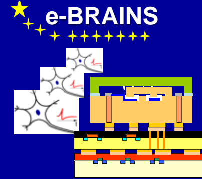
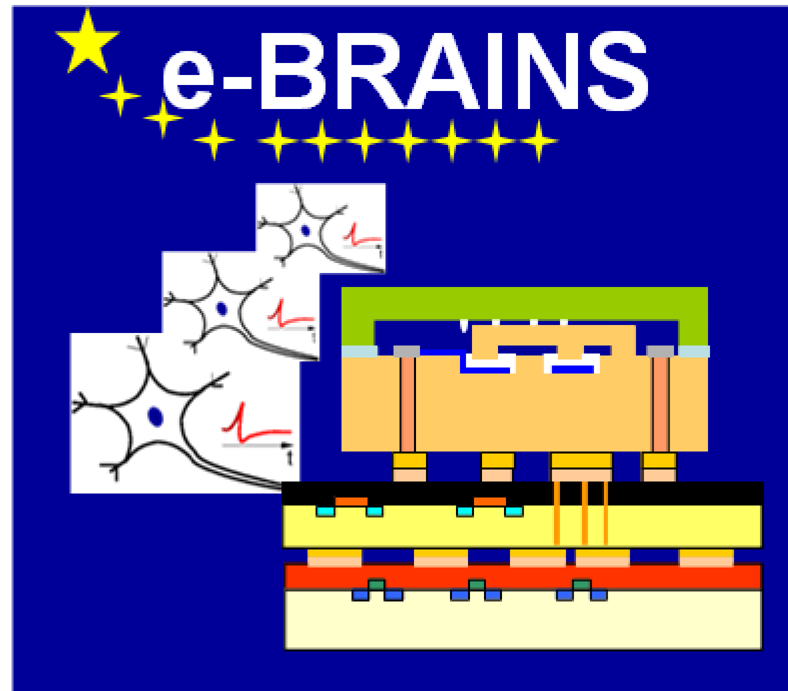
Best-Reliable Ambient Intelligent Nanosensor Systems by Heterogeneous Integration





3D Workshop
ESREF 2012 ,
Cagliari Italy
Reinhard Pufall
Infineon Technologies AG

Dr. Reinhard Pufall, Infineon
Dr. Klaus Pressel, Infineon

Project Presentation
Outline

- Project resources
- Project partners (consortium)
- Project structure (components)
- Strategic objectives of the project
- Technological objectives of WP1 and WP2
- Innovative applications (WP3)
- Methodology for Reliability and Robustness
- Conclusions

Project history (co-ordinator Infineon)

e-BRAINS

2009-03-07 e-CUBES Review meeting in Leuven (BE)

2009-08-19 e-BRAINS was presented in Brussels (Mr. Bonas-Villanova)

2010-01-13 Hearing in Brussels
(Francisco IBANEZ GALLARDO)

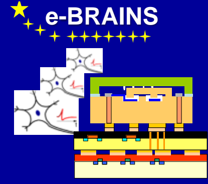
2010-07-14 Signed contract EU-Infineon

2010-08-10 Signed consortium agreement

2010-09-01 Change of Consortium leader
(Werner Weber hands over to Reinhard Pufall)

2010-09-07 e-BRAINS kick-off meeting in Munich

Project resources
IST-257488



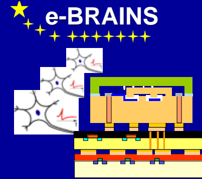
Best-Reliable Ambient Intelligent Nanosensor Systems by Heterogeneous Integration

- **20** partners from **9** European countries
  - **8** major European system manufacturers
  - **4** SMEs (small and medium enterprises)
  - **5** large research institutes
  - **3** Universities

