



# ESCCON 2021

## - GaN Supply Chain -

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# GaN Supply Chain

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## Agenda

- United Monolithic Semiconductors (UMS)
- GaN Supply Chain for RF/microwave
- EUGaNIC
- Experiences from EUGaNIC
- Presenter's view and conclusion



# UMS at a glance

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- European source of RF MMIC solutions, GaAs and GaN foundry services
- Shareholders: Thales SA / Airbus DS GmbH
- Industrial facilities in:
  - **Ulm (Germany):** GaAs & GaN technology development and production
  - **Villebon (France):** product development, back-end production and support
- 76.4 M€ turnover (2020)
- 416 people
- Long heritage of supplying to most demanding applications

# UMS Markets

## Defence & Security



- Phased Array Radar
- Electronic Warfare
- Communications

## Space



- Communications
- Earth Observation
- Scientific Missions

## Automotive ISM



- Long Range Radar
- Short Range Radar
- Industrial Sensors

## Telecom

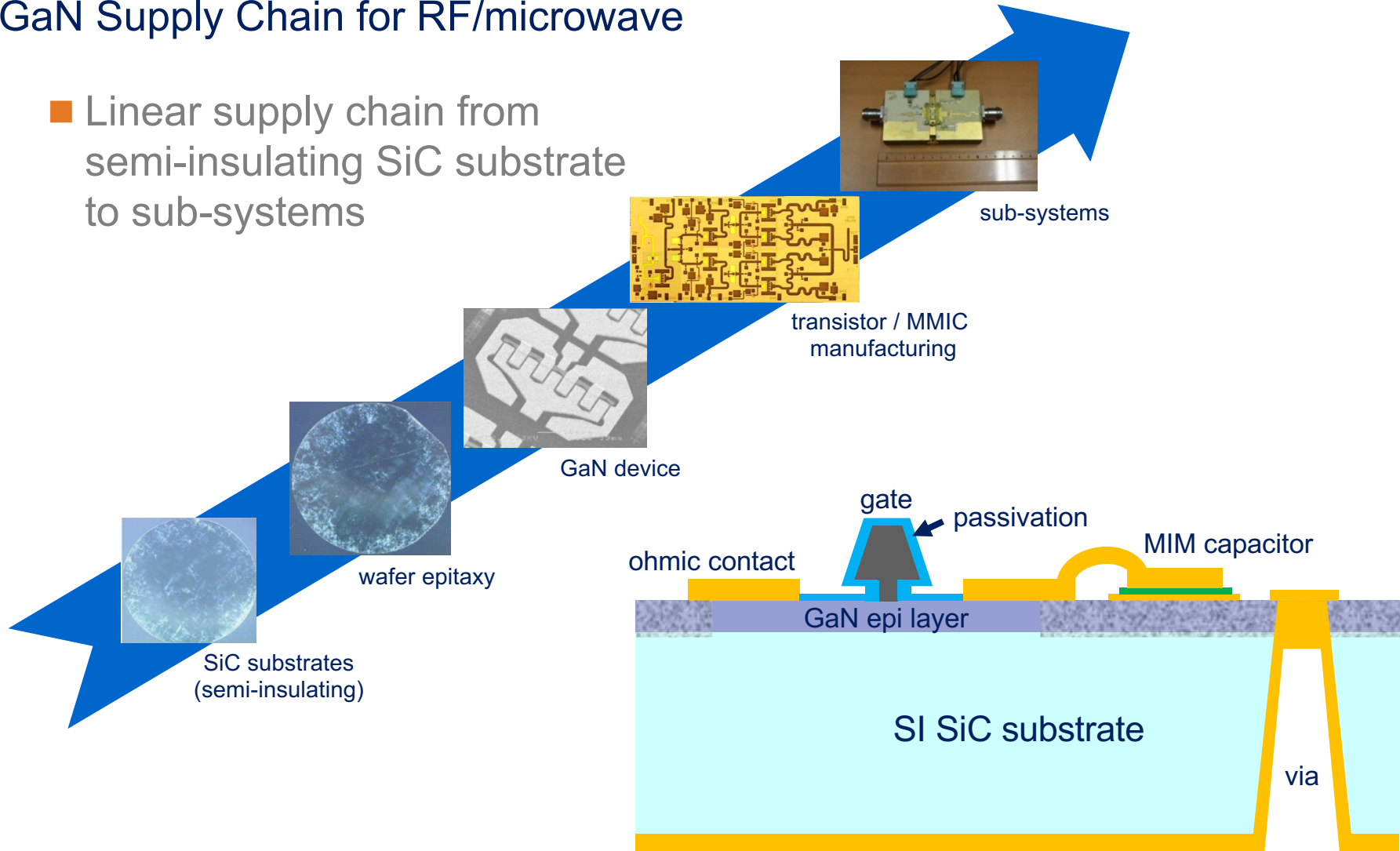


- Point to Point
- VSAT Terminal
- Base Stations

