4G Antennas and Related SAR for Wireless Eyewear Devices

JOURNEES SCIENTIFIQUES 2014, L'HOMME CONNECTÉ, PARIS

A. Cihangir[1], W. Whittow[2], C. Panagamuwa[2], F. Ferrero[3], G. Jacquemod[1], F. Gianesello[4], R. Pilard[4], C. Luxey[1]

1 EpOC, Université Nice-Sophia Antipolis
2 Wireless Communications Research Group, Loughborough University
3 CREMANT-CNRS-LEAT
4 STMicroelectronics, Crolles

OUTLINE

- INTRODUCTION

- FEASIBILITY STUDY
  - BANDWIDTH POTENTIAL
  - SAR SIMULATIONS

- MANUFACTURED PROTOTYPES

- MEASUREMENT RESULTS

- CONCLUSION

INTRODUCTION

- Wearable technology devices becoming more popular day by day

- Smart watches, rings, glasses, etc…

- Many products, getting ready to be launched in 2014 by different companies

- What is exactly an eyewear device?

- "An interactive eyewear device that can transmit/receive information to its surroundings using EM waves"

PROBABLY NOT THE BEST WAY

INTRODUCTION

- Products from different companies
- Limited connectivity to a hotspot or peripheral using Wi-Fi or Bluetooth
- Antennas generally placed behind the ear, like in a wireless headset
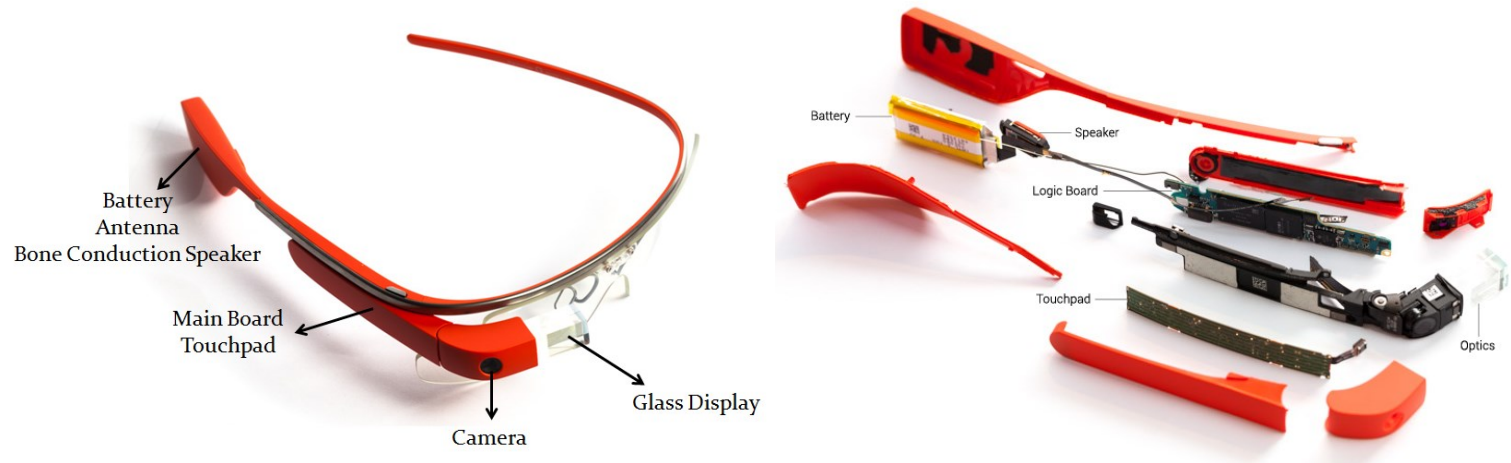- Antenna problem is easy to solve, SAR out of concern

VUZIX M100

DUAL CORE CPU
BLUETOOTH
WIFI
ANT+
GPS
WITH ON BOARD GYROSCOPE, ACCELEROMETER, MAGNETOMETER, ALTIMETER AND THERMOMETER
OPTICAL TOUCHPAD
HD CAMERA
WITH MICROPHONE AND SPEAKER
POLARIZED LENSES
CHANGEABLE BATTERY
HIGH RESOLUTION DISPLAY
WITH IR GAZE DETECTION

