



Dependable VLSI Platform using Robust Fabrics

Director

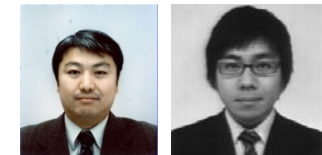
H. Onodera (Kyoto Univ.)

Principal Researchers

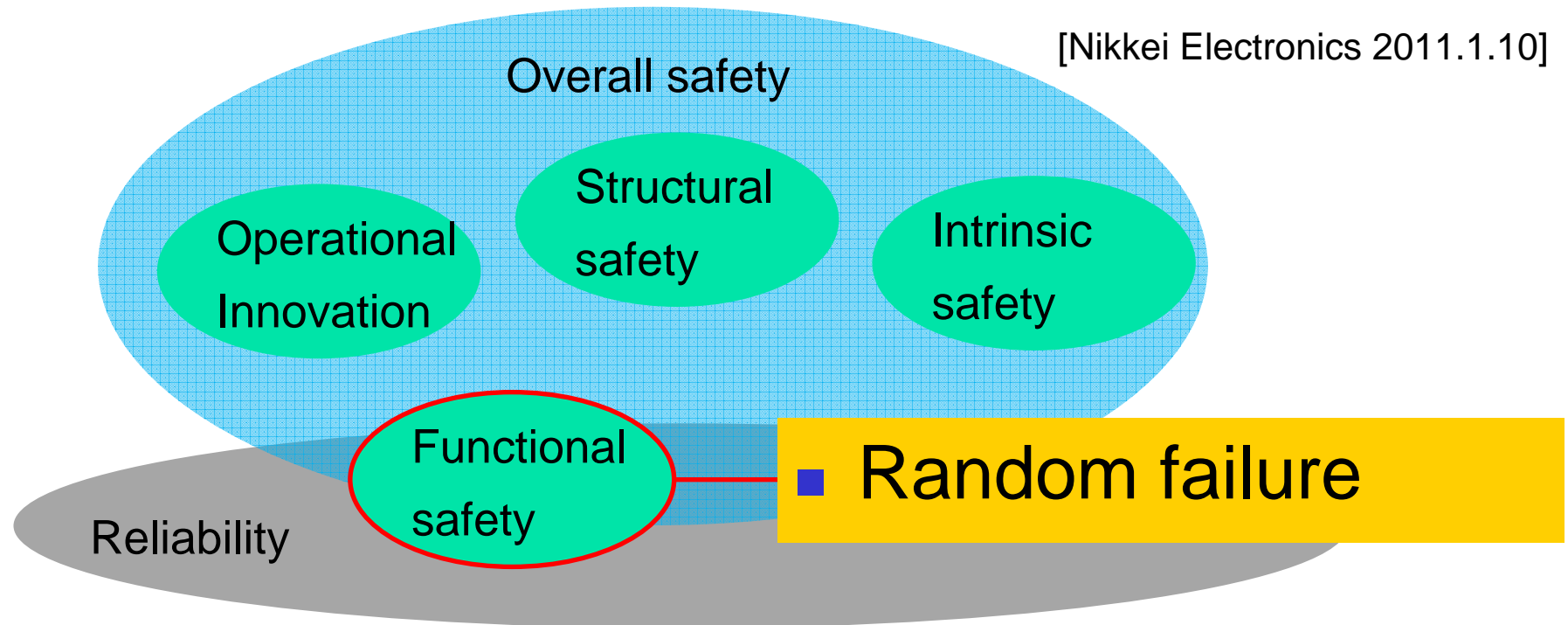
T. Onoye, Y. Mitsuyama, **K. Kobayashi**,
H. Shimada, H. Kanbara, K.
Wakabayashi