# GaN Supply Chain

## GaN Supply Chain for RF/microwave

- Linear supply chain from semi-insulating SiC substrate to sub-systems

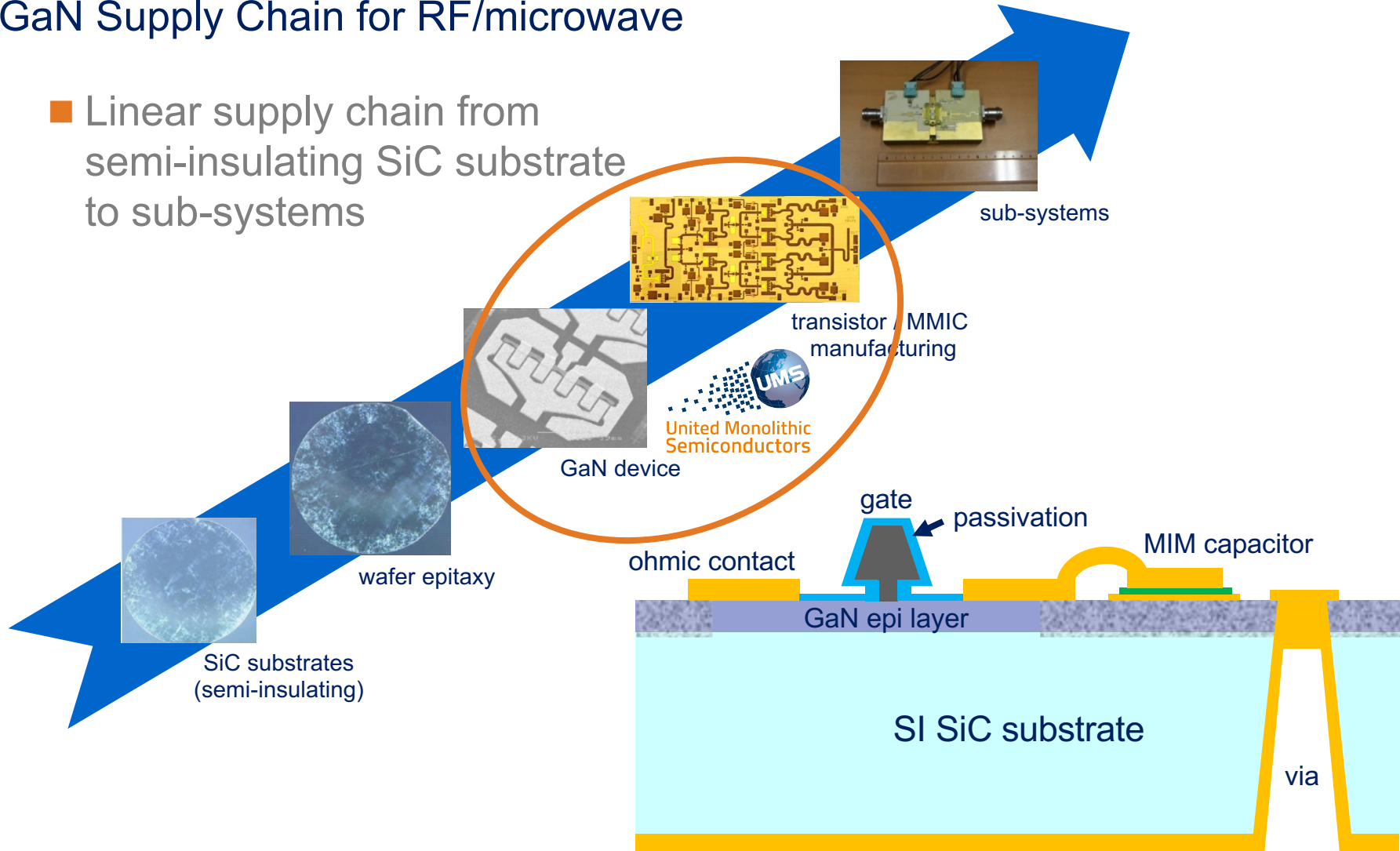




# GaN Supply Chain

## GaN Supply Chain for RF/microwave

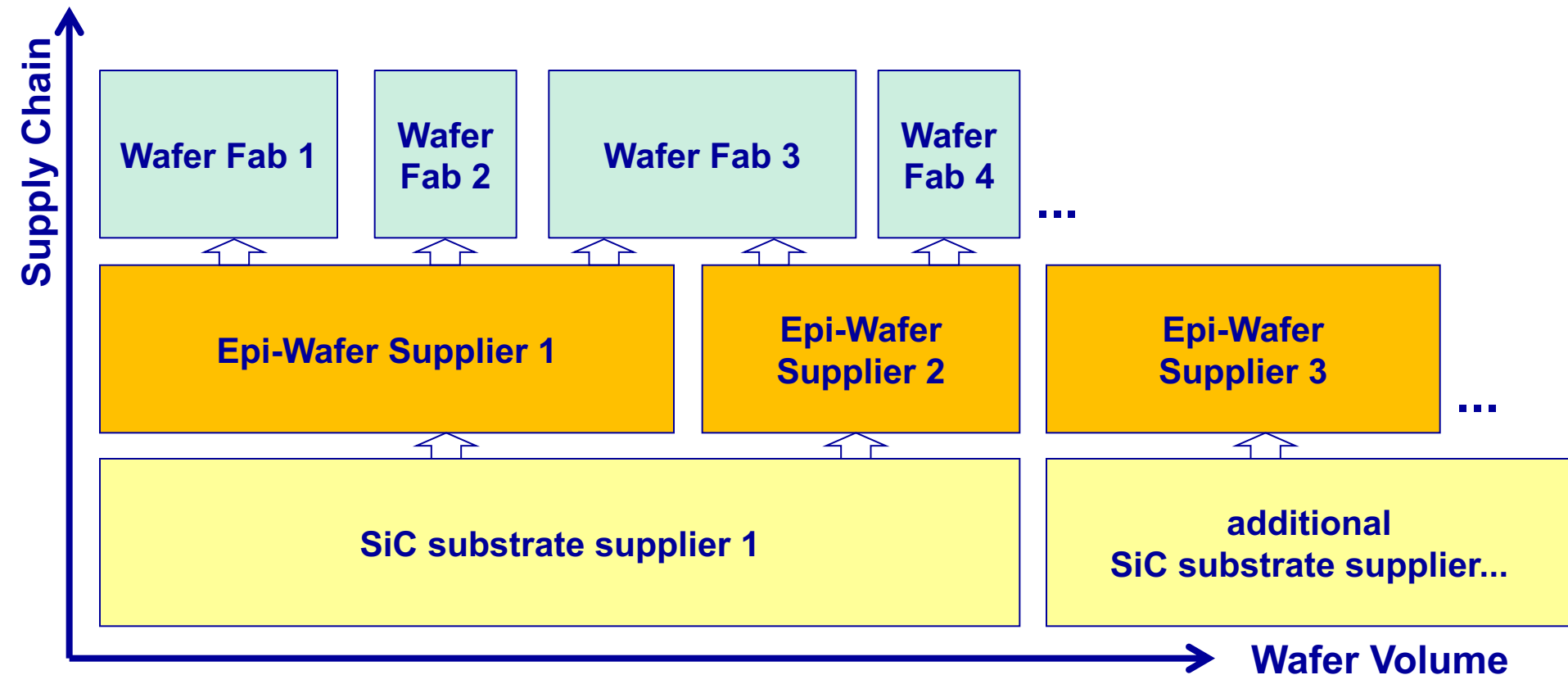
- Linear supply chain from semi-insulating SiC substrate to sub-systems



# GaN Component Supply Chain

## ● Supply Chain versus Wafer Volume

- high cost of new supplier qualification → limitation to low number of suppliers
- high CAPEX per supply chain step → one supplier needs various customers



