CARAC 2019 6th edition

November 28th-29th 2019 | Grenoble

the event dedicated to the material characterisation for industry

Platform for Advanced Characterisation Grenoble PAC-G

Supported by the French government under the IRT Nanoelec Investissements d'avenir economic stimulus package, (reference ANR-10-AIRT-05).

Rafael Varela Della Giustina,

Business developer engineer PAC-G

varela@ill.fr

+33 457428077

NANOELEC. PLATFORM FOR ADVANCED CHARACTERISATION GRENOBLE

With the support of:

The PAC-G: an unique framework

Single entry point for characterization services, dedicated to micro- and nano-electronics industry

Supported by the French government under the IRT Nanoelec Investissements d'avenir economic stimulus package, (reference ANR-10-AIRT-05).

The PAC-G: an unique framework

Single entry point for characterization services, dedicated to micro- and nano-electronics industry

The ESRF: the most intense synchrotron generated light in the world

ESRF – Grenoble, France

A research facility unique worldwide

- ✓ **N.1** in **scientific output**
- ✓ **Over 25000 articles** referencing the ESRF
- ✓ **6,500 scientific visitors** every year including **4,000 users**
- ✓ **2,000 proposals** per year: **900 accepted**, 1,550 experimental sessions
- ✓ **30%** of the research involves **industrial developments**

The PAC-G: an unique framework

Single entry point for characterization services, dedicated to micro- and nano-electronics industry

