ADC starting at 2.4 MeV/mg/cm² @ 125 °C
  at 33 MeV/mg/cm² at room temperature
- SEU not easy to separate from SET of ADC but estimated to start not below 55 MeV/mg/cm²
- SEE cross section is about 10^{-6} cm² per device

Due to digital filtering of ADC outputs low SET threshold of ADCs is uncritical within the actual application.

Actual SEE tests show that due to design techniques the technology is well suitable for space applications.

KNUT Qualification Results

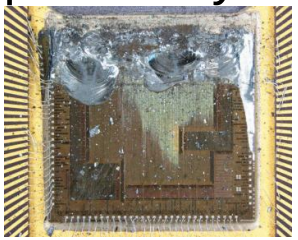
- Knut has been qualified successfully for its intended application.
- Chart F2 tests passed successfully.
- All detailed analyses were performed (SEM, vis. Inspection, ...)
- The device showed a TID capability of at least 200 krad.
  The weakest parameter was the static power consumption of one single device. (To be investigated)



- The SEE device cross section is about 10^{-6} cm² resulting in very low event probabilites. No SEL up to 100 MeV/mg/cm² were detected.

- Chart F3 tests also passed successfully.
- Initial yield was 96%, one device failed PIND, Power Burn In drifts within the range of measurement repeatability.
- Chart F4 tests passed successfully.
  Again drift measurements were within range of measurement repeatability.

Setup of tests for repeatability to be kept in mind especially for analog / mixed signal functionality!



KNUT Qualification vs. Qualified ASIC Vendor

KNUT

- Full Custom qualification solution with many subcontractors and high management effort.
- Full Custom infrastructure used for small quantity of devices only.
- Timely coordination of subtasks difficult
- Constraints of subtasks not known to all participants

Qualified ASIC Vendor

- Well known qualification flow, efficiently optimized.
- Reusable infrasturcture for time and effort intensive tasks.
- Reduced flexibility in terms of functionality.
- Bound to dedicated technologies.

Conclusions

- KNUT was successfully qualified for space applications.
  Designs using UMC process with DARE library and analog functions can be qualified according to ESCC 9000.
- Pure design and silicon manufacturing is rather cheep.
- There are partners available that support the choosen flow.
- These partners are specialists for their subtasks but beginners for the overall customer controlled FM qualification flow.
- Qualification effort for „full custom“ approach rather high.
- Management effort for subcontractor managment is rather high.
- Standardization could reduce cost and schedule for qualification and would allow competition between different service providers.

Acknowledgements

Thanks for the good support and collaboration to

- IMEC analog design, layout and subcontractor management
- UMC silicon processing
- HCM packaging, mechanical tests, inspections
- Microtest electrical tests, screening, life test, radiation tests
- Maprad radiation test facility
- Maser ESD/Latch-up tests, mechanical / environmental tests

and

- the audience for its attention