# GaN Supply Chain

## GaN Supply Chain for RF/microwave

- Linear Supply Chain for GaN-on-SiC
  - Semi-insulating SiC substrates
    - niche compared to n-type SiC substrates (just a few percent)
    - defect density important for epi-quality
  - Wafer epitaxy defines the electron channel in the semiconductor
    - Extremely critical know-how with many developments ongoing
  - GaN technology with transistor and MMIC manufacturing
    - 4" fabs dominating with trend towards 6"
  - Sub-system development unit decides about the device/MMIC
    - Performance, quality, access and price!
- Supply Chain → Access needs to be ensured!
  - European non-dependence / sovereignty
  - Control of GaN Supply Chain
- Performance / Quality to be at the same level as world-wide competition → EUGaNIC





# GaN Supply Chain

EUGaNIC – a project of the European Defence Agency (EDA)



## Objectives of EUGaNIC

- Support for a European supply-chain for military GaN electronics technology
- Improvement of GaN material quality with respect to final device performance and reliability
- Advanced GaN structures for improved performances and new application domains

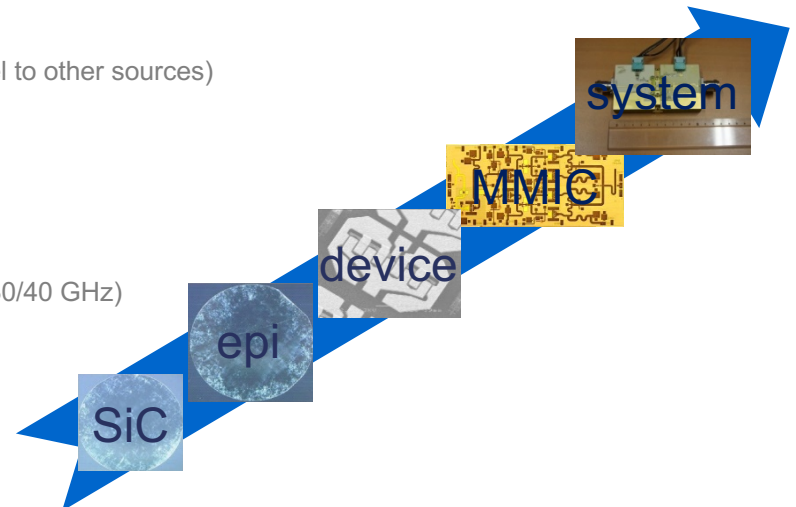
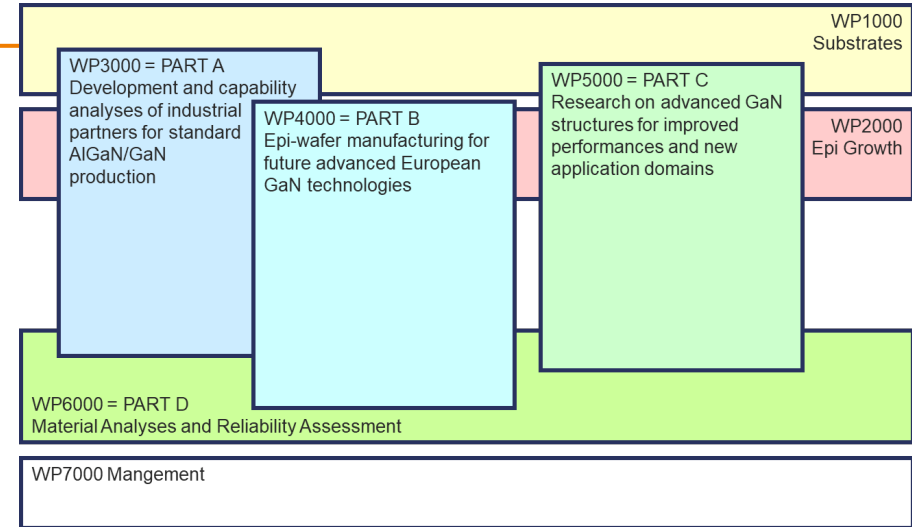
## Structure of EUGaNIC

- 11 European partners from industry and academia
- MoD Support from Germany, Italy, France and Sweden
- Budget: 10,2 MEuro (excl. VAT)