The ILL: ILL is the most intense neutron source in the world

1400 users from an active community of 12 000 scientists

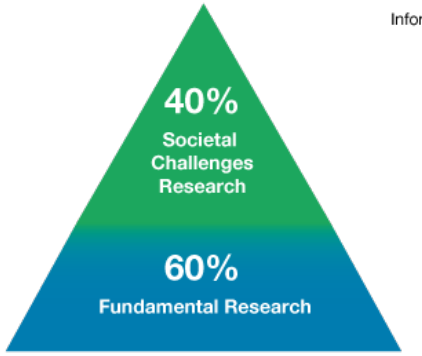
850 experiments/year

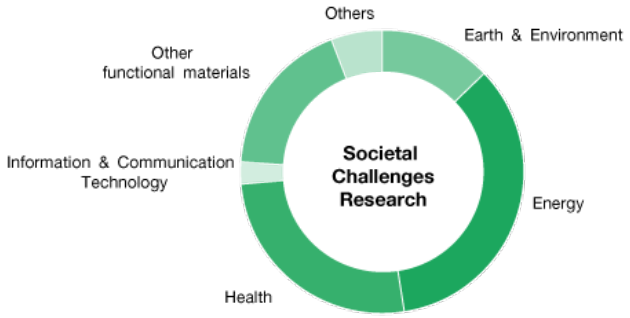
650 publications/year

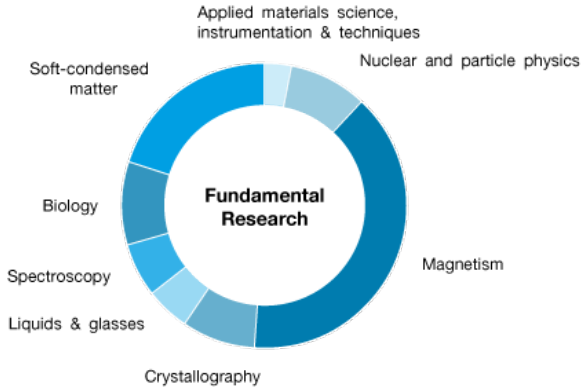
38 countries

28 instruments + 10 CRG

4 cycles of 50 days/year





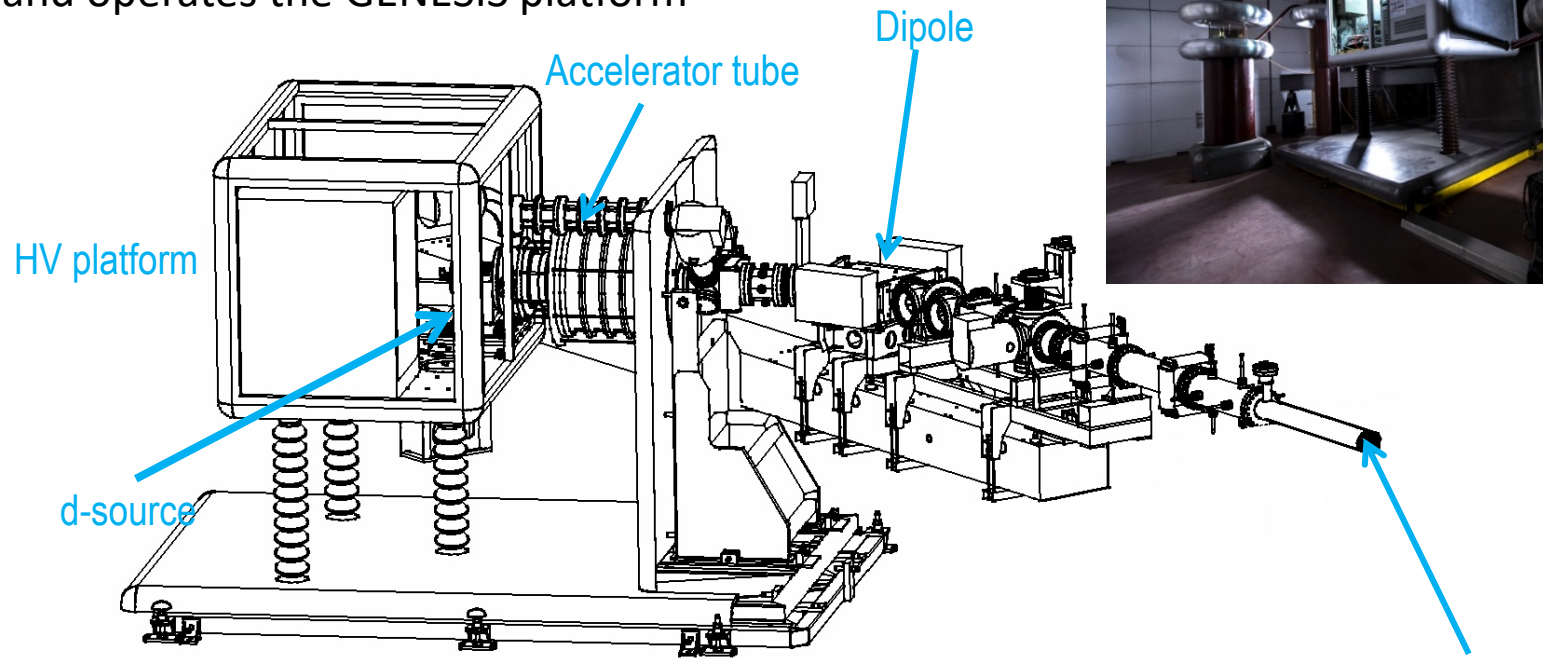


The PAC-G: an unique framework

Single entry point for characterization services, dedicated to micro- and nano-electronics industry

LPSC/GENESIS : High energy neutrons source

LPSC is a joint research unit CNRS/IN2P3 - UGA - G INP and operates the GENESIS platform



Fast neutrons

- Energy : 14 MeV (or 2.5 MeV)
- Flux up to 5.10^7 $n.s^{-1}.cm^{-2}$

Irradiations for

- 5 industrial companies
- Research labs and universities

The PAC-G: an unique framework

Single entry point for characterization services, dedicated to micro- and nano-electronics industry

