ITSS 2014 - Copenhagen

TECHNISCHE UNIVERSITÄT DARMSTADT

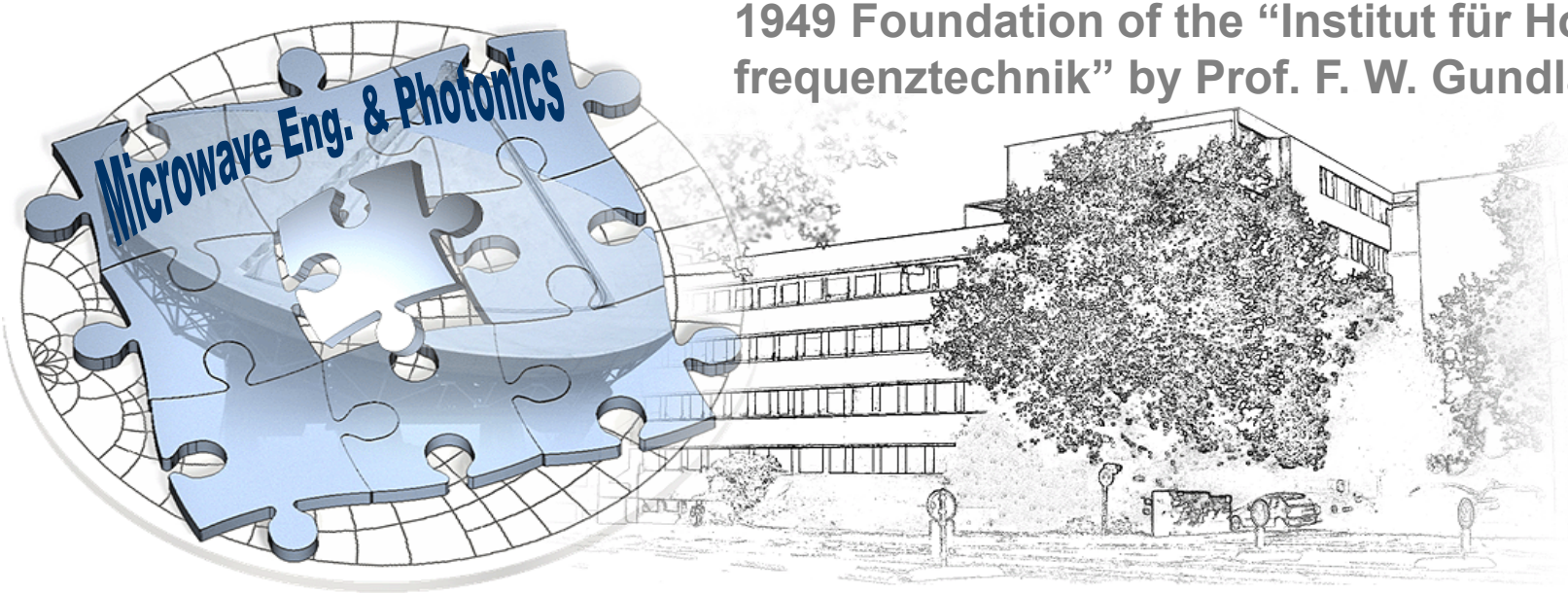
Dipl.-Ing. Daniel Kienemund

IMP

Institute of Microwave Engineering & Photonics (IMP)

TECHNISCHE UNIVERSITÄT DARMSTADT

Microwave Engineering	Head: Prof. Jakoby
Optical Communications	Head: Prof. Küppers, Prof. Meißner
Microwave Electronics	Head: Prof. Hartnagel



