SERENA
H2020 PROJECT:
Workshop #1: Heterogenous Integration for High Performance mm-wave Electronics

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The SERENA project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 779305.

SERENA

gan-on-**S**ilicon **E**fficient mm-wave eu**R**opean syst**E**m i**N**tegration pl**A**tform

SERENA WEBINAR

WITH SPEAKERS FROM:

ERICSSON CHALMERS FOI Fraunhofer IZM
TU OMMIC soitec infineon

SAVE THE DATE!

SIGN UP NOW!

Heterogeneous Integration for High Performance mmWave Electronics

28.10.2021, 3-4pm

This workshop will cover requirements and design aspects of the system and its semiconductor components with an emphasis on mmWave heterogeneous integration. Using results from SERENA the system aspects, as well as the RF and thermal design of components and packages will be illustrated base on an em-bedding packaging technology.

UWE MAAß (FRAUNHOFER)

KRISTOFFER ANDERSSON (EAB)

FRANZ DIELACHER (IFAT)

SIGN UP NOW!

GaN-on-Si for mm-wave applications

04.11.2021, 3-4pm

This workshop will cover GaN-on-Si processes and design tools for mm-wave applications as well as GaN-on-Si substrates for RF and mm-wave applications. Another focus will be on 60 nm GaN-on-Si based mm-wave amplifiers for RF sensing and wireless communication.

RÉMY LEBLANC (OMMIC)

MARIANNE GERMAIN (SOITEC)

ROBERT MALMQVIST (FOI)

SIGN UP NOW!

Multi-physical modelling for active antenna transmitter systems

11.11.2021, 3-4pm

During this seminar, speakers from TU Berlin and Chalmers University of Technology, will discuss how thermal, electric, and electromagnetic hardware effects will influence the performance of millimeter wave communication transmitters and communication systems. Both theoretical and experimental studies will be included to illustrate typical applications of the methods discussed.

CHRISTIAN FAGER (CHALMERS)

THOMAS KUEHNE (TUB)

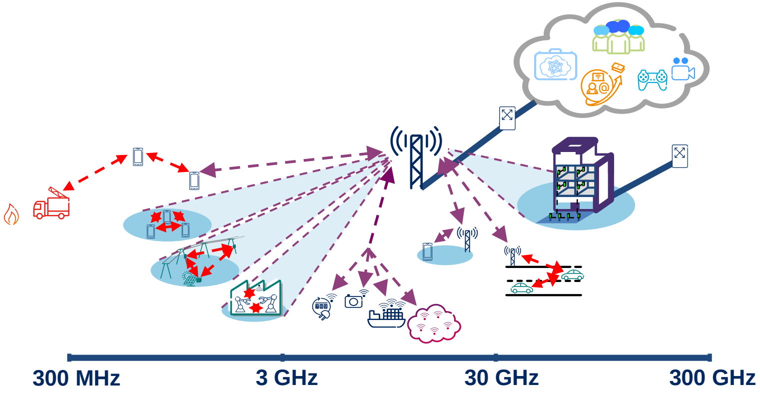
Webinar Outline

5G Requirements from system perspective	Kristoffer Andersson	Ericsson	15 min
Why heterogenous integration/packaging is important for 5G ICs	Franz Dielacher	Infineon	15 min
Heterogenous integration	Uwe Maaß	Fraunhofer IZM	20 min
Q&A and wrap-up			10 min

5G Requirements from a system perspective

- Introduction
- Challenges
- Requirements

5G mm-wave brings new new challenges



- path loss, $(d/\lambda)^2$ => use many antennas
- Gb/s data rates and ms latency
- higher cell capacity and optical links
- Technology and radio architecture provide opportunities

mm-wave 5G

- Utilize mm-wave spectrum for radio access (mobility)
  - Large available bandwidth (up to 800 MHz/channel)
  - Capacity proportional to bandwidth (Shannon – Hartley)
  - First bands at: 24 GHz - 30 GHz and 37 GHz – 42 GHz

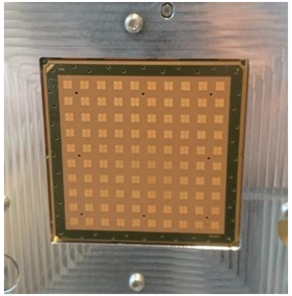
- Harnessing mm-waves is tough
  - Increased path loss, $(d/\lambda)^2$
  - Limited performance of semiconductor technologies

mm-wave 5G – how?