# GaN Supply Chain

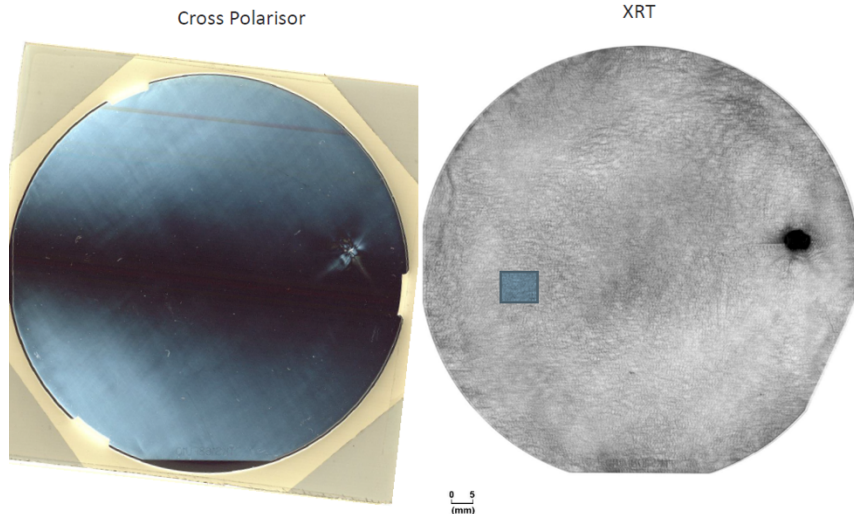
## EUGaNIC – Overview

- Project for the technical development of a European GaN Supply Chain
  - 5 years activity with start in 02/2016 and end in 2021
  - 460 substrates used
  - 360MB wafer data base
  - 2700 pages of reporting
- Project structure
  - WP1000 – SI-SiC Substrate
    - Evaluation of European substrates
    - Evaluation of other substrates (from Asia)
    - Assessment of substrate defects (by round robin experiments)
  - WP2000 – Epi growth
    - Optimization of epi (to have comparable performance/quality level to other sources)
    - Implementation of new volume reactors
    - Development of new epi-structures
  - WP3000/WP4000 – European GaN technologies
    - Evaluate European epi / SiC substrate with existing technologies
  - WP5000 – advanced GaN technologies
    - Research for the next generation of GaN technologies (going to 30/40 GHz)
    - Comparison of various solutions
  - WP6000 – material analyses and reliability assessment
    - Intensive robustness/reliability test campaigns
    - Long lifetime tests on European material
    - Defect and degradation mechanisms



# GaN Supply Chain

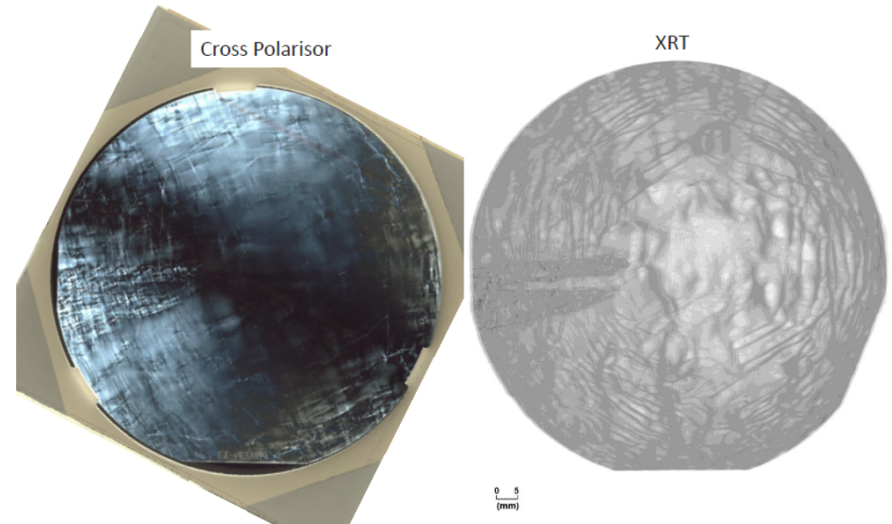
## EUGaNIC – WP1000, substrate evaluation



- Chinese SI SiC substrate
  - First procurement of 10 wafers
  - Very low price
  - Good quality based on cross polarisor / XRT inspection!
  - Is this standard quality??