1949 Foundation of the “Institut für Hoch-frequenztechnik” by Prof. F. W. Gundlach

Institute of Microwave Engineering & Photonics (IMP), Merckstr. 25

Scientific Staff: 39

Technical Staff: 4, Administrative Staff: 4

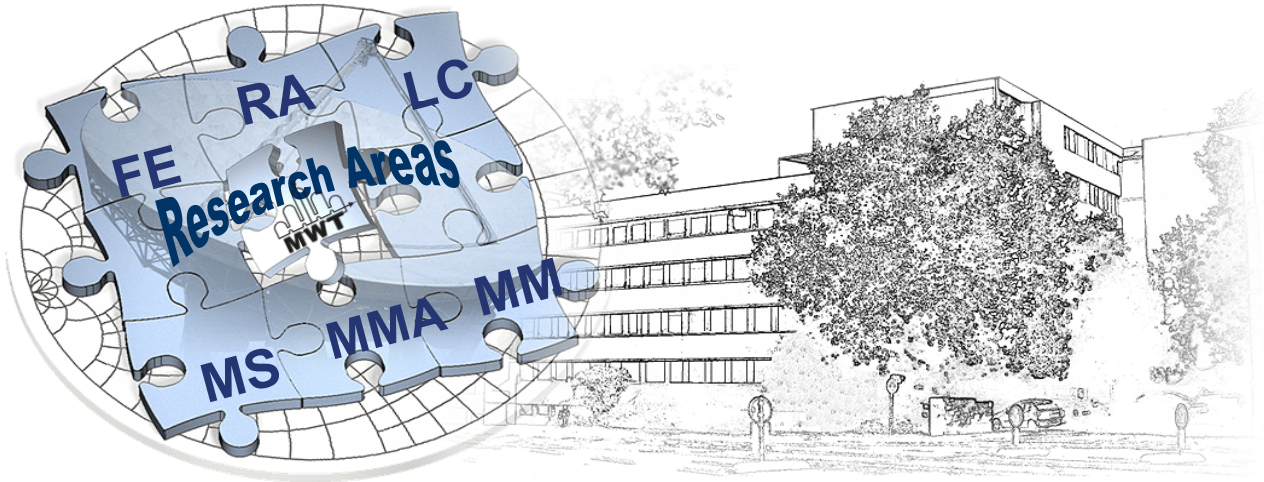
IMP

Microwave Engineering
FG MikroWellenTechnik

TECHNISCHE UNIVERSITÄT DARMSTADT

Head: Rolf Jakoby

Interdisciplinary research on agile microwave devices with novel approaches, functional materials & innovative technologies



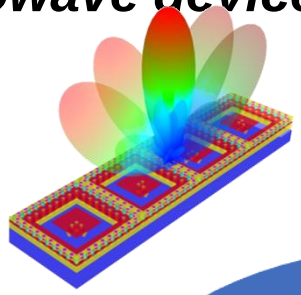
Microwave Technology (MWT) Hans Busch Institut (HBI)

FerroElectrics
Reconfig. Antennas
Liquid Crystals
MetaMaterials
MM Applications
Microwave Sensors

Microwave Engineering group
Research areas

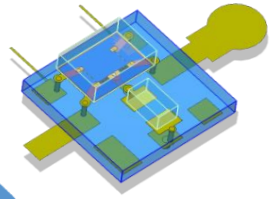
TECHNISCHE UNIVERSITÄT DARMSTADT

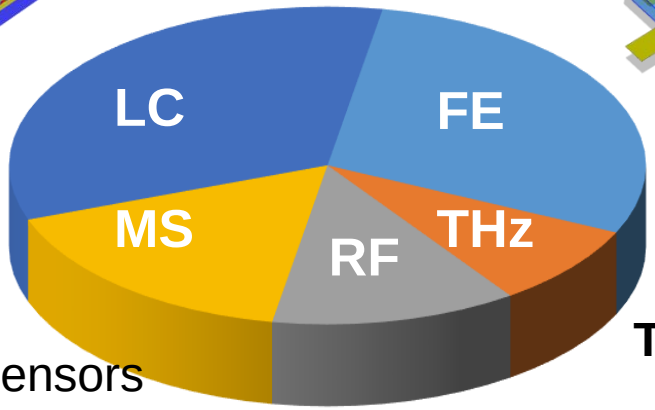
Objective: **Novel approaches for cost- & energy-efficient, *agile microwave devices with innovative functional materials & technologies***