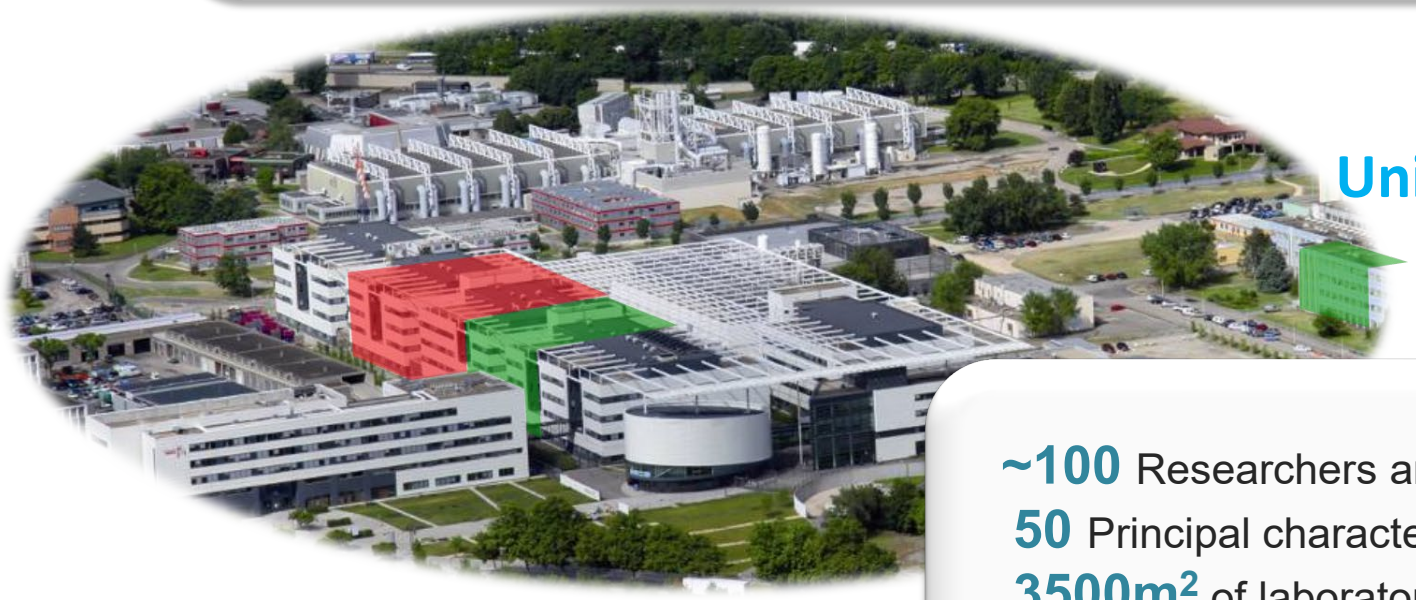
PFNC… at a glance

Created in **2006**…

… within the **Minatec Campus,**

Federation of the resources of three Institutes based at CEA/Grenoble

- **leti** (DRT/Laboratory for Electronics & Information Technology)
- **liten** (DRT/Laboratory for Innovation in New Energy Technologies & Nanomaterials)
- (DSM/Institute for Nanoscience & Cryogenics)