### ■ US SI SiC substrate

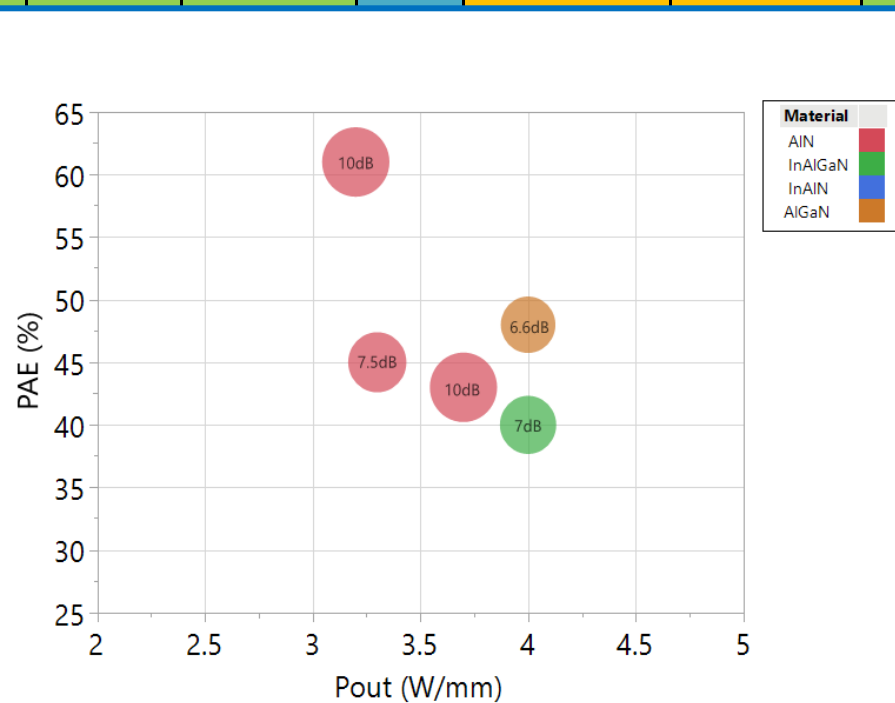
- Standard material, world wide use
- Long lead time
- Typical quality based on cross polarisor / XRT inspection!
- Continuous supply??



# GaN Supply Chain

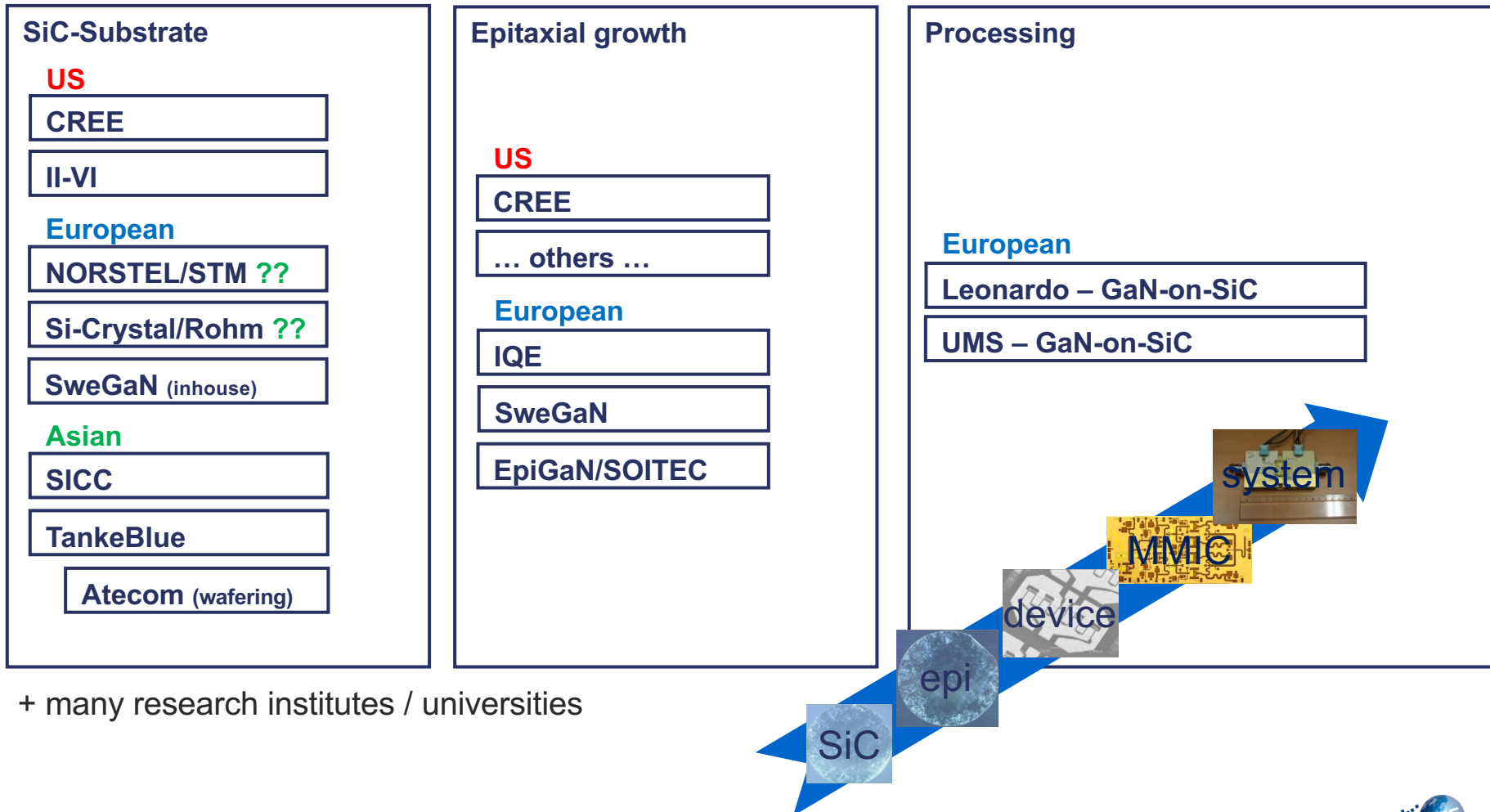
## EUGaNIC – WP5000, figure-of-merit table