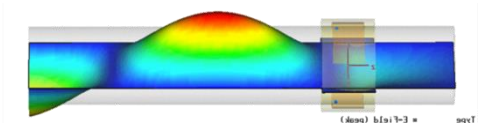
Liquid
Crystals

Ferro**E**lectrics



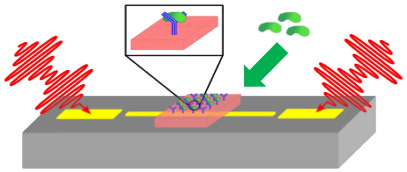


Microwave **S**ensors
&
Devices



RF Sensors
&
RFID

THz Sensors &
Devices



3 Post-Docs

27 Doctoral Candidates

1 Management

2 Administrative

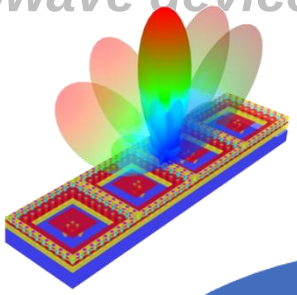
2 Engineers

3 Technicians

Microwave Engineering group
Research areas

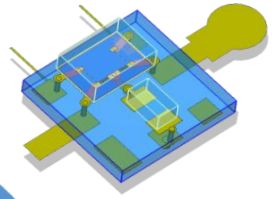
TECHNISCHE UNIVERSITÄT DARMSTADT

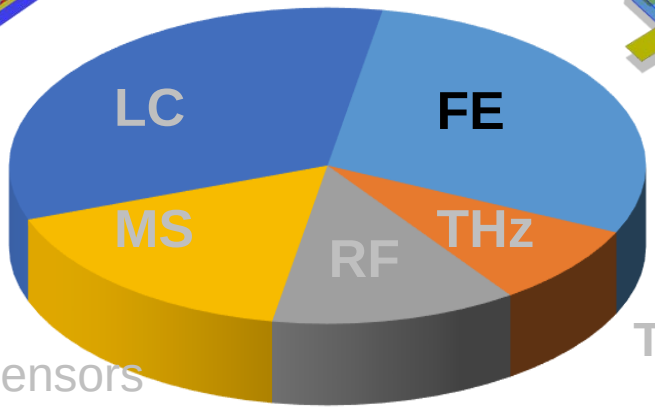
Objective: Novel approaches for cost- & energy-efficient, *agile microwave devices with innovative functional materials & technologies*



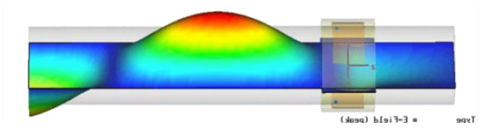
Liquid Crystals

FerroElectrics



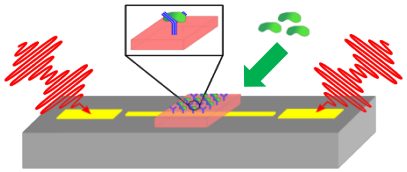


Microwave Sensors & Devices



RF Sensors & RFID

THz Sensors & Devices



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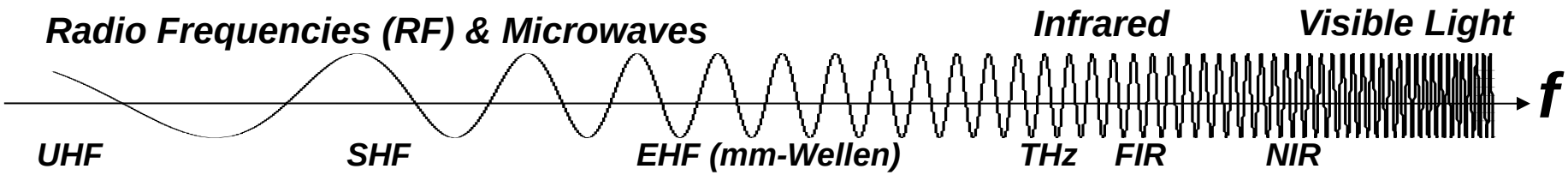
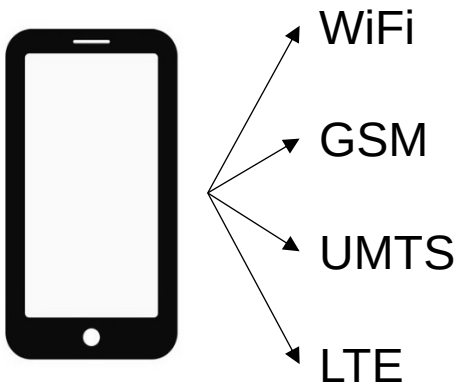
Motivation – Ferro Electrics



Source: Introduction to MWT Lecture Wiens

- Modern communication applications require a variety of frequency bands
- Optimization of the hardware components within the radio frontend in regard to one frequency
  - ➢ Inefficient hardware usage with other frequencies
- Power Amplifier (PA) essential component within the radio frontend in regard to efficiency
  - ➢ Impedance matching of the PA vital to increase the efficiency of the radio frontend