Unique in Europe

~100 Researchers and Technicians,

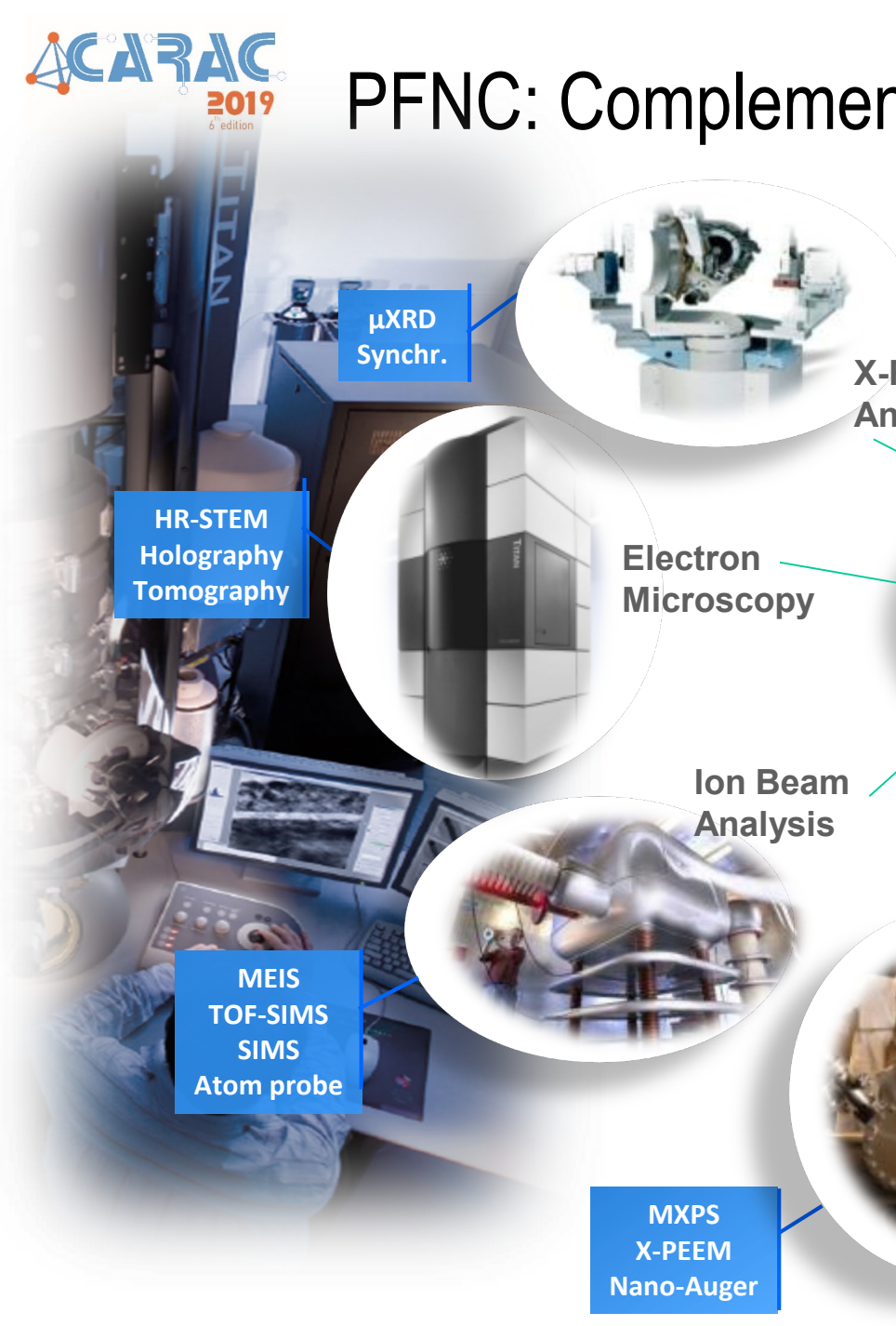
50 Principal characterisation tools,

3500m² of laboratories,

1 partnership with SERMA Tech

PFNC: Complementary techniques

8 Centers of Competences



µXRD
Synchr.

X-Ray
Analysis

Sample
Preparation

Magnetic
Resonance

RMN
DNP

HR-STEM
Holography
Tomography

Electron
Microscopy

FIB-DB
Polishing,
chemical prep...

Scanning Probe

SSRM
SCM
KFM

Ion Beam
Analysis

MEIS
TOF-SIMS
SIMS
Atom probe

Surface
Analysis

MXPS
X-PEEM
Nano-Auger

Optics

Ellipso, FTIR,
PL, cathodo...

Platform for Advanced Characterization Grenoble (PAC-G)

Irradiation services

- High energy neutrons
- Low energy neutrons
- Synchrotron X-rays
- Fast neutrons irradiation (14 Mev)
- Thermal/cold neutrons (25meV)
- Pulsed X-ray microbeam
- Focalised X-ray nano-beam

Imaging & failure analysis

- Synchrotron X-ray micro-imaging
- Synchrotron X-ray nano-imaging
- Neutron imaging
- Micro-tomography
- Ultra-fast radiography
- Nano-tomography
- Micro-tomography
- Neutron and X-ray micro-tomography

Physical/chemical characterisation

- Strain/Stress measurements
- Structural characterization
- Interface characterization
- K-map
- Rocking Curve Imaging
- XRD
- XRDI
- SAXS
- SANS
- X-ray and Neutron Reflectivity (XRR, NR)

SERMA TECHNOLOGIES leti cea tech cnrs ILL NEUTRONS FOR SOCIETY ESRF The European Synchrotron