RECON JET

Bluetooth®

OLYMPUS MEG4.0

OPTINVENT ORA

INTRODUCTION

- Products from different companies
- Limited connectivity to a hotspot or peripheral using Wi-Fi or Bluetooth
- Antennas generally placed behind the ear, like in a wireless headset
- Antenna problem is easy to solve, SAR out of concern

INTRODUCTION

- These devices are foreseen to replace mobile phones in the future
- ➔ Necessity for antennas covering LTE frequency bands
  - 700-960 MHz (Low-Band), 30% Bandwidth
  - 1.7-2.7GHz (High-Band), 45% Bandwidth

- Space reserved for the antenna is electrically small
- ➔ Low real part of input impedance, high Q-factor
- ➔ Low bandwidth potential
- Need to benefit the radiation coming from the currents induced on the system ground plane

INTRODUCTION

- Capacitive coupling elements (CE)

- Inherently non-resonant

- Used to excite resonating currents on the ground plane

- Matching network needed to tune the antenna to desired bands
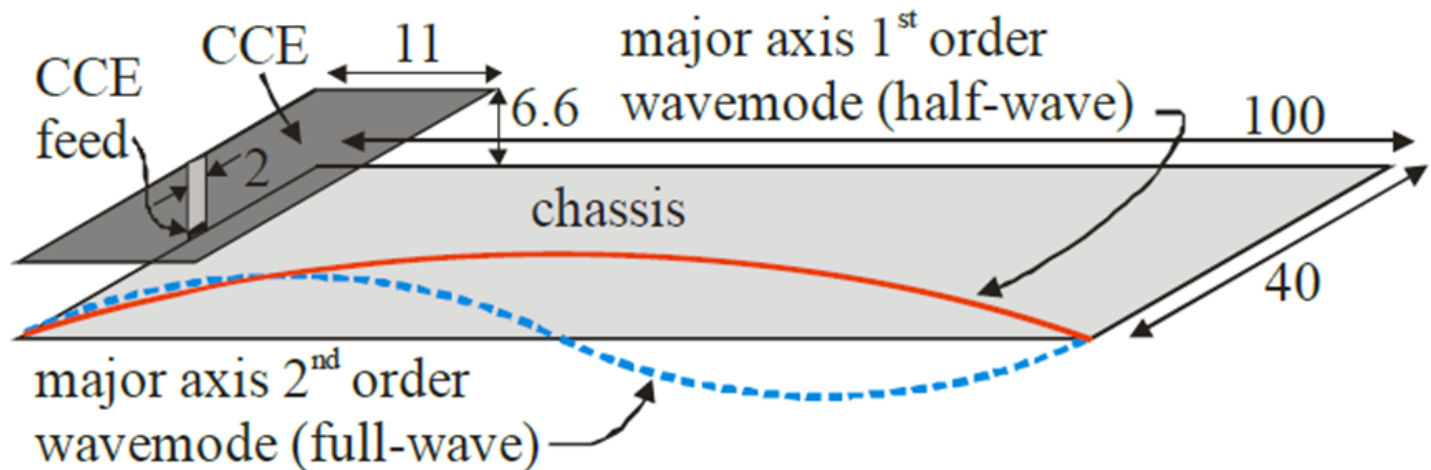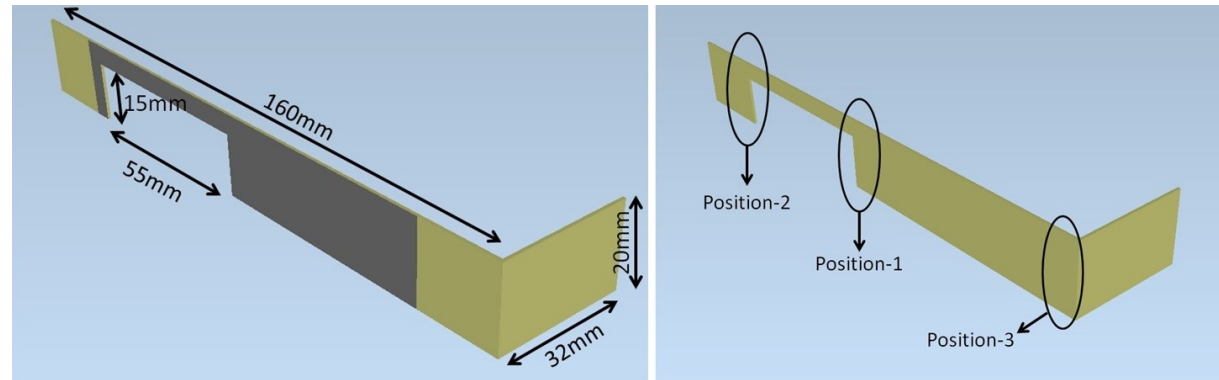

