

ALLOS
Semiconductors

The Right Strategy for Developing GaN Power Electronics

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**No need to take photos – just email me and get a copy of this presentation
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ALLOS is a fabless
IP licensing and
technology company

Establish 150 and 200 mm
GaN-on-Si technology for all
applications on customers'
reactors

**ALLOS enables customers
to master GaN-on-Si
epiwafer technology**

We are continuously
improving our technology
to stay ahead

Based on 18 years track record
at University Magdeburg,
AZZURRO and ALLOS

ALLOS delivers performance and made-for-manufacturability



- ✓ 200 mm
- ✓ 725 μm thickness
- ✓ 7 μm epi-thickness with 0.3 % uniformity
- ✓ 30 μm bow, no cracks
- ✓ TDD: $2 \times 10^8 \text{ cm}^{-2}$
- ✓ 0.005 $\mu\text{A}/\text{mm}$ lateral leakage @ 600 V
- ✓ R_{sheet} : 340 $\Omega/\text{sq.}$
- ✓ < 3 USD / cm^2 total cost

A. Where is GaN-on-Si today?

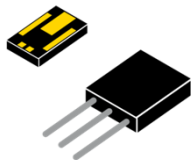
B. Who has successfully developed products, and why?

C. What is the right strategy for fast followers?

D. Make or buy your GaN-on-Si epiwafers?

The GaN-on-Si revolution is taking place right now

HPE



GaN-on-Si enables more energy-efficient, less complex and smaller high power electronic (HPE) devices out of silicon lines

RF



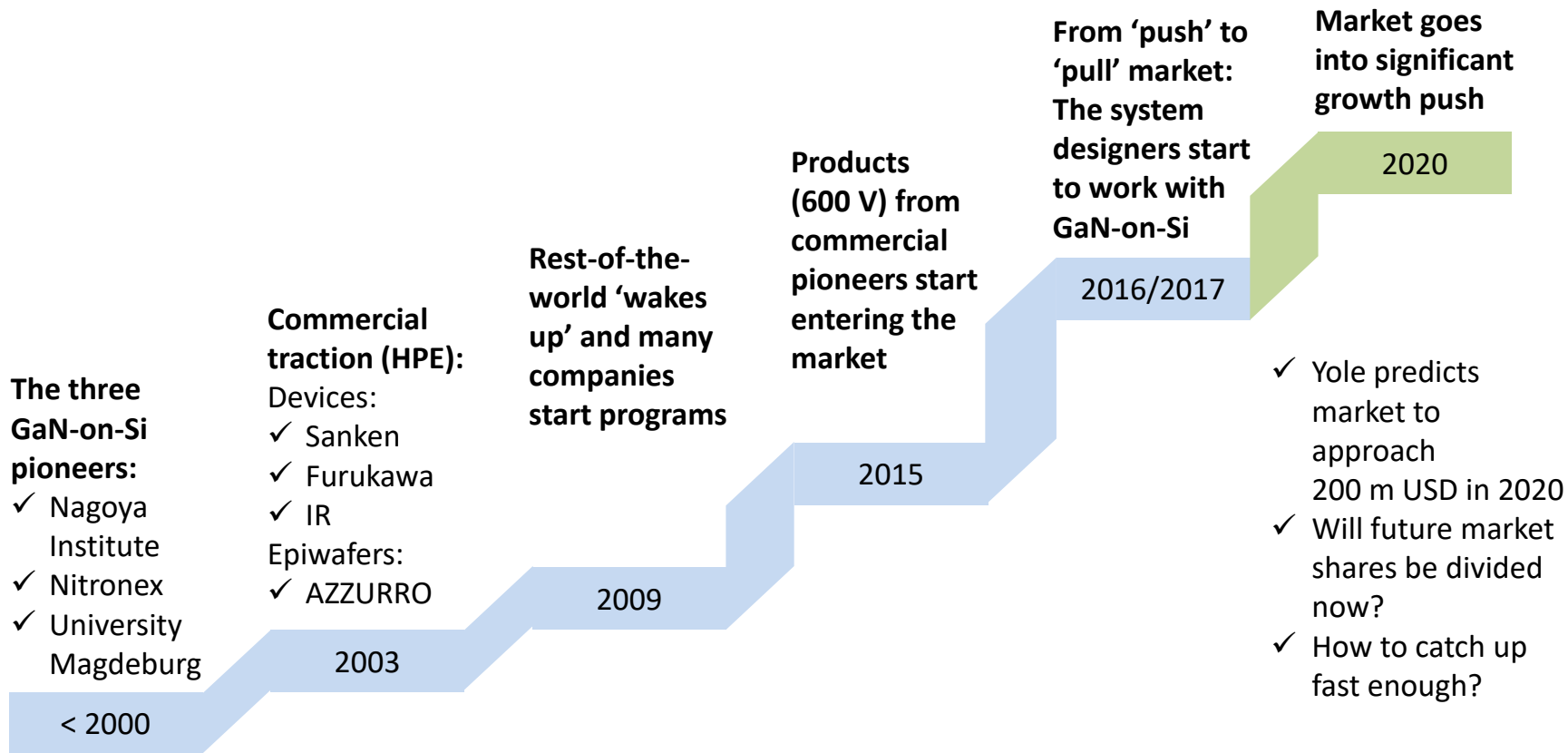
GaN-on-Si provides higher performance and lower cost for RF devices