Why use large-scale facilities

Non-destructive testing

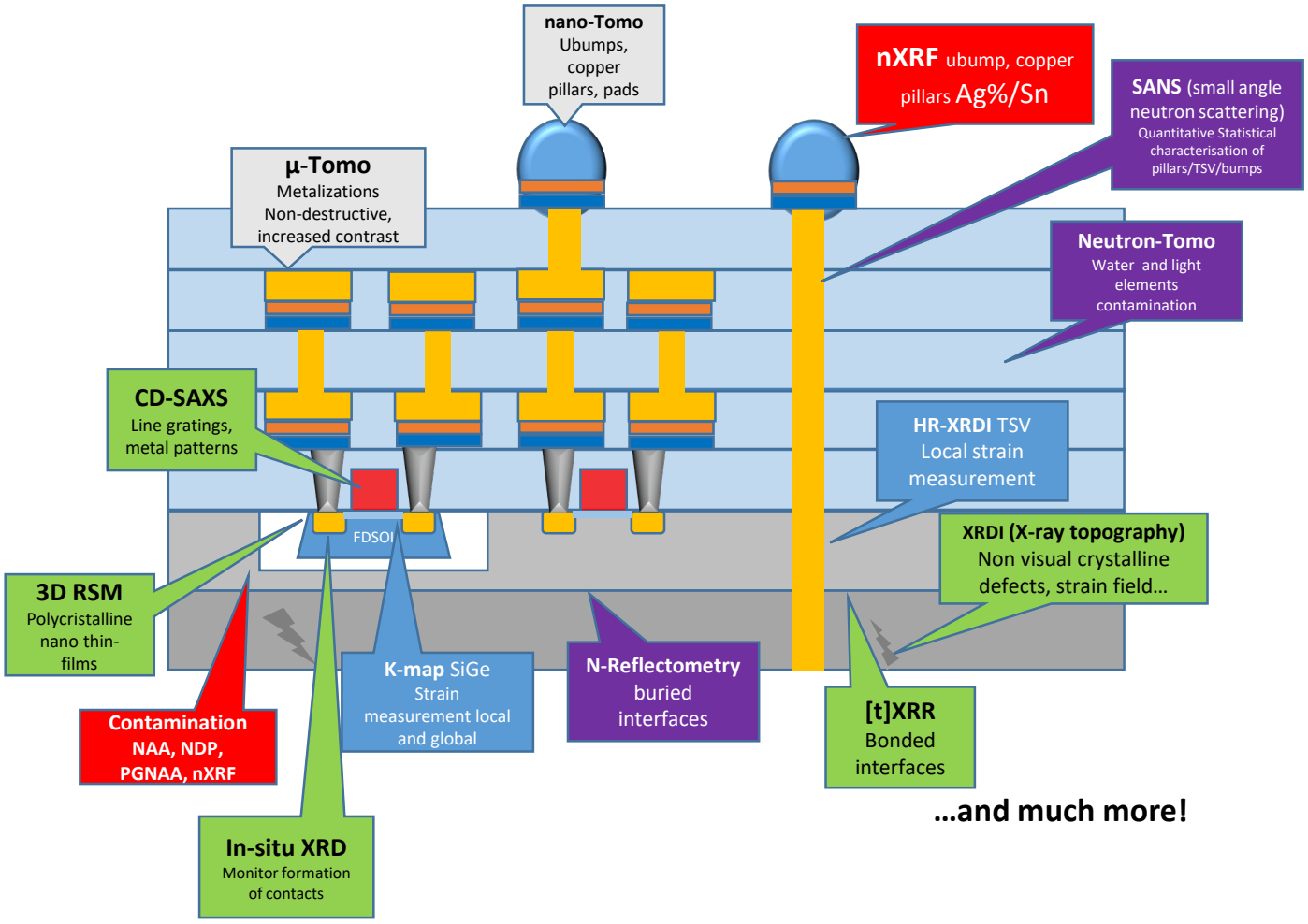
In-situ and/or In-operando investigations (sample environments)

Statistical characterisations (fast acquisition time)

Very high spatial and time resolutions

Unmatched detection capabilities

What applications?



List of techniques

Physical and Chemical Characterisation

X-ray white beam topography
X-ray monochromatic beam topography
X-ray rocking curve imaging
X-ray rocking curve imaging + Section topography
X-ray high resolution rocking curve imaging
X-ray diffraction (in-situ / ex-situ)
X-ray reflectivity XRR
Reciprocal Space mapping 3D (3D RSM)
CD-SAXS
Neutron Reflectivity
k-map
High resolution diffraction imaging (HR-XRDI)
Nano fluorescence

Imaging techniques

X-ray micro tomography
X-ray nano tomography
Neutron tomography
Neutron + X-ray tomography
Ultrafast radiography

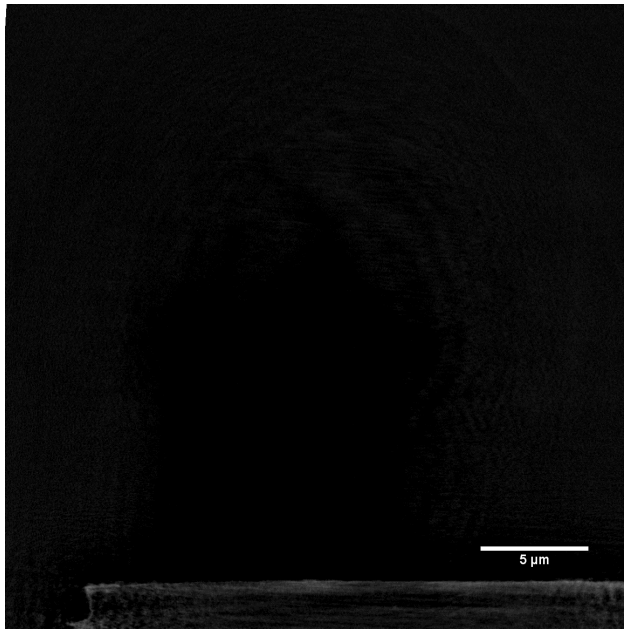
Irradiation for SEE testing

Fast neutrons irradiation
Thermal neutrons irradiation
Synchrotron X-ray Irradiation