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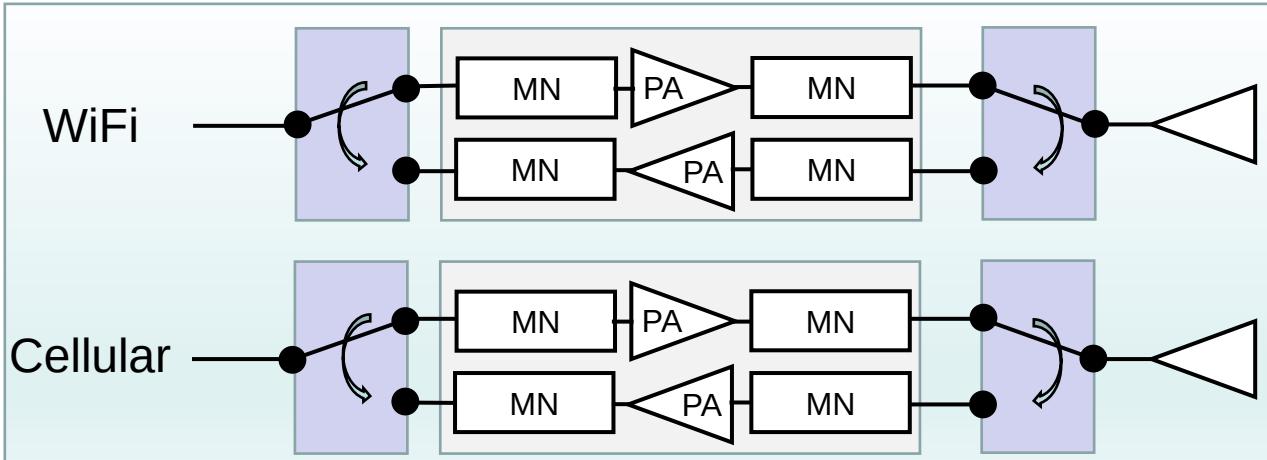
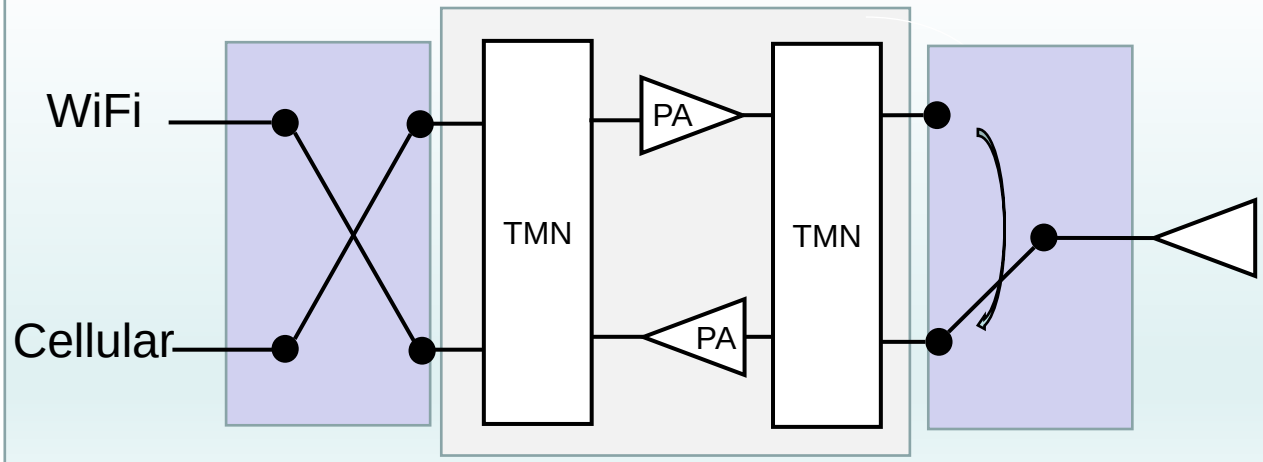


Radio Front End:

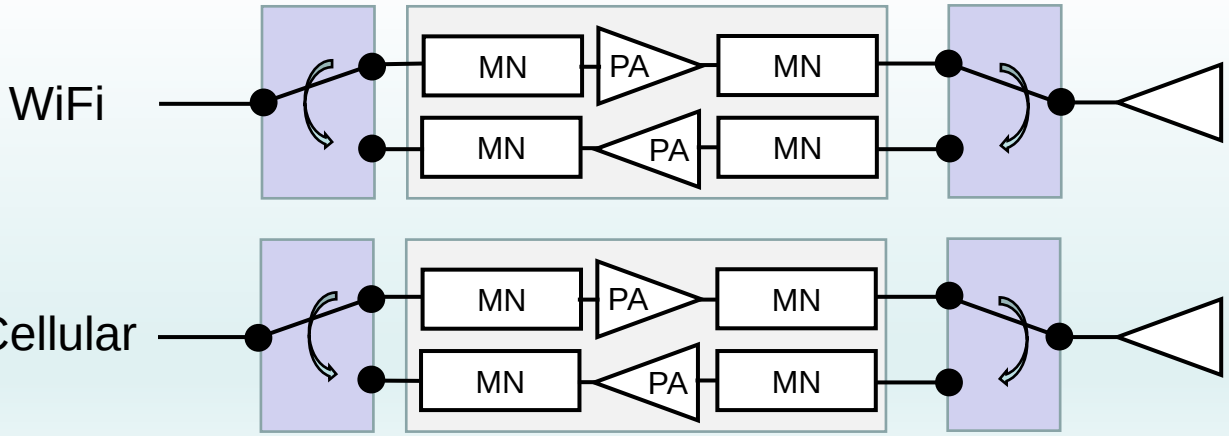
- Matching Network (MN)
- Power Amplifier (PA)
- Multiplexer Switches
- Antenna



Radio Front End:

- Tunable Matching Network (TMN)
- Power Amplifier (PA)
- Multiplexer Switches
- Antenna

Motivation – Ferro Electrics



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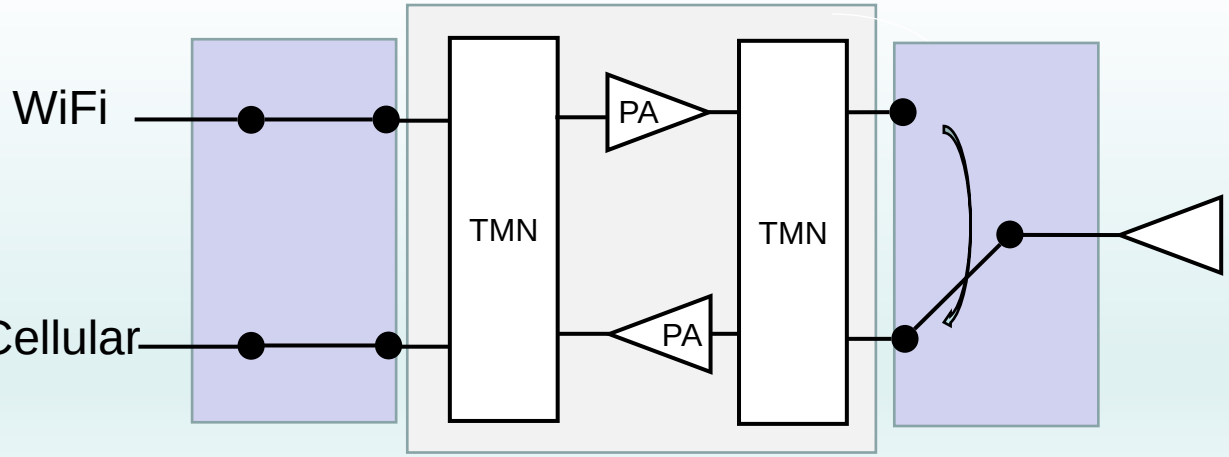