- Total budget is **€ 15.24 Mio**, requested grant **€ 9.86 Mio**

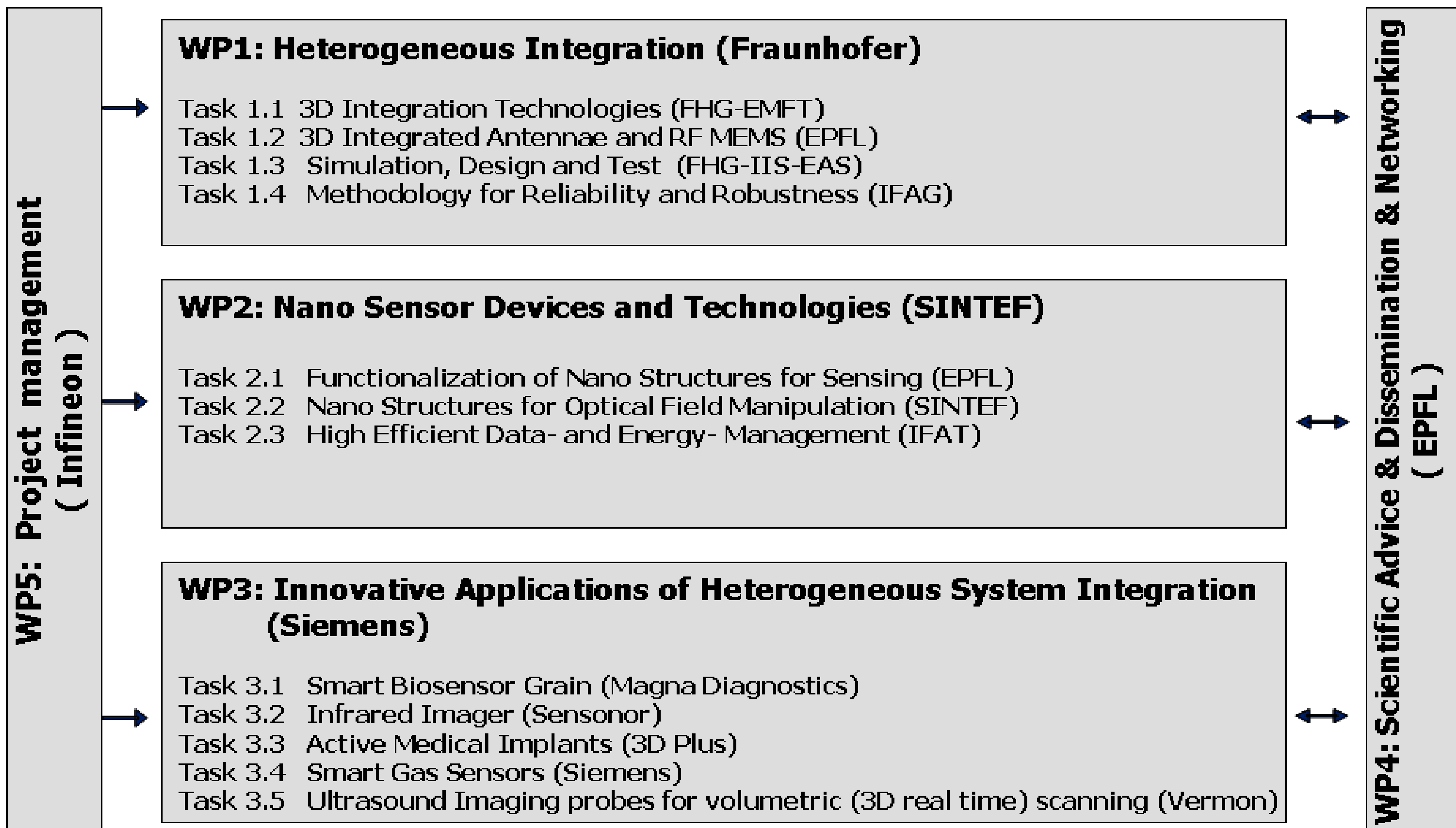
- Project started on **1st Sept 2010,** runs for three years until **Aug 2013**

Initial consortium



No	Name	Short name	Country	Project entry month[10]	Project exit month
1	INFINEON TECHNOLOGIES AG	IFX	Germany	1	36
2	STIFTELSEN SINTEF	SINTEF	Norway	1	36
3 **21**	DICE Danube Integrated Circuit Engineering GmbH & Co KG	DICE **DMCE**	Austria	1	36
4	SensoNor Technologies AS	Sensonor	Norway	1	36
5	INFINEON TECHNOLOGIES AUSTRIA AG	IFAT	Austria	1	36
6	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	Tyndall-UCC	Ireland	1	36
7	MAGNA DIAGNOSTICS GMBH	MAGNA	Germany	1	36
8	3D PLUS SA	3D PLUS	France	1	36
9	TECHNISCHE UNIVERSITAET CHEMNITZ	TUC	Germany	1	36
10	ELA MEDICAL SAS	SORIN	France	1	36
11	ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE	EPFL	Switzerland	1	36
12	VERMON SA	VERMON	France	1	36
13	INSTYTUT TECHNOLOGII ELEKTRONOWEJ	ITE	Poland	1	36
14	SIEMENS AG	SIEMENS	Germany	1	36
15	FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V	Fraunhofer	Germany	1	36
16	TECHNISCHE UNIVERSITAET GRAZ	TU Graz	Austria	1	36
17	INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM VZW	IMEC	Belgium	1	36
18	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	France	1	36
19	eesy-id GmbH	EESY-ID	Germany	1	36
20	IQE Silicon Compounds Ltd	IQE SILICON	United Kingdom	1	36