Application in advanced packaging

Synchrotron X-ray nano tomography

Looking for intermetallic alloys, voids and defects in Cu-pillars (10, 25 and 50µm) non-destructively

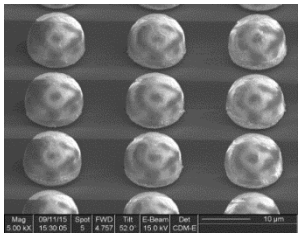


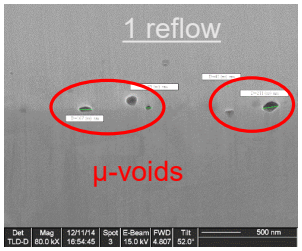
World record resolution 30nm

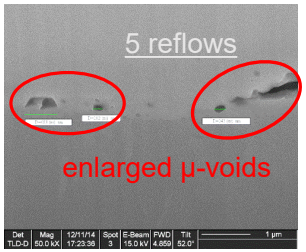
A. FRACZKIEWICZ- "Développement de la tomographie par rayons X en synchrotron pour l'industrie : application à l'analyse de défaillance en intégration 3D - Grenoble, 2017»

Innovative solutions to characterization challenges

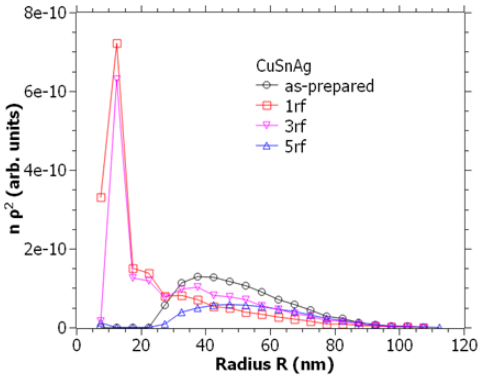
Statistical analysis of voids in several Cu-pillars.



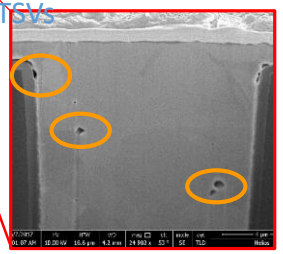




Small Angle Neutron Scattering



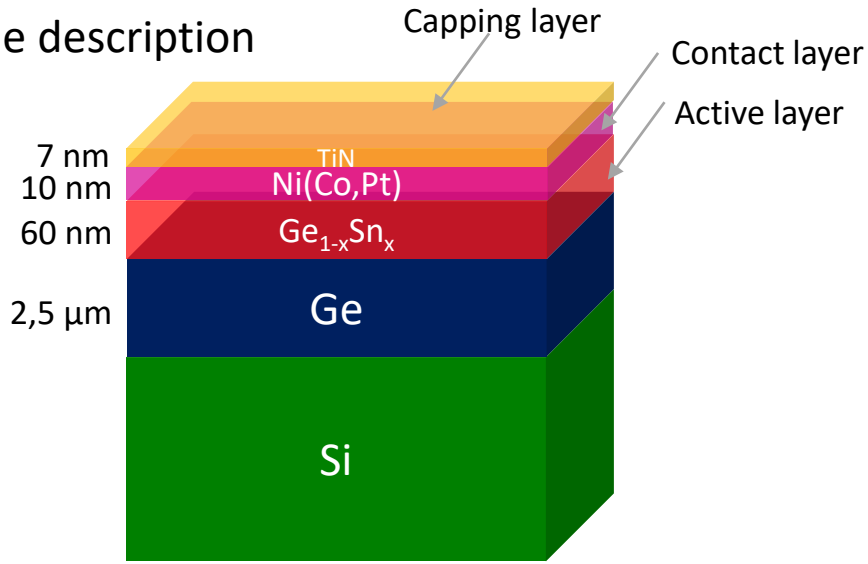
Applicable to similar problems: defects in TSVs