J. Holopainen, "Compact UHF-band antennas for mobile terminals:focus on modelling, implementation, and user interaction," Ph.D. dissertation, Department of Radio Science and Engineering, AALTO University, Helsinki, 2011.
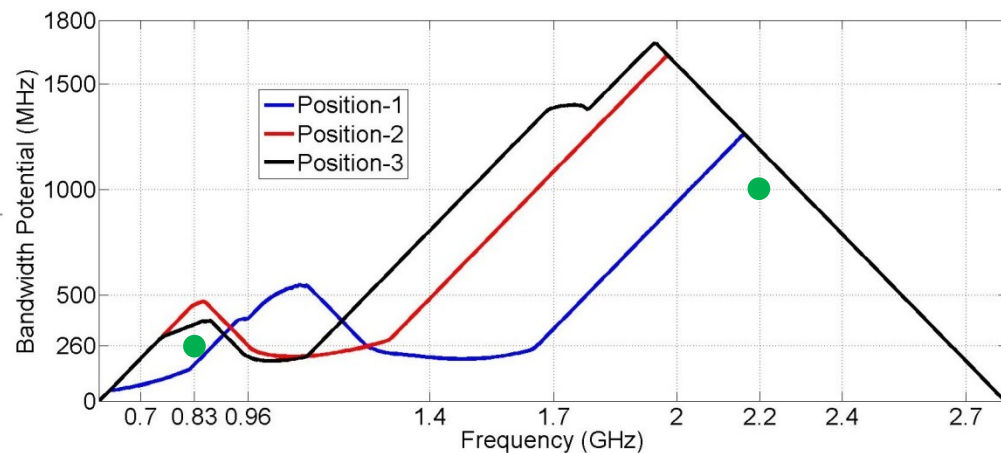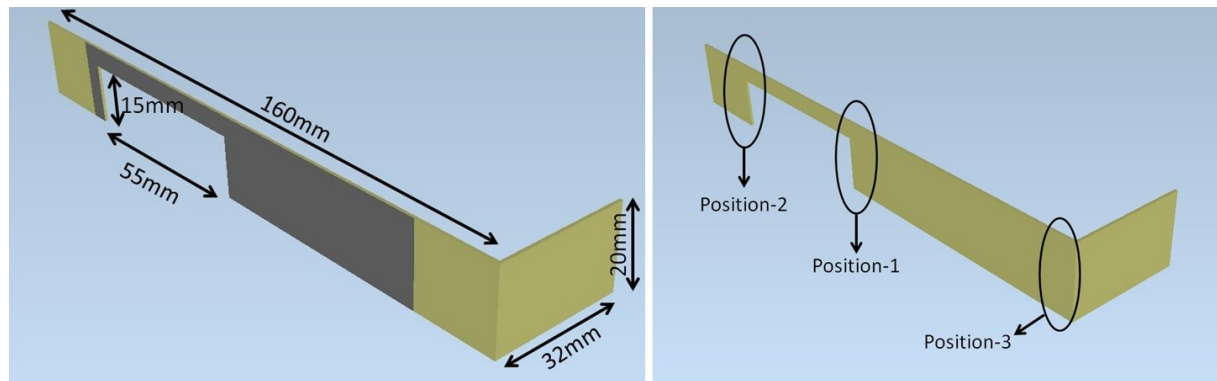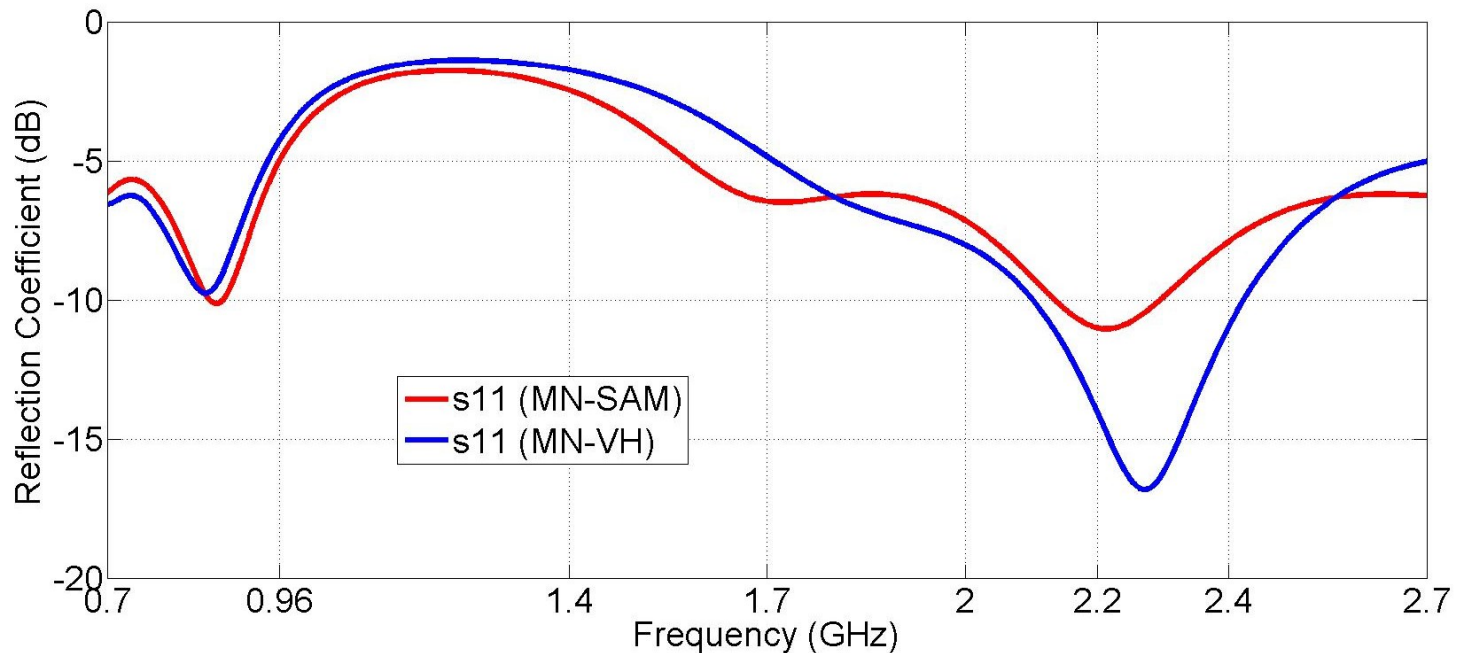
FEASIBILITY STUDY