Whole Research Group

- Robust Fabric
 - Library-level Reliability
 - Onodera, Sato, Tsuchiya (Kyoto U.)
- Reconfigurable Architecture
 - FRRARY: Hardware-accelerator-level Reliability
 - Onoye, Hashimoto (Osaka U.), Mitsuyama (Kochi U. Tech)
- Reliable Processor
 - DARA: Processor-architecture-level Redundancy
 - BCDMR: Circuit-level Redundancy.
 - Kobayashi (Kyoto IT), Shimada, Yao (NAIST)
- Mapping Tools
 - Reliable Mapping
 - Ochi, Tsutsui (Kyoto U.)
- C-based Mapping Tools
 - Mapper for FRRARY
 - Wakabayashi, Takenaka, Noda (NEC)
- Applications
 - Dependability Evaluations and Applications for Reliability
 - Kanbara (ASTEM)



Our Approach to ISO26262



- For random failures ('soft-errors') and self-recovering.
 - FRRARY(cluster array for hardware accelerator)
 - DARA (processor core)
- To reduce random failures
 - BCDMR-FF (Robust Flip-Flop)

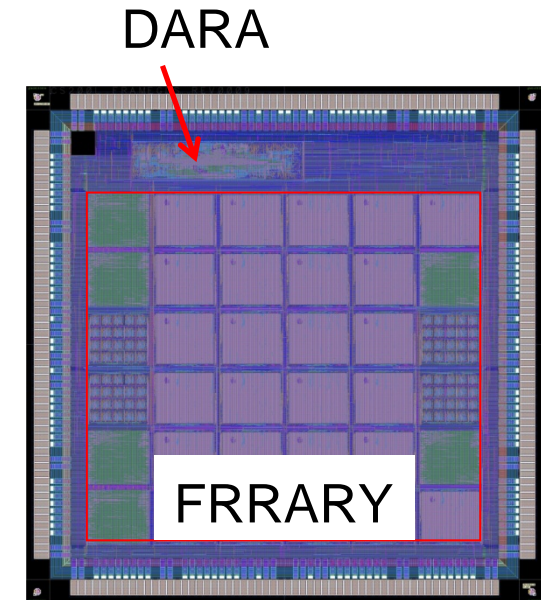
SoC for Dependable Platform

Functional Safety

- FRRARY (Flexible Reliability Reconfigurable Array)
 - Reconfigurable Hardware-accelerator-level Redundancy
- DARA (Dynamic Adaptive Redundancy Architecture)
 - Processor-architecture-level Redundancy
 - Pipeline-level Reliability Check