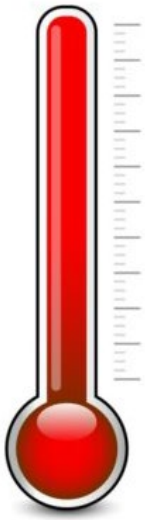


In-situ diffraction: monitoring of solid-state reaction kinetic of Ni (Co, Pt) with Ge(Sn)/Si

Objective: Study the alloy formation (NiCoPtGeSn) to improve the ohmic contact between the active layer and the TiN

Sample description





Several experiments on several samples:

Samples:

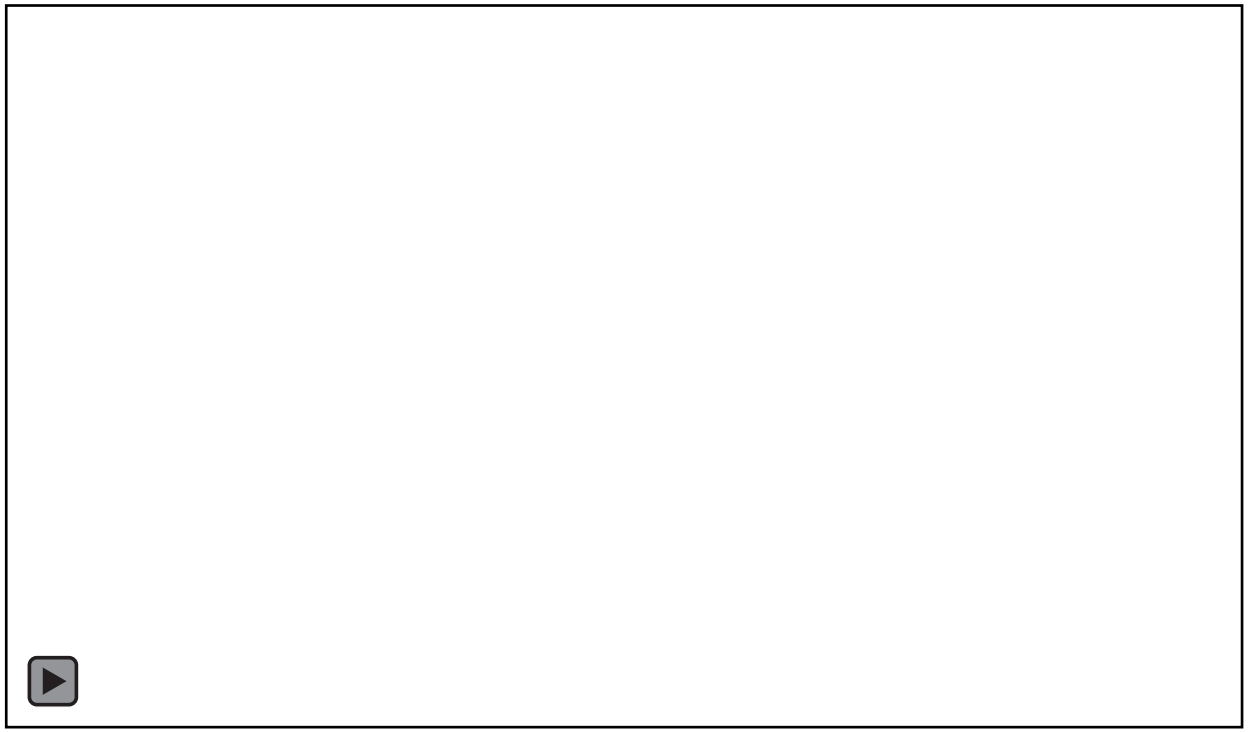
- NiPt/GeSn(10%)
- Ni/GeSn(6%)
- Ni/GeSn(10%)
- Ni/Ge
- **NiCo/GeSn(10%)**