Project components



Strategic objectives (1)

Integration of heterogeneous technologies (such as CMOS, bipolar, advanced memories, MEMS/NEMS, …) with 3D integration technology

- **High-performance sensor devices**
- **Miniaturization**
- **Wireless communication**
- **Best-reliability**

Encourage product designers to apply advanced nano technologies (nano must fulfil certain reliability requirement)

Strategic objectives (2)

- Enable Heterogeneous integration
- Use 3D integration wherever possible
- Enable Nano Sensors for integration
- Make reliability assessable
- Use for Ambient Assisted Living
- Build Wireless Sensor Systems
- Build Heterogeneous Systems
- Miniaturization
- Develop methodology for reliability and robustness.

e-BRAINS benefits from the established European 3D technology platform of e-CUBES

Expected benefit enabled through heterogeneous integration

Innovative Applications of Heterogeneous System Integration	Form factor	Sensitivity, efficiency	Power reduction	Cost reduction
TASK3.1 Smart Biosensor Grain	**3-5 x**			
TASK3.2 Infrared Imager	**6 x**	**2 x**	**1 x**	**5 x**
TASK3.3 Active medical implants	**16 x** 8 cm^3-> 0.5 cm^3			Follow-up cost, drastic reduction
TASK3.4 Smart Gas Sensors	**1000 x** 25 x 14 x 6 cm3 -> 1 x 1 x 1 cm3	**20 x**		**20 x** 200€ ->10€
TASK3.5 Ultrasound Imaging probes for volumetric (3D real time) scanning	**50 x** 250cm^3 -> 5cm^3	**2 -10 x**	n.a	**4 x** (PU from 3000$ to 750$)

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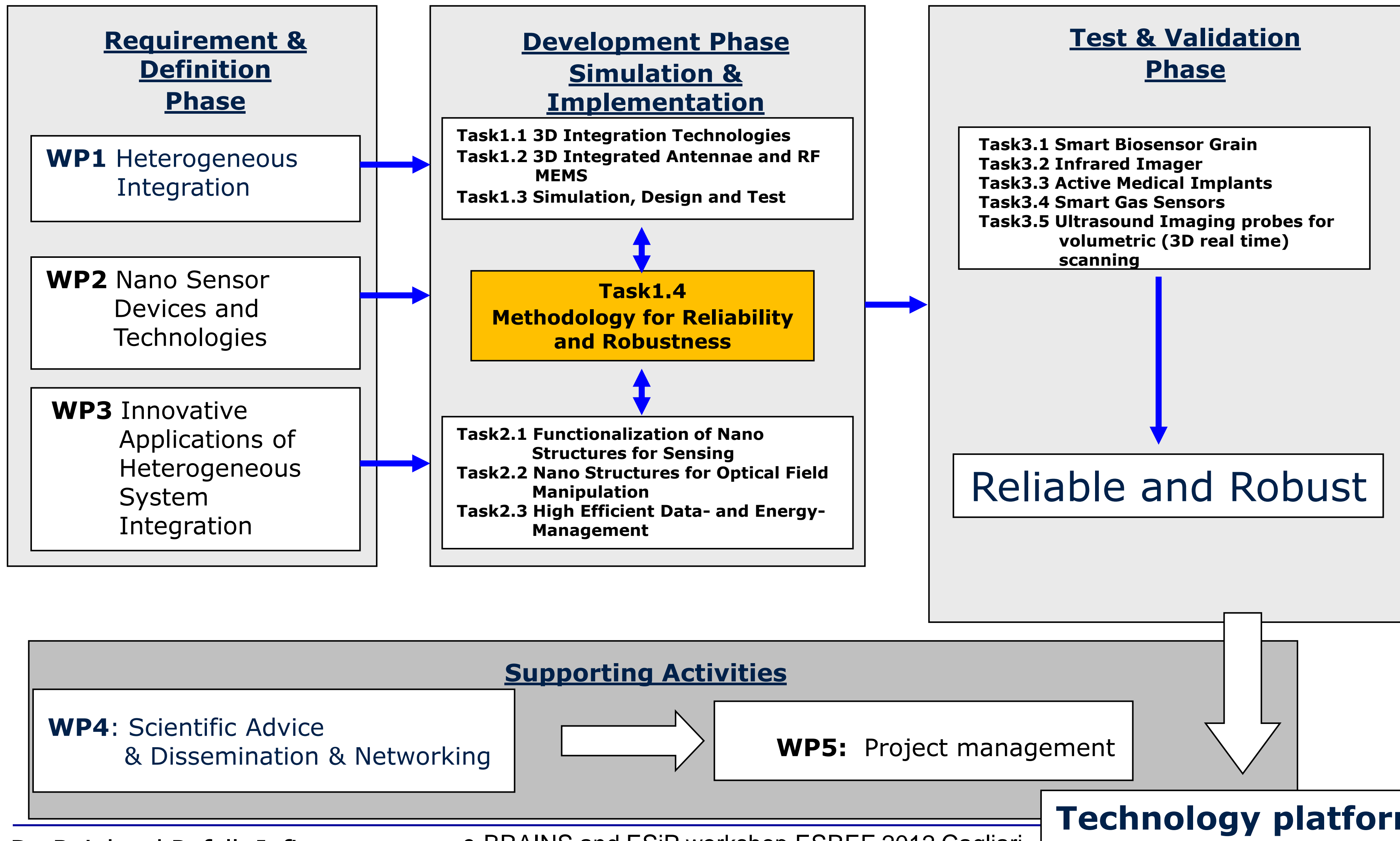
Dr. Klaus Pressel, Infineon