- CE (printed on the FR4 substrate) evaluated in three different locations (Homogenous and heterogeneous models)
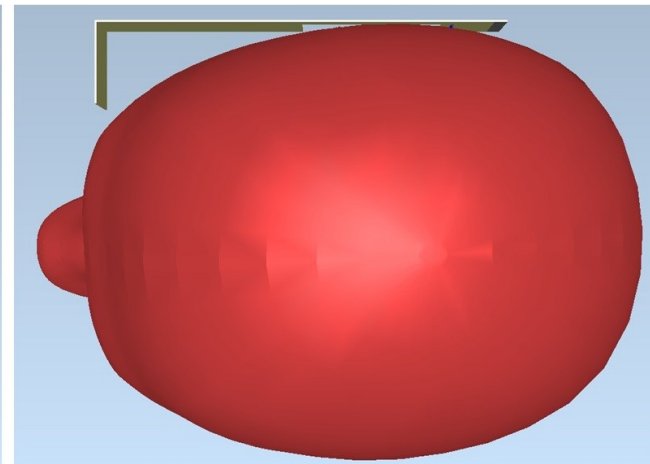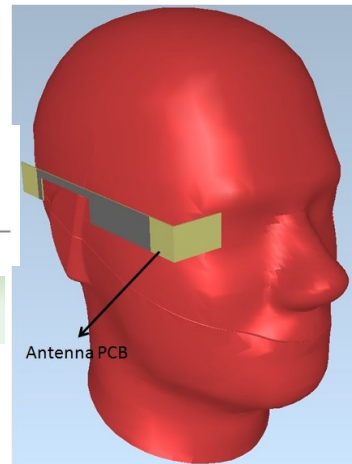
FEASIBILITY STUDY