Micro LED



Only GaN-on-Si allows super-uniform, CMOS-compatible 200 mm epiwafers needed for micro LEDs

How did we get where we are today? And what's next?



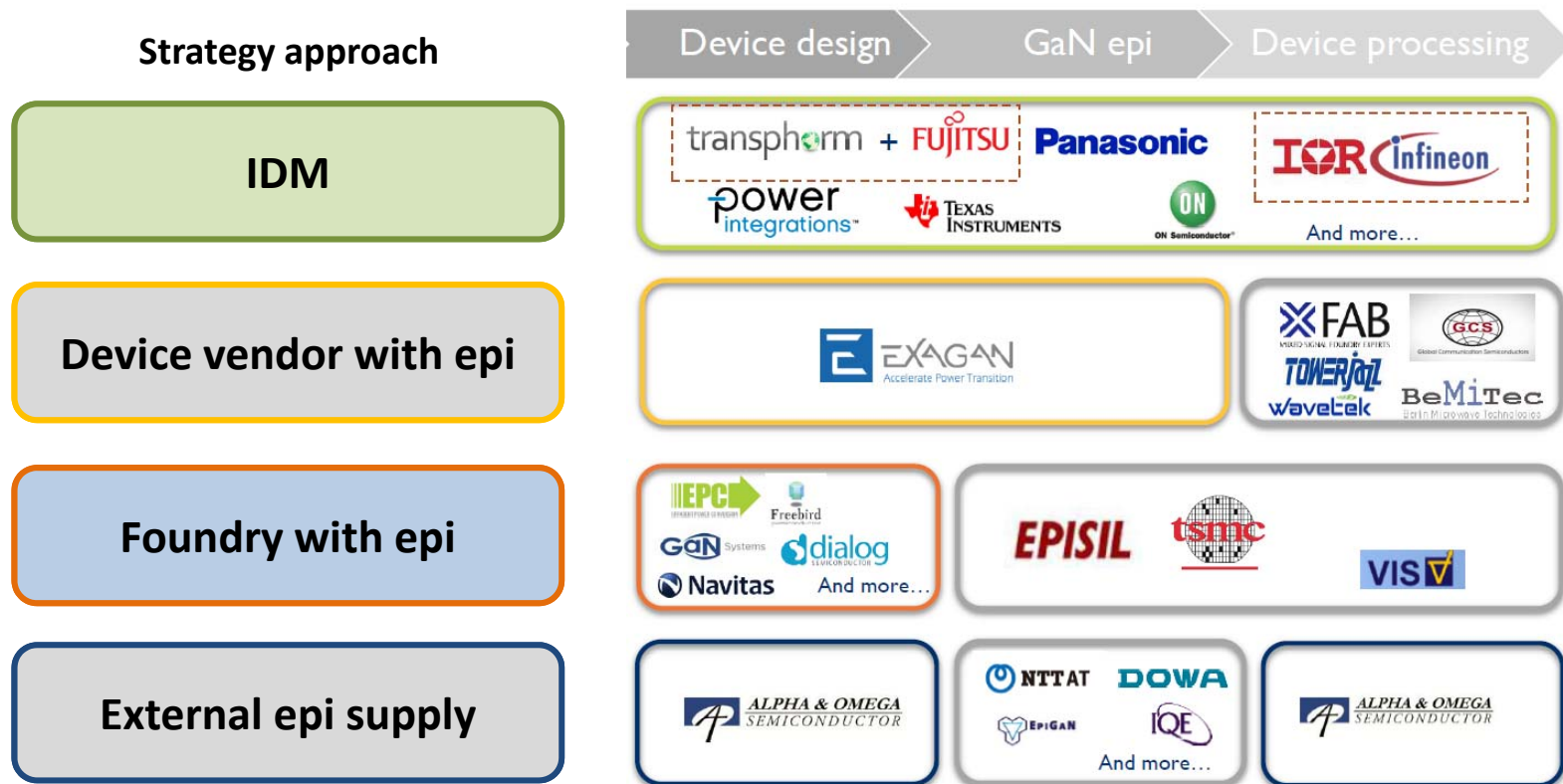
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Yole describes four strategy approaches to GaN-on-Si



