

Technologies for Wireless Sensor Networks - e Grain™

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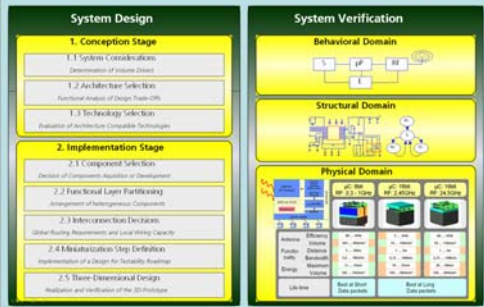


in cooperation with



Fraunhofer Institut Zuverlässigkeit und Mikrointegration

3D Design Methodology



Flexible Thin Film Interposer

- Wafer Level Processing
- Separation Layer
- Integration of passives R, L, C
- Foldable, stackable
- 3-D integration
- Polyimide dielectric with
 - 4 Cu metal layers
 - Ni/Au bond pads

Size: 9,8 mm x 31,2 mm x 35 µm
Components: 2 IC, 2 sensors, Passives

Assembly

Ultra Thin Flip Chip Interconnects

Thermal cycles: -55 / +125°C

Specifications:

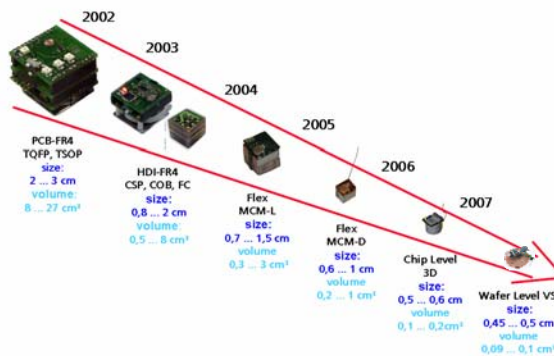
- 50 µm IC (Si) / 5µm Ni(Au) bumps
- 25 µm PI Flex with Cu (NiAu) met.
- ACA, 10 µm Ag particles

Ultra thin ~10 µm

Wafer Level Batteries

- Thin effective encapsulation;
- High degree of miniaturization → increasing energy density
- Battery system: Li₂C₂ / Li₂ / (Ni)CoO₂
- Wafer level lamination process
- Thin film encapsulation (8 µm) by means of polymer/metal layer ⇒ Polyene C / aluminum
- Parameter:
 - Voltage: 3,6 V
 - Energy density: 106 mWh

e Grain Roadmap



Energy-efficient Networking

- Wireless sensor nodes are battery-driven
- Main problem with multi-hop networks of such nodes:
 - ⇒ Current communication protocols have costly overhead
 - Nodes are mostly in idle listening mode
 - Do not consider tradeoff of required protection/spatial reuse

Existing wireless multi-hop network with brightness sensing

Low Power RF Frontend

2.45 GHz Wake-up Circuit

- RF-frontends activation on demand
- Currentless detection of wake-up signals (<<1 µA)
- Omnidirectional wake-up antenna

24 GHz RF Circuits

- GaAs-HBT MMIC technology
- Oscillator (VCO) with 19% efficiency (SoA: 10%), 4 dBm RF output at 15 mW DC
- Down converter unbalanced
 - I_{dc}=3mA@3 V, Conversion Gain: 7.5 dB
- Upconverter LO balanced
 - I_{dc}=4 mA@3 V, Conversion Gain: 10.7 dB

Antenna

4 Sector Antenna for Communication

- Slot radiator in flip chip technology
- 3D Package
- Integrated 24 GHz GaAs MMIC

Single Antenna for Communication and Wake-up

- Mini-loop principle in microstrip/Flex technology
- Patch antenna with 18 dB front-to-back ratio
- Omni directional
- 2,45 GHz
- adjustable emissions direction, Gain 9 dBi

Folded Patch for Wake-up

Applications

- Smart buildings
- Smart grids
- Smart agriculture
- Smart transportation
- Smart healthcare
- Smart security
- Smart industry
- Smart energy
- Smart environment
- Smart infrastructure
- Smart cities
- Smart manufacturing
- Smart logistics
- Smart retail
- Smart education
- Smart entertainment
- Smart sports
- Smart tourism
- Smart agriculture
- Smart forestry
- Smart fishing
- Smart mining
- Smart oil & gas
- Smart power
- Smart water
- Smart waste
- Smart recycling
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