- RTA – rapid thermal annealing
- Slow heating
- isothermal

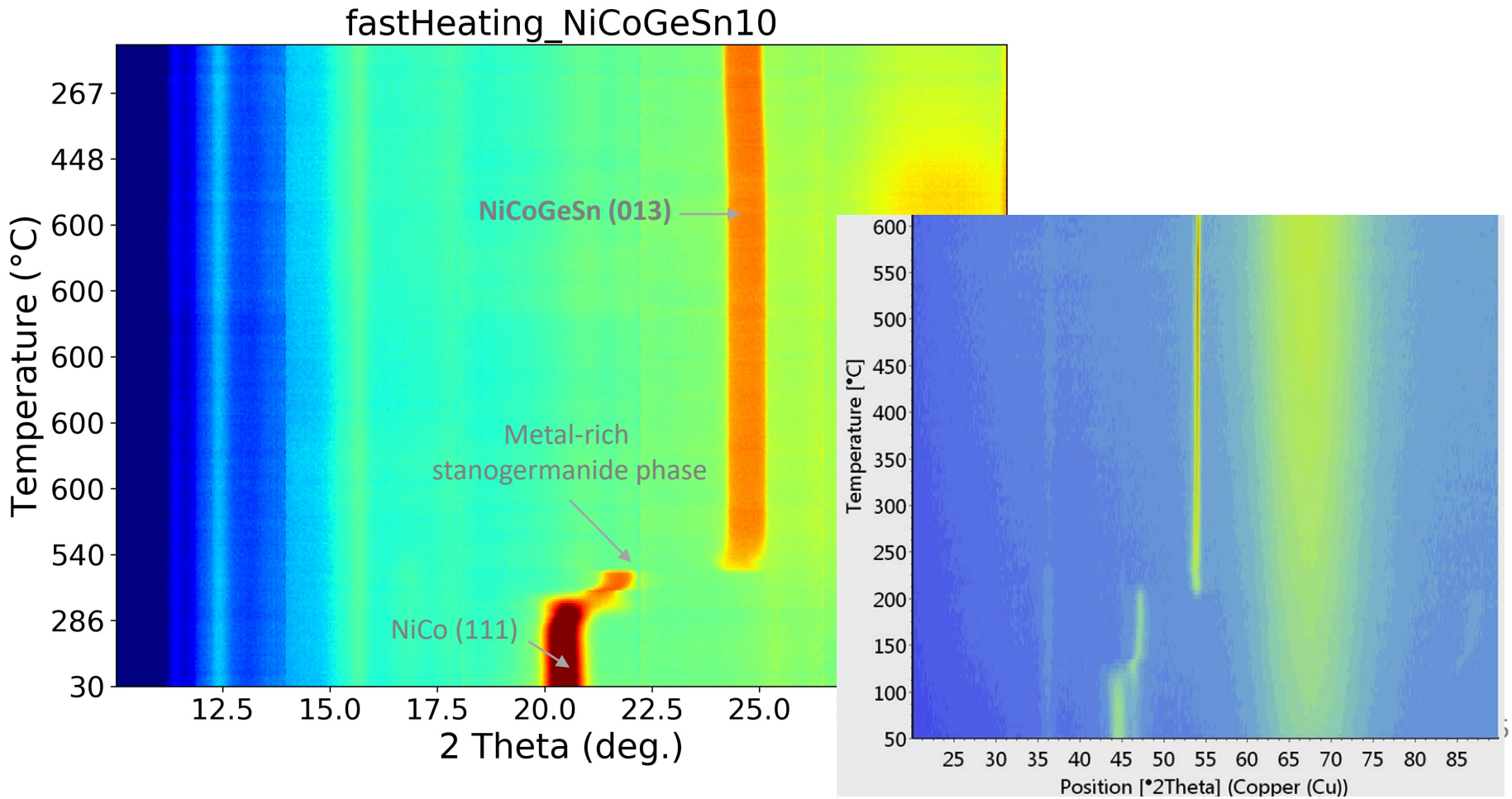
Solid-state reaction between contact layer Ni(Co,Pt) and semiconductor $Ge_{1-x}Sn_x$ → source & drain contacts

In-situ diffraction: monitoring of solid-state reaction kinetic of Ni (Co, Pt) with Ge(Sn)/Si

In-situ diffraction of NiCo/GeSn(10%) – fast heating



In-situ diffraction: monitoring of solid-state reaction kinetic of Ni (Co, Pt) with Ge(Sn)/Si



Lab measurement, copper source, 7 minutes per temperature, 13 hours for this map

Key take-aways

- The PAC-G is a service platform dedicated to the microelectronics industry using the large scale research facilities of Grenoble (ESRF, ILL, LPSC) with the support of the CEA Leti's PFNC
- More than 20 services are available through this platform and dedicated personel insure customer satisfaction
- The PAC-G has its first industrial collaboration agreement with SERMA Technologies, a well stablished company in the electronics sector

Thank you!

Rafael Della Giustina
Business developer for PAC-G
Email address