Interaction between technology and heterogeneous integration considering reliability as key factor



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Heterogeneous Integration

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WP1 → Task 1.x → Sub-Task 1.x.x

Task 1.1
3D Integration Technologies

Task 1.2
3D Integrated Antennae and RF MEMS

Task 1.3
Simulation Design and Test

Task 1.4
Methodology for Reliability and Robustness

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WP2 → Task 2.x → Sub-Task 2.x.x

Task 2.1 Functionalization of nano structures for sensing

Task 2.2 Nano structures for optical field manipulation

Task 2.3 High efficient data- and energy management

WP3 → Task 3.x

Task 3.1 Smart Biosensor Grain

Task 3.2 Infrared Imager

Task 3.3 Active Medical Implants

Task 3.4 Smart Gas Sensors

Task 3.5 Ultrasound Imaging probes for volumetric (3D real time) scanning

Scientific Advice & Dissemination & Networking

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WP4 → Task 4.x

Task 4.1
Dissemination and Scientific Advice

Task 4.2
Networking

Task 4.3
Training

Heterogeneous Integration

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WP1 → Task 1.x → Sub-Task 1.x.x

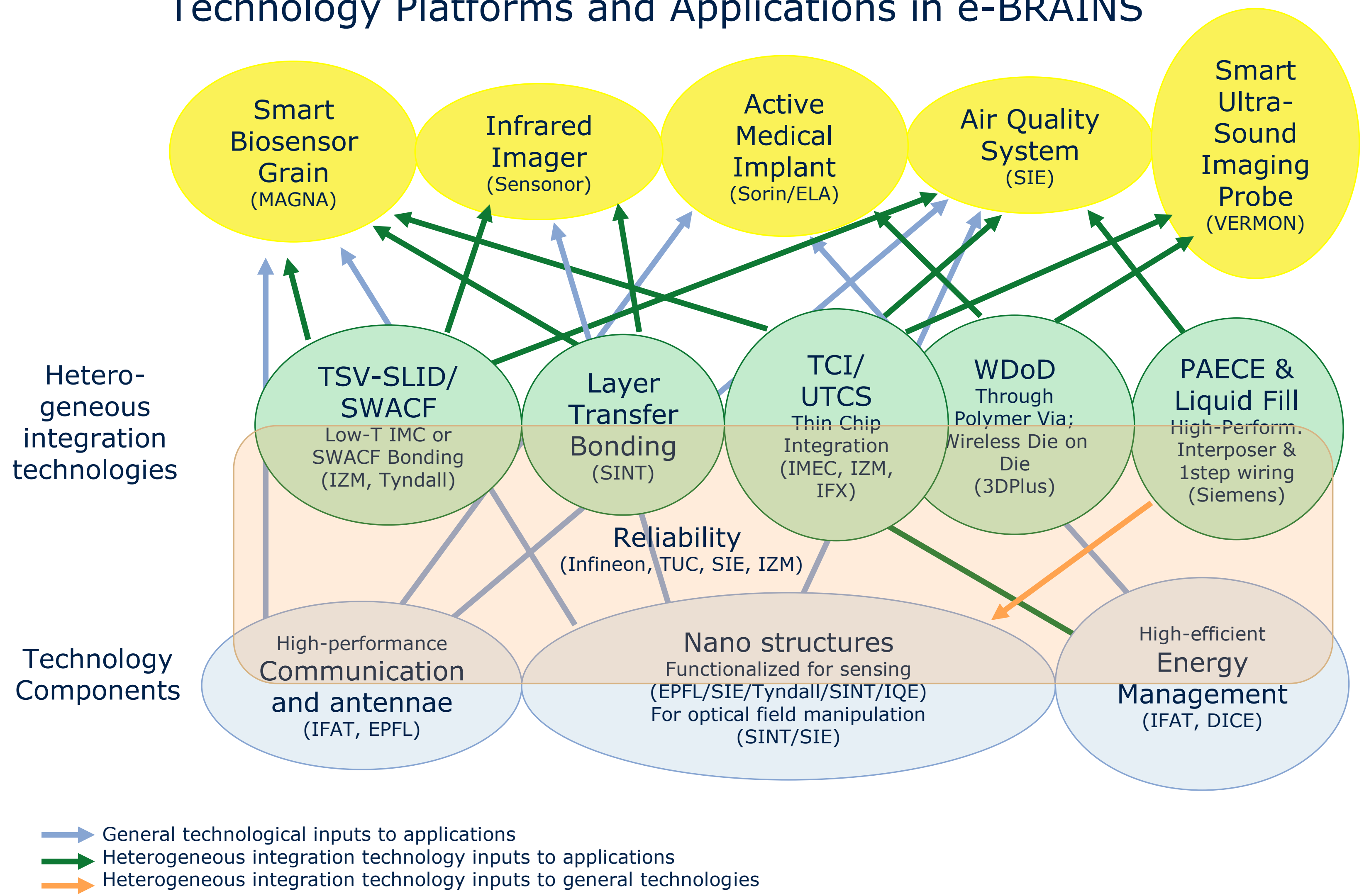
Task 1.1
3D Integration Technologies

Task 1.2
3D Integrated Antennae and RF MEMS

Task 1.3
Simulation Design and Test

Task 1.4
Methodology for Reliability and Robustness

Interaction between technology and heterogeneous integration



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Need for methodology for reliability and robustness impact of temperature on product lifetime

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Use conditions

Cap-Chip (Wafer)
MEMS/NEMS Device possibly with TSV
Advanced bonding system (Stacking2)
Metallisation System 2