- CE (printed on the FR4 substrate) evaluated in three different locations (Homogenous and heterogeneous models)
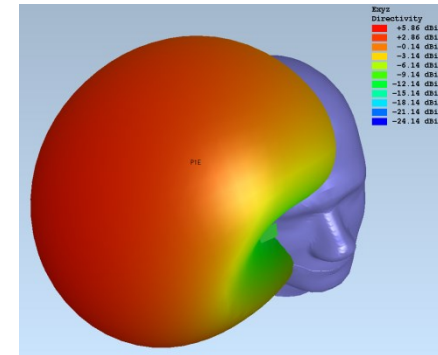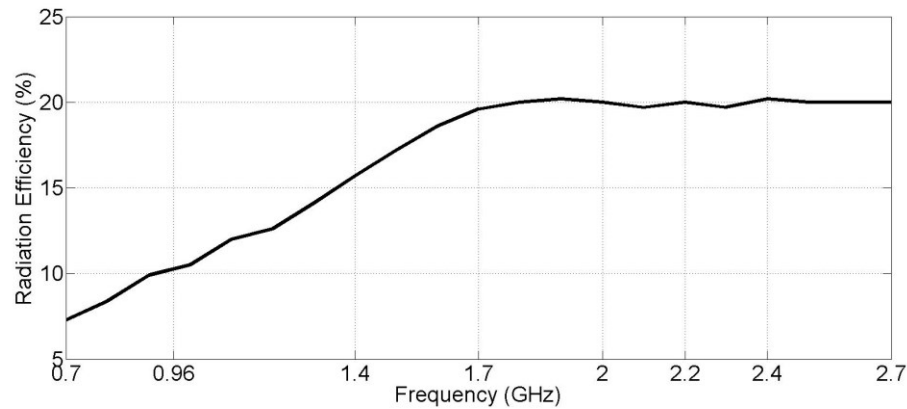
FEASIBILITY STUDY

- Antenna position-2 (behind the ear)
- MN consisting of two lumped elements
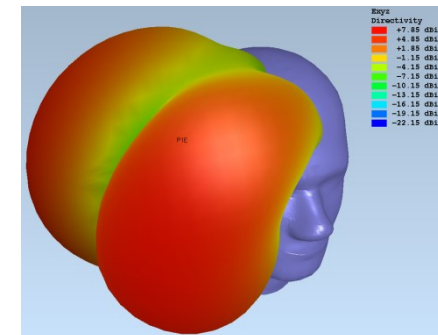- Able to cover 0.7-0.96GHz and 1.7-2.7GHz