Reduce random failures

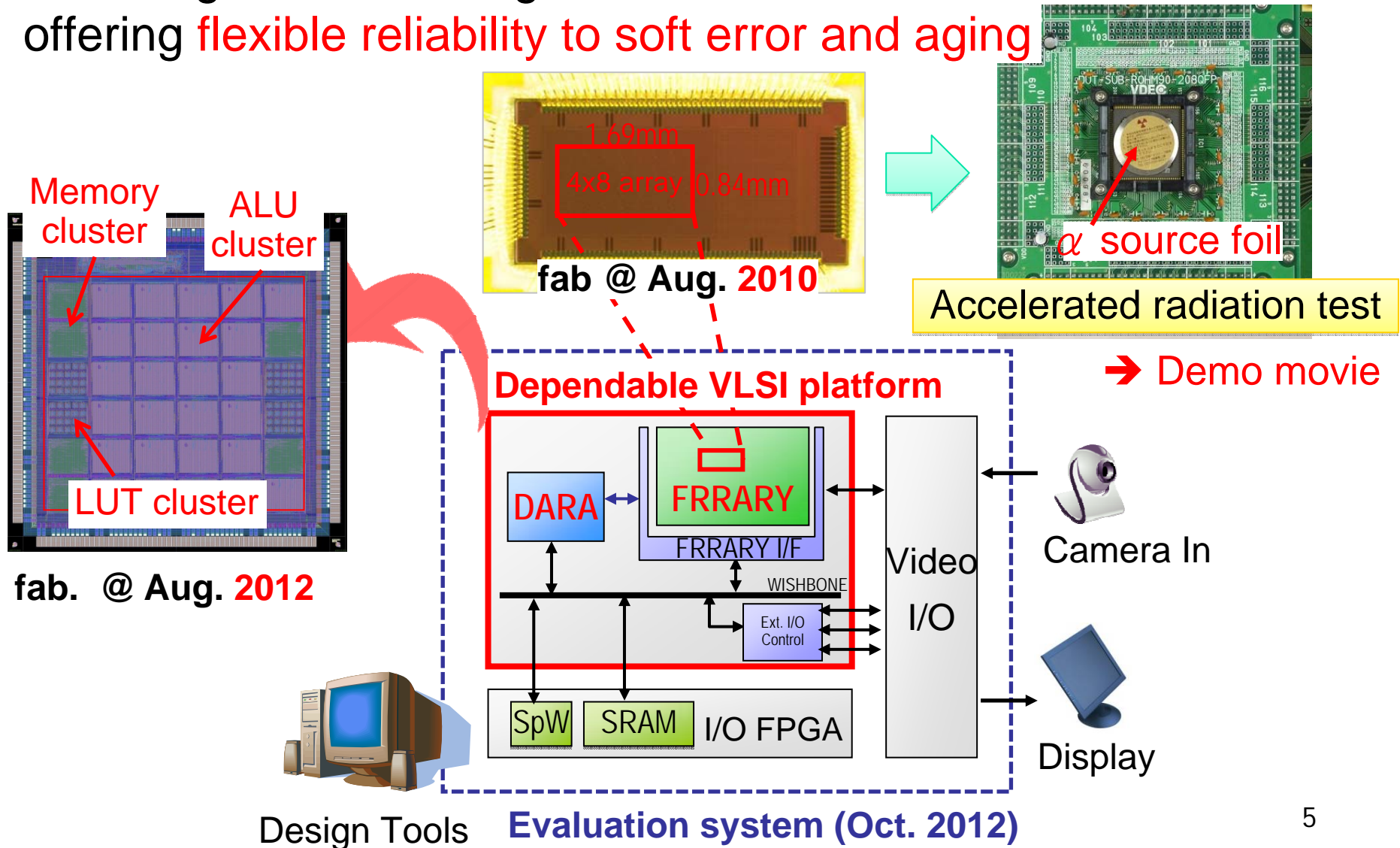
- BCDMR FF (Bistable Cross-coupled Dual Modular Redundancy FF)
 - Circuit-level Redundancy
 - Robust to alpha-particle and neutrons



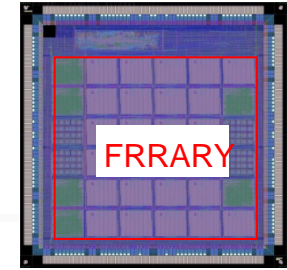
65nm 4mmx4mm Chip
Mar. 2012 TO, will be
fabricated Aug. 2012

Flexible Reliability Reconfigurable Array (FRRARY)

Coarse-grained reconfigurable architecture offering **flexible reliability to soft error and aging**



Advantages of FRRARY

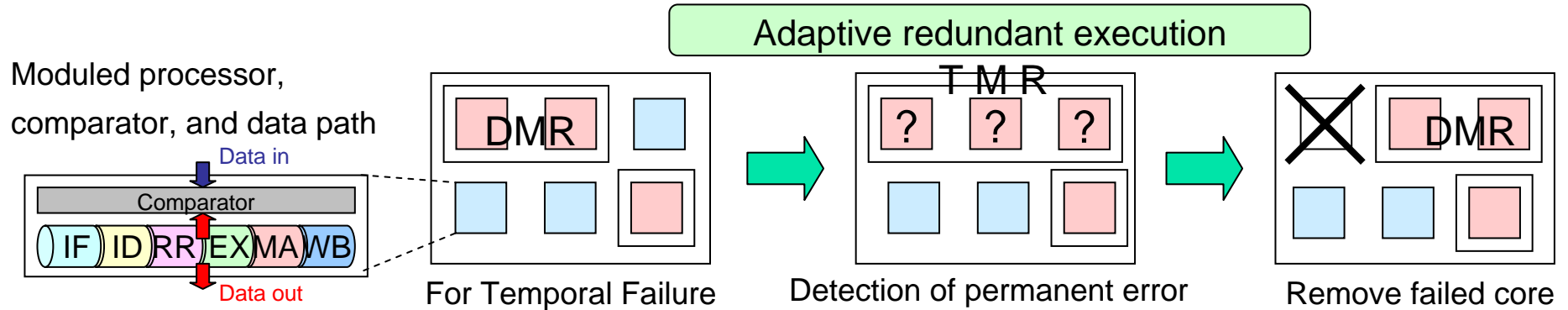


- Reconfigurable architecture-level Redundancy
 - Adaptively changes redundancy according to required reliability