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- Tunable Matching Network (TMN)
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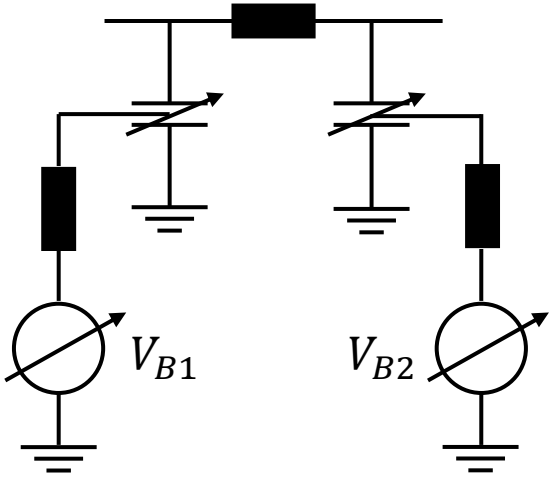
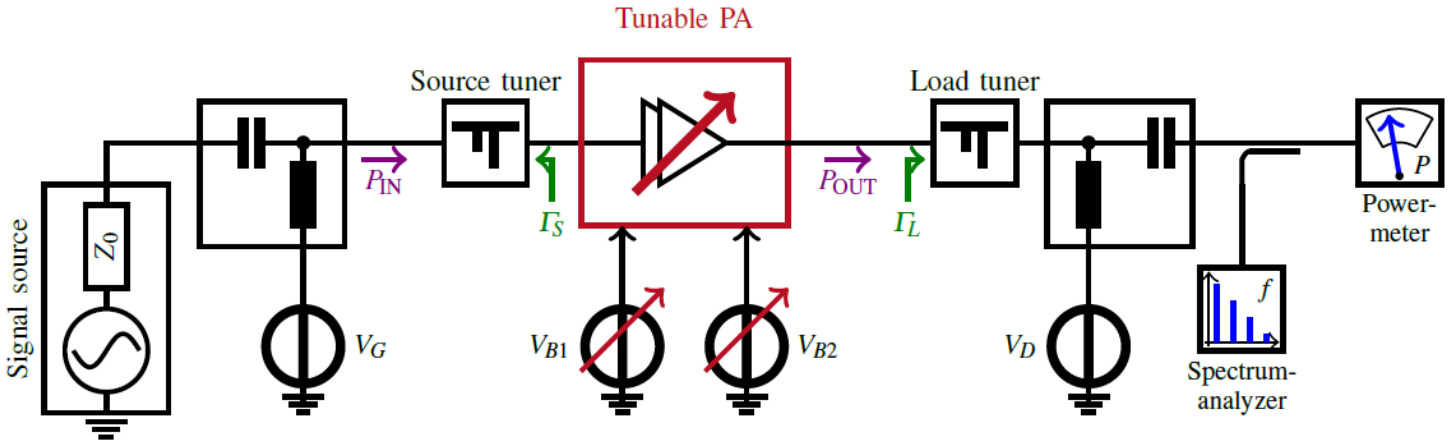
Tunable Matching Networks

- Tunable Matching Networks based on the π-Filter
- Tuning via a DC voltage
  - ➢ Decoupling of RF and DC voltage components essential
- Tunable input and output impedance of the PA



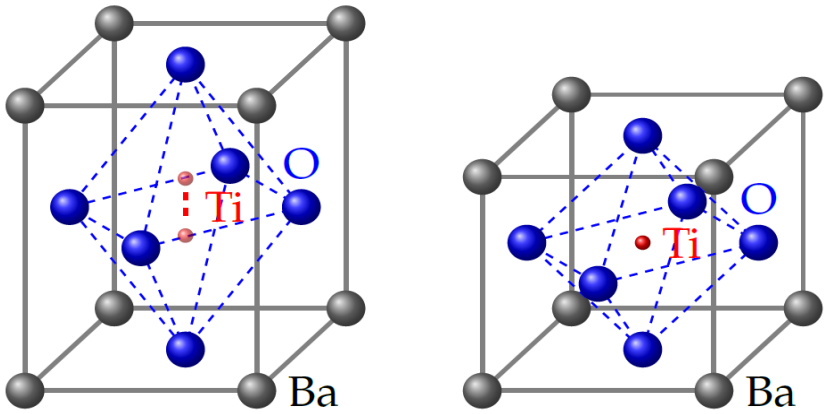


Source: Paper Wiens

Barium Strontium Titanate

- Based on the ferroelectric material Barium Titanate
- Curie Temperature separates the paraelectric from the ferroelectric phase
- Mixture with Strontium decreases the Curie Temperature
- In the paraelectric phase the losses emerging from hysteresis are reduced
- Additional doping of BST changes the dielectric properties

$T > T_C$ $T > T_C$



Source: PhD Thesis Maune

Dielectric Properties of doped BST at 2 GHz

Dopant	$\varepsilon_r(0V)$	Q$(0V)$	$\tau(10V\mu m^{-1})$
Fe – F	260	60	20%
Cu – F	400	40	40%

Source: Paper

Summary

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- Advantages enabled through Tunable Matching Networks:
  - Higher efficiency of the radio frontend @
    - Various frequencies
    - Various input power levels
  - Lesser components required
- Possible tuning of the input and output impedance
- Barium Strontium Titanate as the tunable material
  - Adapting of the operating temperature via mixture ratio
  - Adapting of the dielectric properties via doping
  - Varactor based circuit design (π-Filter)

Thank you for your attention