Substrate supplier	Hetero and sample Name	Epi & Process Team	Device geometry	Bias point Vds - Ids (V) (mA/mm)	Gate Leakage (mA/mm)	STS (mV/decade)	fo (GHz)	Associated power gain CW (dB)	PAE CW (%)	CW power density @30GHz (W/mm)
Norstel	InAlGaN BB	III-VLab	0.10μm	Vds =						
4-inch	TS1037	III-VLab	2x50μm	Ids =						
Norstel	AlN	EpiGaN	0.15μm	Vds =						
4-inc	HEMT	IEMN	2x25	Ids =						
CREE	AlN	EpiGaN	0.11μm	Vds =						
4-inc	HEMT	IEMN	2x50	Ids =						
CREE	AlN	EpiGaN	0.11μm	Vds =						
4-inc	HEMT	IEMN	2x50	Ids =						
CREE	AlN	EpiGaN	0.15μm	Vds =						
4-inc	HEMT	IEMN	2x50	Ids =						
CREE	AlN	IQE	0.10μm	Vds =						
4-inc	HEMT	IAF	4x45μm	Ids =						
CREE	AlGaIn	IAF	0.1μm	Vds =						
4-inch		IAF	4x45μm	Idq = 150	(@ Vg=-7V, Vds=15V)			(max gain: 7.7)	@ 38 GHz	@ 38GHz



# GaN Supply Chain

EUGaNIC – GaN-on-SiC industrial supply chain at the end of the project

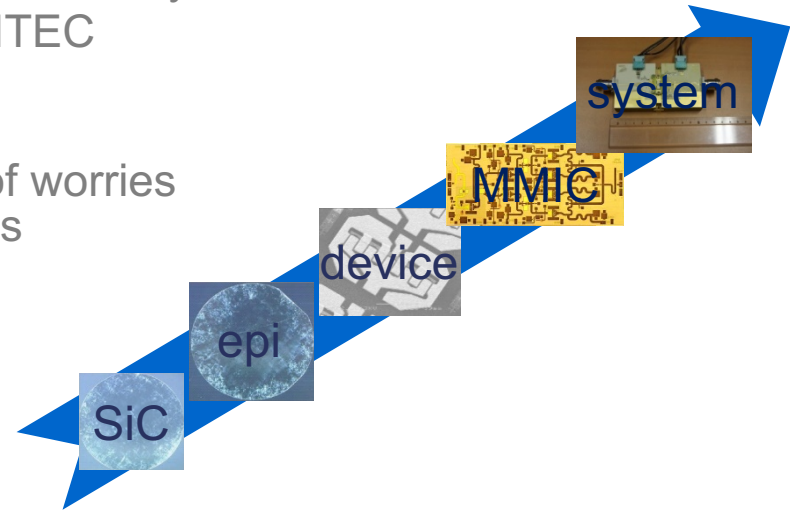


+ many research institutes / universities

# GaN Supply Chain

## Experiences from EUGaNIC

- Changes before/during the EUGaNIC project
  - Changes in the funding situation (MoD-level) at the creation of the project
  - SiC substrate market dominated by power electronics (n-type material; larger wafer diameter, i.e. 4" → 6"/8") → suppliers interested in volume
  - Infineon tried to acquire CREE material business, but deal was refused by US government
  - Norstel (substrate) → acquired by Chinese investor → acquired by ST
  - Qinetiq stopped work on GaN-epi growth → activity transferred to IQE UK
  - EpiGaN (epi growth) was acquired by SOITEC
- Company strategies
  - Restricted access to substrate, because of worries by substrate manufacturers that substrates might be used as seed
  - Prices at extreme levels (low/high)
- European GaN Supply Chain has demonstrated its capability to provide state-of-art GaN technology and to develop next GaN RF technology generation