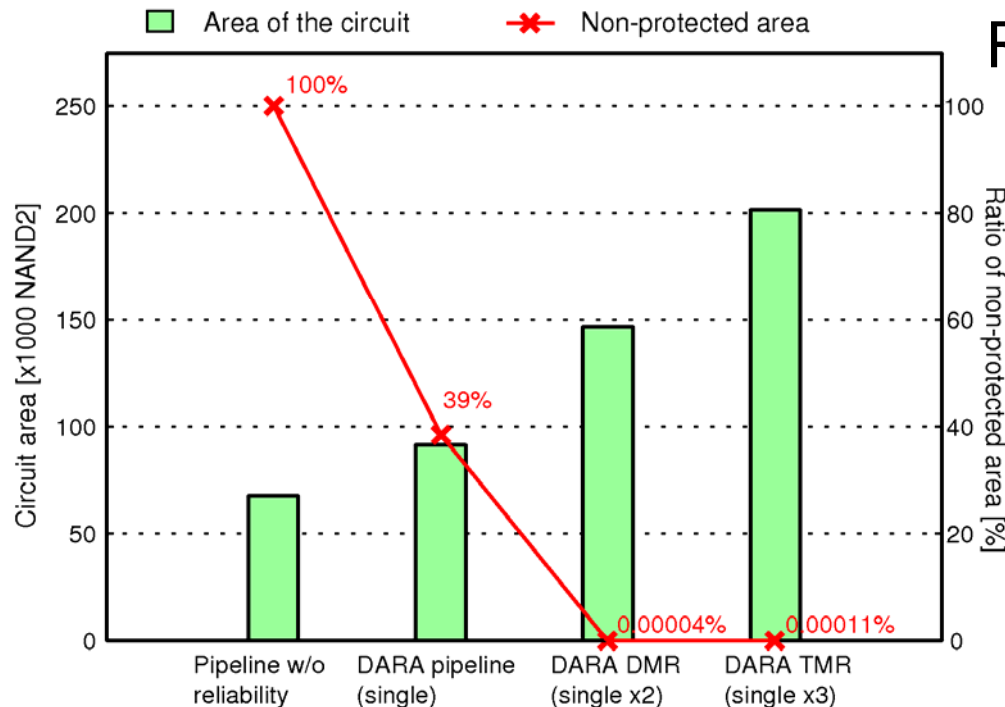


- Configuration data size is considerably smaller than that of FPGAs
 - Almost 1% of FPGAs → 100x soft error resiliency
- ➔ FRRARY can achieve **over 78000x** reliability