Source: Yole Développement 2017

All who have already introduced device products to the market follow one of just two of the strategy approaches



IDM
(device design, epi and processing integrated)



Foundry with epi
(fabless product vendor works with epi and processing foundry)



The pattern for successful GaN-on-Si product development

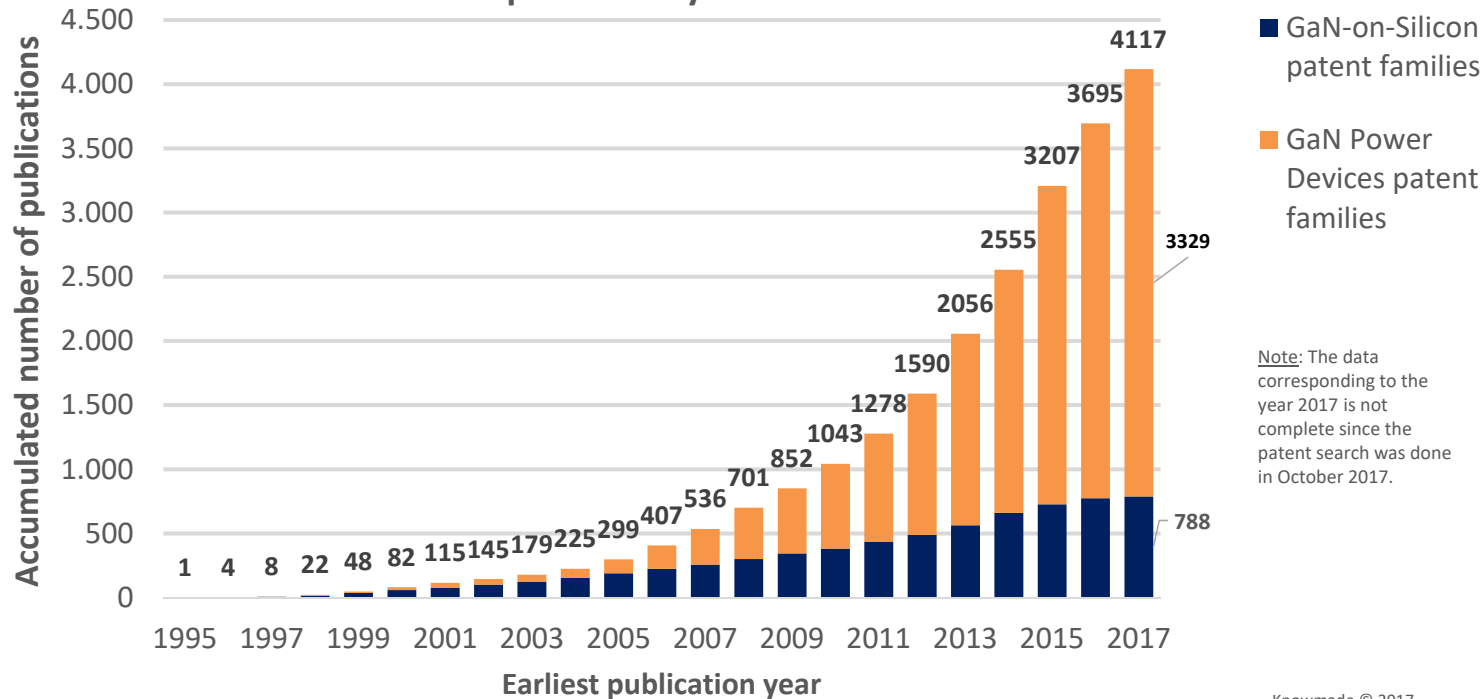


- Started at least five years ago
- Each invested xx to xxx million USD
- Device designers, epi engineers and processing people work closely together
- Epiwafer technology developed in-house
- All work on 150 mm epiwafer diameter
- E-mode HEMT 600 V devices dominate
- Have reference designs and dev. boards

IP space is getting more and more crowded



GaN power IP dynamics



Note: The data corresponding to the year 2017 is not complete since the patent search was done in October 2017.

Knowmade © 2017

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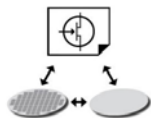
Why not wait and see? Why being a fast follower?

- GaN-on-Si is a disruptive technology for the HPE (device maker) industry
 - Significant changes in vendor's market shares are possible
- ➔ **Fast followers want to benefit from this opportunity**

Chairman, ensure the right mind-set for GaN-on-Si



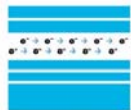
Invest! No business before you built your GaN capabilities



Designs, epiwafer and processing need to be cross-optimized



Seek value on system-level



Epitaxy determines 70 % of performance and value of device

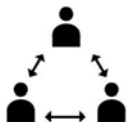


Be prepared for changes and setbacks

Program manager, enable your organization to move fast



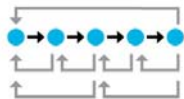
Create an environment where engineers work and learn together



Everyone needs to share a good understanding of designs, epiwafer, processing and their interdependencies



Maximize learning, do many reactor runs and processing cycles



Speed up cycle time, use quick tests, correlate feedback levels



Invest in demonstrators to test and show benefits and reliability

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MAKE epiwafers in-house

BUY epiwafers from a vendor

Openness

- Open environment, mutual learning
- The team wins and fails together
- Gain better and faster understanding

- Two-way confidentiality concerns
- Better material enables your competitor
- Risk for two-way blaming feud

Time-to-market

- Very fast cycle time
- Very flexible development
- Does built up of epi delay the start?

- Start device development immediately
- Can you avoid being slowed down by cross-organizational coordination?

Cost

- Investment and fixed running cost
- Only marginal cost for each additional wafer

- Who pays customization effort?
- Supplier needs to charge full cost for each additional wafer