- Overcome path loss by active antenna arrays
  - Half wavelength grid for maximum performance
    3.75 mm x 3.75 mm grid at 39 GHz
- Array specific challenges:
  - Small area available for active electronics => <u>miniaturization</u>
  - Difficult to spread dissipated heat => <u>high efficiency</u>, <u>thermal management</u>
  - Many elements => need <u>low cost</u> per element

First commercial mm-wave radio

- 3GPP 5G NR standard ratified June 14th 2018
- Commercial products
- Ericsson AIR 5121:
  - 28 GHz (band n257)
  - 256 active dual pol. antenna elements
  - 8 beams
  - <1 W total output power
  - 24 dBi antenna gain
  - Beam steering: ± 60° (h), ±15° (v)



5G mm-wave landscape

- System integrators know how to build large active array systems
- Numerous beamformers available
  - Mostly BiCMOS – transition to CMOS (RFSOI or bulk)
  - 4 channels or 2x4 channels for dual polarized panels
  - Integration level increasing
- High-performance external front-ends also available
  - GaN or GaAs
- Analog or hybrid beamforming

Key challenges

- Increasing transmitter power efficiency
- Lowering cost
- Increasing transmitter output power

Shannon – Hartley capacity limit

- Radio capacity of a single channel/beam:

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

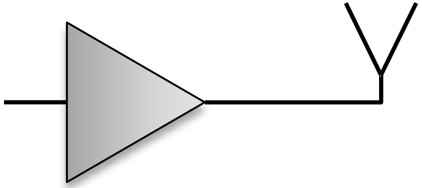
- Increase capacity by increasing bandwidth, *B*
- Wider bandwidth will increase noise: $N \propto Bk_bT_s$
- For maintained SNR, output power must be increased!

- It is practically impossible to reduce the output power while increasing the capacity: <u>mm-wave systems are noise limited</u>

- Focus is on increasing the <u>output power</u> and <u>power efficiency</u> of the transmitter!

Power efficiency

- 1 dB routing loss reduces efficiency 20%



$<P_{out}, P_{DC}>$ $< L >$ $\eta = \frac{P_{out}}{P_{DC}} L = \eta_0 L$

- For lowest cost minimize routing distance
  - Low-loss PCB's are expensive
  - 5 mm of board routing → 0.2 – 0.3 dB loss

Power efficiency

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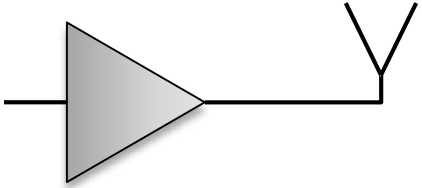

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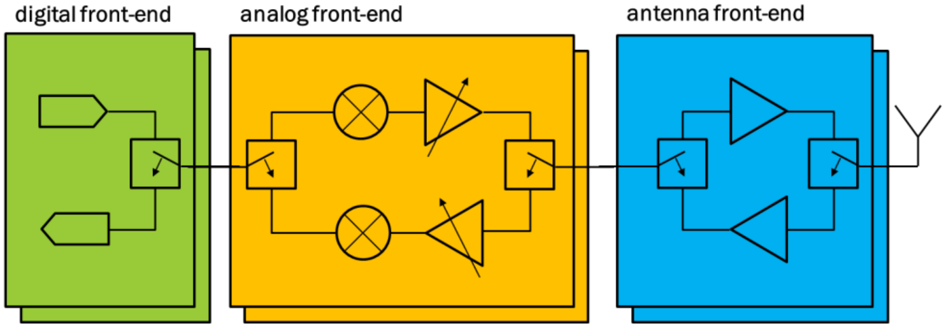
  - Low-loss PCB's are expensive
  - 5 mm of board routing → 0.2 – 0.3 dB loss