FEASIBILITY STUDY
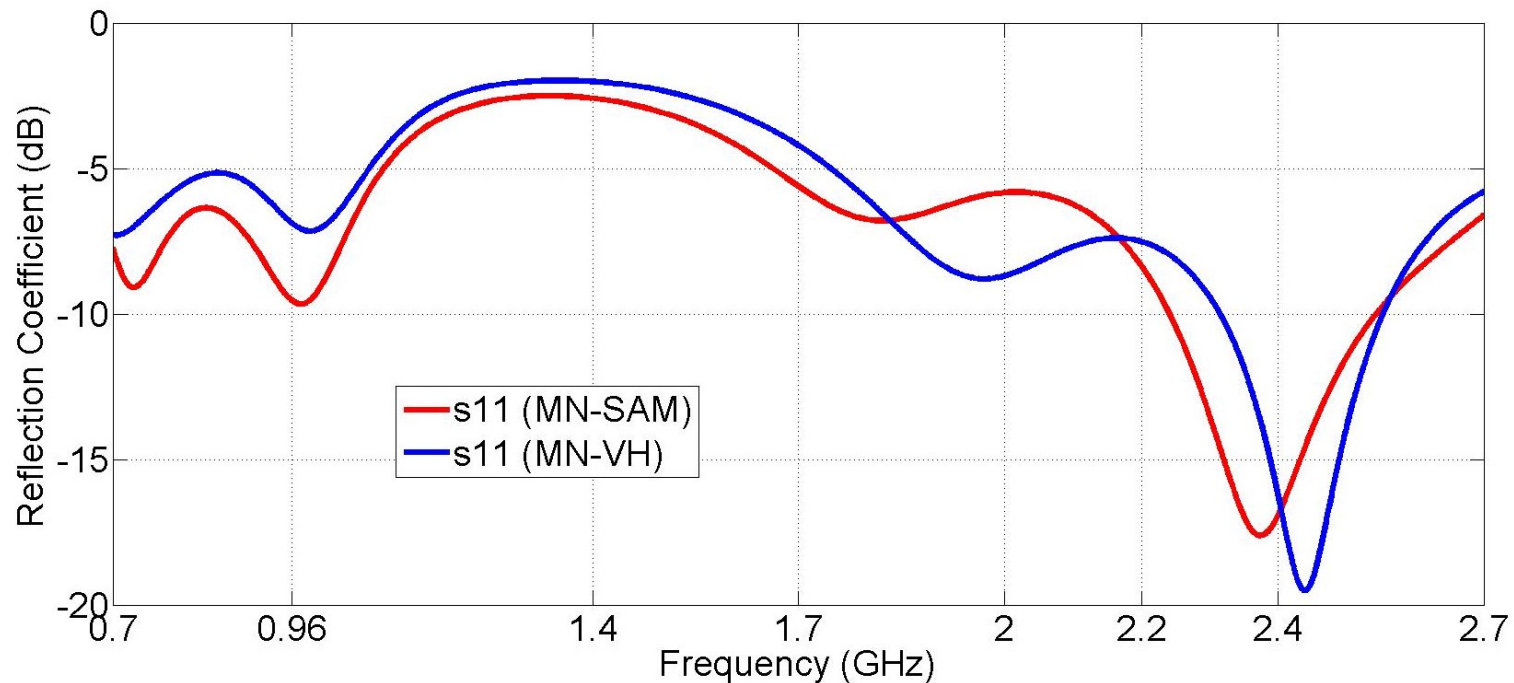
- Position-2

Pattern at 800MHz

Pattern at 2.2GHz

FEASIBILITY STUDY

- Antenna position-3 (close to the eye)
- MN consisting of three lumped elements
- Able to cover 0.7-0.96GHz and 1.7-2.7GHz