IC Device 2 (Technology 2) with TSV
Advanced bonding system (Stacking1)
Metallisation System 1
IC Device 1 (Technology 1)

T
ΔT
grad T

T: mean temperature
ΔT: temperature swing
grad T: local temperature distribution

Temperature depends on time and location

Very high impact on thermal mechanical performance (thermal mismatch)

TASK1.4 Methodology for Reliability and Robustness (IFX)

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Quantify Adhesion

- Determine fracture toughness (cohesive and adhesive)
- 4. point bending
- Button shear test
- Simulation for prediction

Crack Detection

- When (0h or after stress)
- Which feature size for detection necessary
- Nano sensor technology?

Degradation Progress

- Interdiffusion of metals
- Ageing of anisotropic films for interconnects
- Ageing of adhesives
  - polymers
  - glues
  - encapsulants

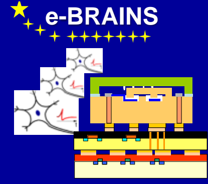
Precision Measurement

- Very good spatial resolution
- AFM (atomic force
- X-ray tomography
- µ-Raman spectroscopy

Partners involved
Bi-weekly meeting

Infineon, TUC, Tyndall
IMEC, Siemens, EMFT

TASK1.4: Methodology for Reliability and Robustness (IFX) is divided into Sub-Tasks



Sub-Task 1.4.1: Develop methods to make reliability assessable

Sub-Task 1.4.2: Study degradation mechanisms based on physics of failure

Sub-Task 1.4.3: Develop lifetime models and simulation models for the prediction of degradation under use conditions

Sub-Task 1.4.4: Develop highly accelerated stress tests (i.e. combined tests) to detect weaknesses quickly

Methodology for Reliability and Robustness Conclusions

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- Encourage product designers to apply advanced nano technologies (nano must fulfil certain reliability requirement)

- Reliability is the key factor for innovation in new applications