Requirement #1:
minimize routing distance
from antenna to front-end

Lowering cost

- Use the cheapest technology per function



7nm CMOS

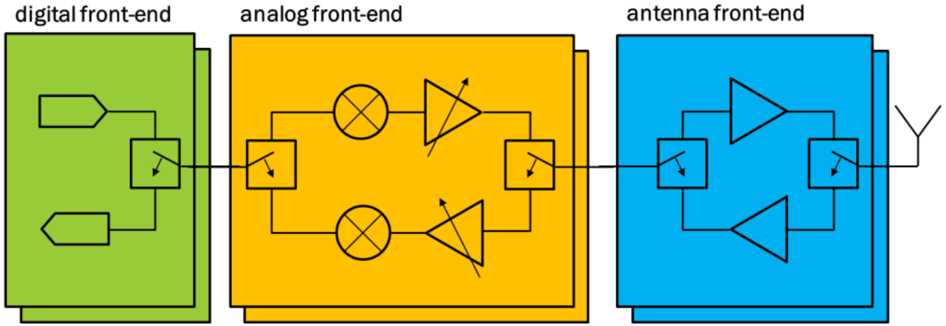
22nm CMOS

45nm CMOS

150nm GaN

Lowering cost

- Use the cheapest technology per function



7nm CMOS

22nm CMOS

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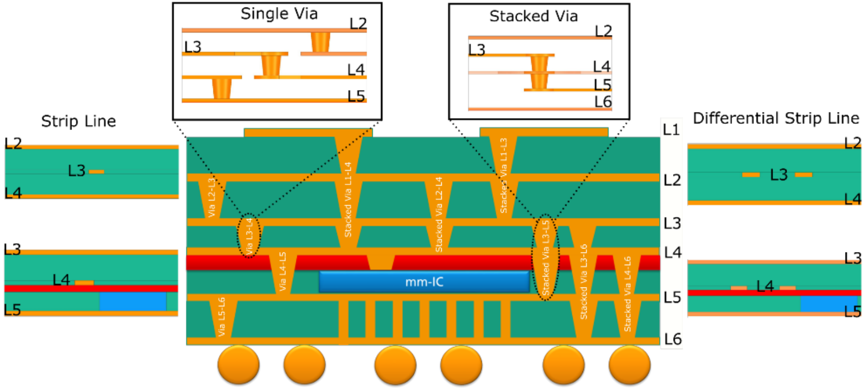
Requirement #2:
scalability and adaptation
to diverse semiconductor
technologies

Increasing transmitter output power

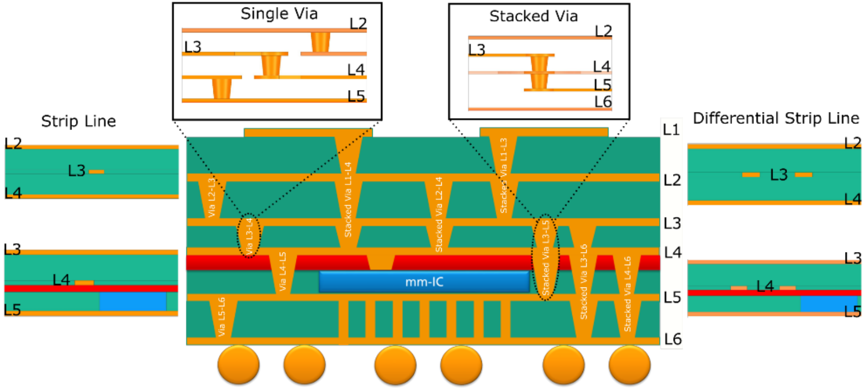
- Arrays are thermally limited



- De-couple electrical and thermal paths
- Minimize thermal resistance from die-to-board

Increasing transmitter output power

- Arrays are thermally limited



- De-couple electrical and thermal paths
- Minimize thermal resistance from die-to-board

Requirement #3:
close to die routing (DC, RF, digital) and low thermal resistance from die to board

Requirements

- Low-loss routing from die to antenna
- Integration of Silicon and III-V technologies
- Close to die DC, RF and digital routing
- Low thermal resistance – die to board

GaN-on-Silicon Efficient mm-wave European System Integration Platform

SERENA

- Project start: 1st January 2018
- Duration: 3 years
- Total costs/EC contribution: EUR 3.9M
- 9 partners from 5 European countries
- 3 SMEs, 2 research organizations, 2 industrial partners, 2 universities

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www.serena-2020.eu

SERENA-H2020

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5G mm-wave heterogenous integration

- Explore the possibilities of …
  - GaN-on-Si MMICs
  - Separate thermal and electrical paths
  - Module integration of GaN-on-Si, SiGe and antennas

- While providing a path to low cost
  - GaN-on-Si
  - Low-cost PCB packaging

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If you need further information, please contact the coordinator:

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