FEASIBILITY STUDY

- Position-3
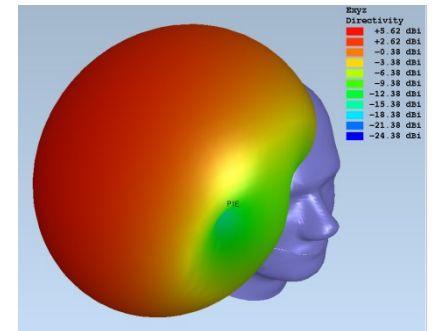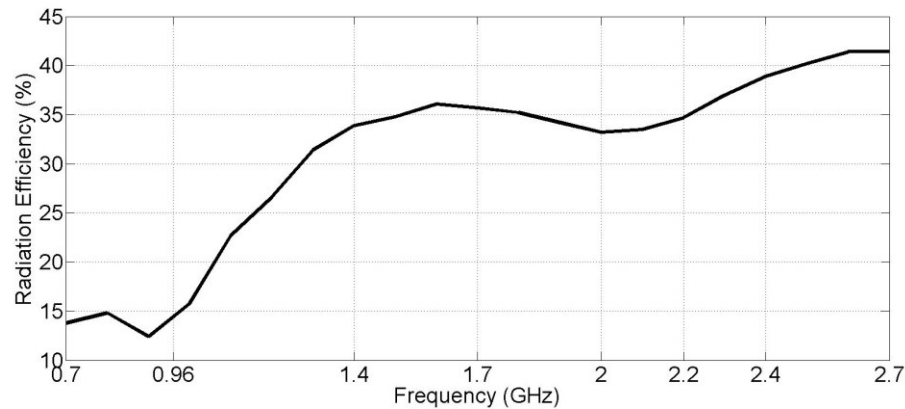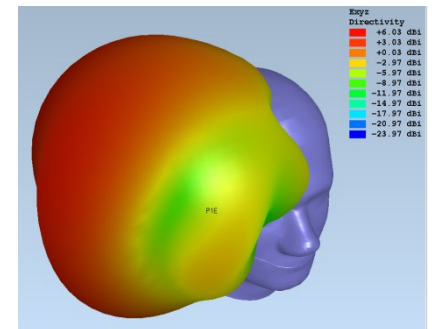

Pattern at 800MHz

Pattern at 2.2GHz

FEASIBILITY STUDY

- SAR simulations done with both SAM (homogenous) and VH (heterogeneous) head models

- European standard: 2W/kg averaged over 10g tissue

- US Standard: 1.6W/kg averaged over 1g tissue

PROBLEM IN SAR !

| Position	Freq (MHz)	Radiation Eff (%)	0.25W incident power	
			1g SAR	10g SAR
1	1900	25	7.86	3.32
1	2200	36	4.31	2.07
1	2500	42	4.36	**1.54**
2	835	10	4.33	2.08
2	1900	20	2.97	**1.47**
2	2200	21	4.18	**1.99**
2	2500	21	3.68	**1.83**
3	835	13	4.17	2.03
3	1900	38	2.47	**1.18**
3	2200	33	2.22	**1.04**
3	2500	37	1.96	**0.82**
Limit			1.6	2