Strategy

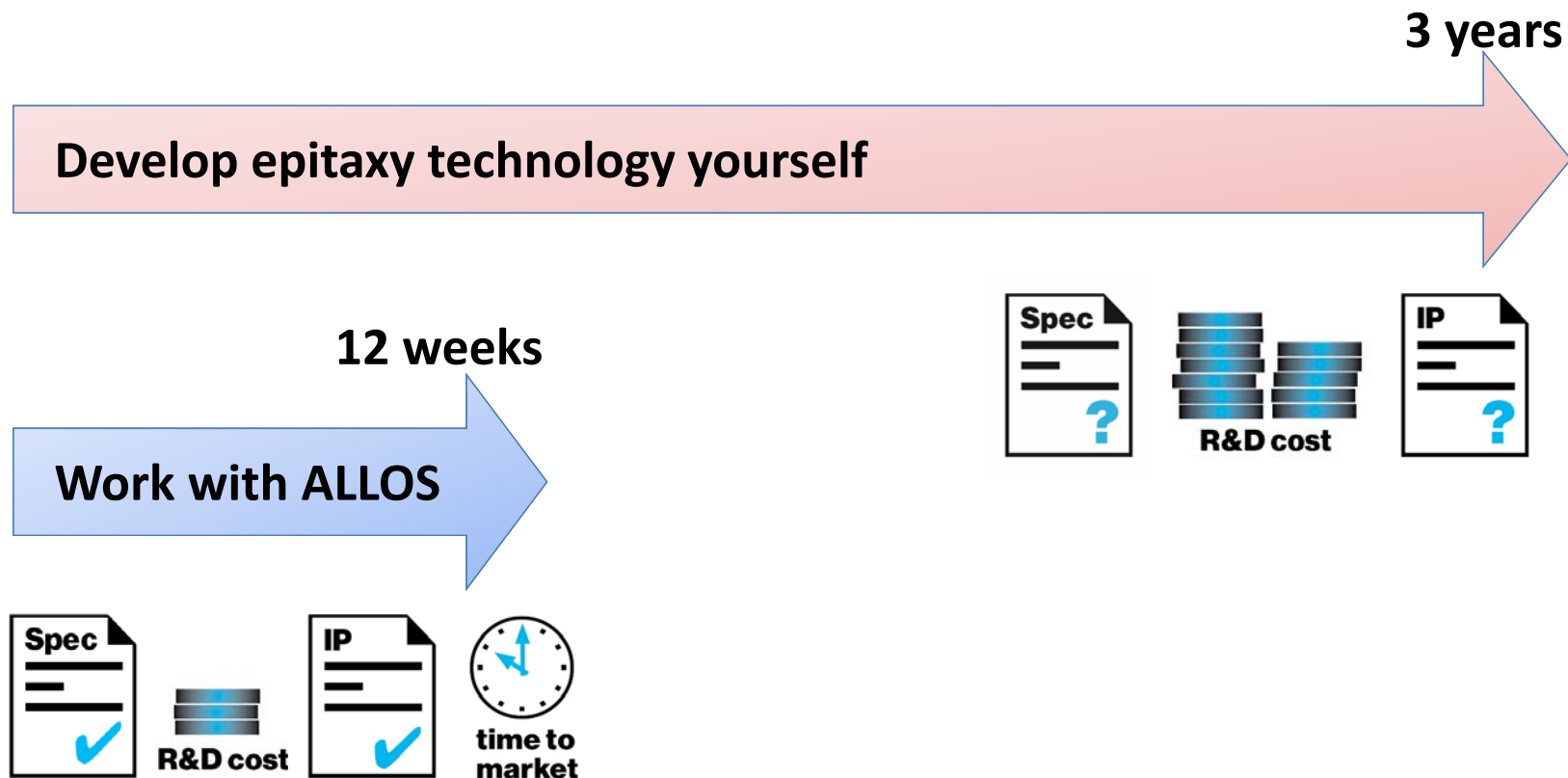
- Full ownership of development result
- Have control over entire value chain
- Being faster and independent

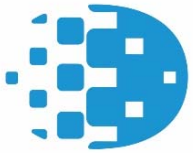
- Focus on fewer things
- Limit your financial exposure

Summarizing: A possible epi strategy for device maker

- Start device and processing development with purchased epiwafers
- In parallel set-up in-house GaN-on-Si epi operations
- **Enter production with integrated product**
(own epi, own processing)
- Explore option to use large-volume, low-cost, epi-foundry for scaling to mass production in the long run

An offer like ALLOS' makes a fast follower strategy attractive





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