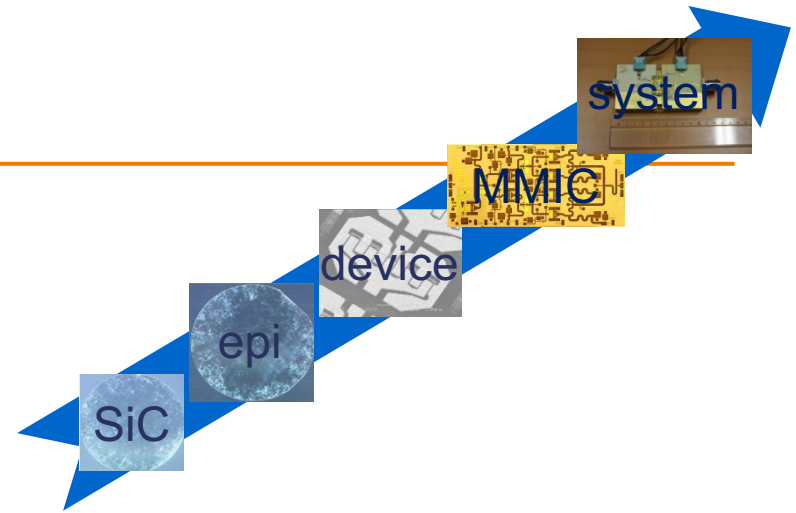




# GaN Supply Chain

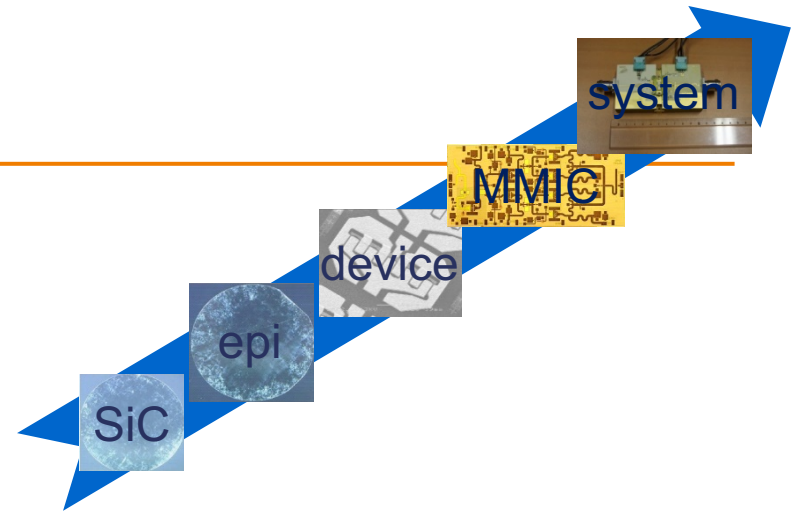
## Presenter's view and conclusion

- The GaN Supply Chain for RF/microwave
- It is a niche market
  - Semi-insulating SiC substrates are needed
  - SiC/GaN production (materials/tools) is dominated by power electronics
- Changes in company ownership and strategy
  - ...makes the creation of a stable GaN Supply Chain difficult
- **Performance/Quality**
  - EUGaNIC has substantially contributed to have state-of-art technology
  - Position needs to be maintained and further developed through R&D projects
- **Access**
  - Europe has all ingredients for a European GaN Supply chain – but it needs to be maintained
- **Price (Commercial conditions)**
  - What is an acceptable price for parts from a European GaN Supply Chain?



# GaN Supply Chain

... last slide



- Many thanks to the European Defense Agency (EDA) for the support to this work in the context of the project entitled **“European Gallium Nitride Industry supply Chain (EUGaNIC)”** funded by Germany, France, Italy and Sweden in the frame of the Project no B-1447-IAP1-GP

**Thank you very much!**  
**Questions??**