Reliable Pipeline Processor : DARA



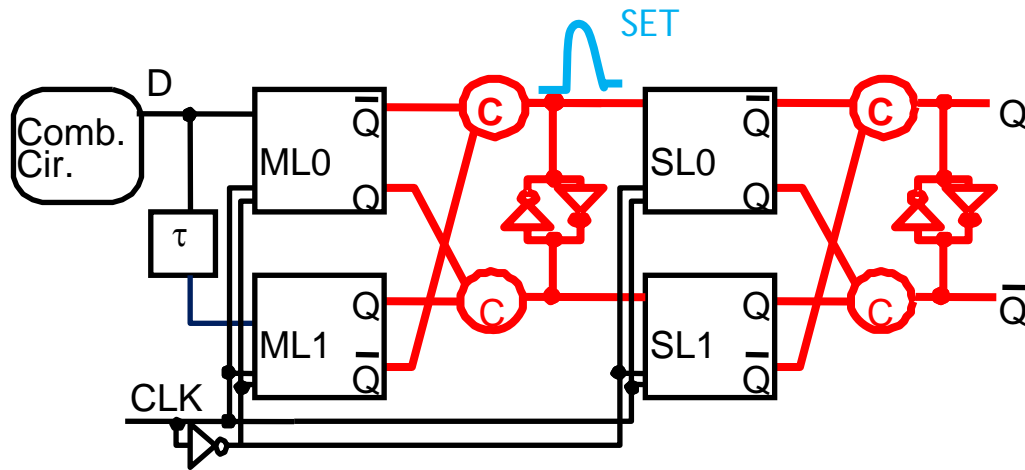
Area/Reliability Tradeoff



DARA: Dynamic Adaptive Redundant Architecture

- Duplicatable pipeline processor cores with comparators
- Adaptive Redundancy
 - DMR for temporal failure
 - TMR for permanent failure
- A test chip results using 180nm LSI
 - **360x** MTTF than single pipeline

Robust FF: BCDMR FF



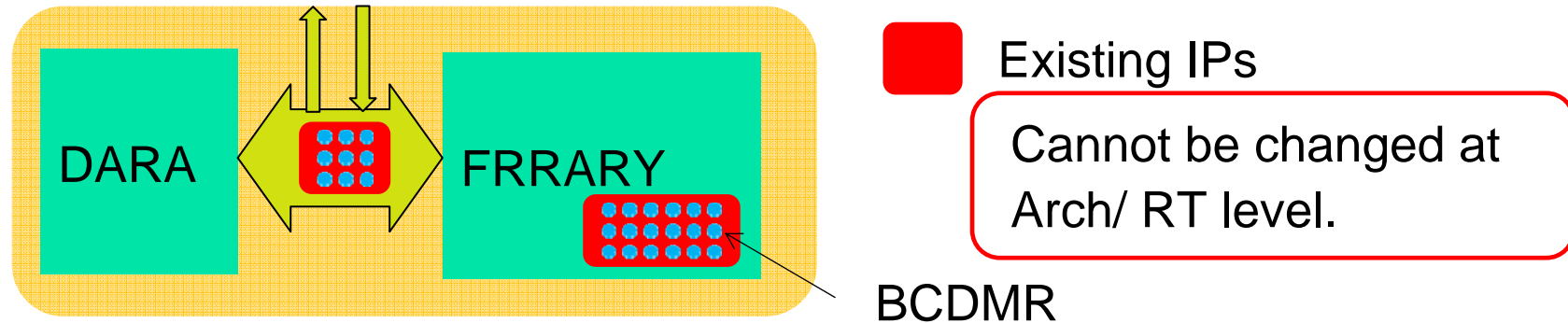
D-FF 1031FIT/Mbit

	well	Clock Freq.[MHz]			
		1	10	100	300
BISER	2	2	3	5	24
	3	1	1	6	12
BCDMR	2	0(<9)	260x	-	-
	3	3	2	2	-

Results from Neutron Irradiation (FIT/Mbit)

- Bistable Cross-coupled Dual Modular FF
 - Redundant FF for soft errors based on BISER (Intel, Stanford)
 - No error is observed in BCDMR on twin (2) well
 - 260x stronger than D-FF

Flexible but Dependable Platform



$$\text{Dependability} = \min(\text{FRRARY}, \text{DARA}, \text{BCDMR})$$

A weak component dominates **Dependability**

- DARA: Processor-level Dependability
- FRRARY: Reconfigurable Dependability
- BCDMR: Circuit-level Dependability
 - Whole circuit cannot be protected by architecture & processor-level

Summary

- Our Approach
 - FRRARY+DARA
 - Functional Safety
 - BCDMR FF
 - Reduce rate of random failures

Dependability = $\min(\text{FRRARY}, \text{DARA}, \text{BCDMR})$

= $\min(78\text{k}, 360, 240)$

= at least **240x** dependability

Architecture to Circuit-level (Overall) dependability

Brand-new Report from DAC2012



DAC community takes care of Dependability

■ Panel Discussion

- “Will Reliability be the Death of Moore's Law?”
 - Physical threats to dependability: Aging, Thermal Effects, Variability etc.

■ Two Oral Sessions

- “Facing Dependability: System-Level Solutions and Cybercar Challenges”
 - Run-Time Adaptivity rather than at lower abstraction
- “Yielding in an Uncertain World”
 - Solution below 22nm at manufacturing level