REALISTIC PROTOTYPES

- Realistic dielectric frame generic for three prototypes

- Manufactured using a 3D printer

- ABS Material, ε_r=2.97, δ_{loss}=0.029

- Antennas excited by WFL cables

2mm

2mm

Holes for the integration of the WFL feed cables

PCB inside the casing

REALISTIC PROTOTYPES

- Realistic dielectric frame generic for three prototypes

- Manufactured using a 3D printer

- ABS Material, ε_r=2.97, δ_{loss}=0.029

- Antennas excited by WFL cables

2mm 2mm
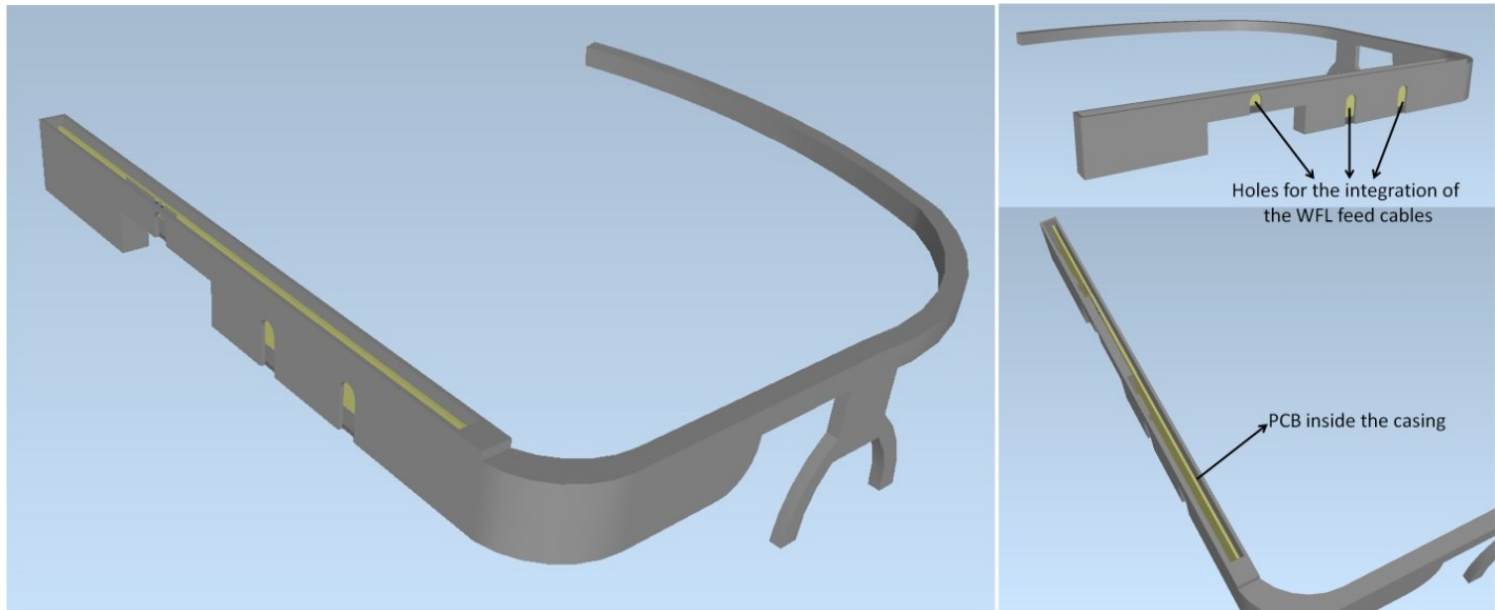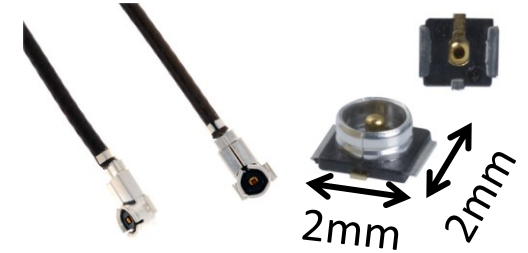
MEASUREMENTS

- S-Parameter and efficiency measurements

Free Space

With Head

With Head & Hand

MEASUREMENTS

- Prototype-1 (CE placed close to the eye)
- MN consisting of three lumped components
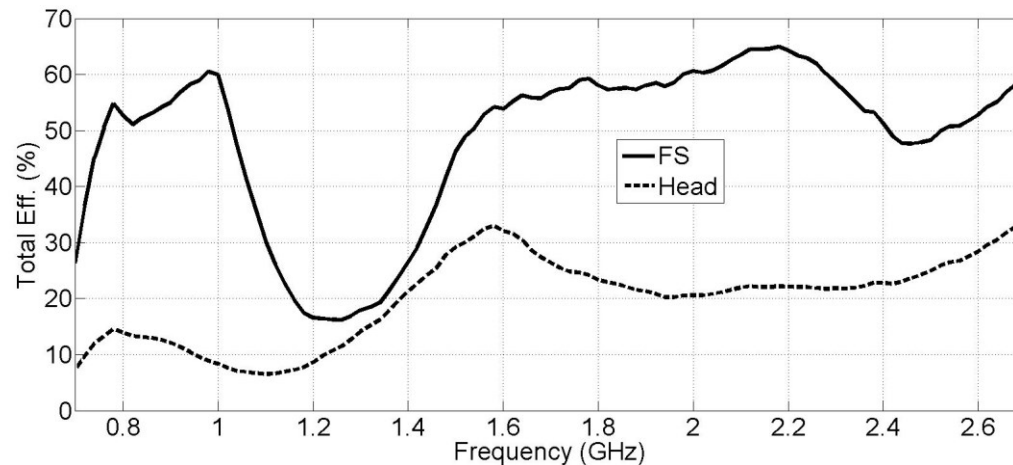
MEASUREMENTS

- Prototype-2 (CE placed in the middle of PCB)
- MN consisting of three lumped components
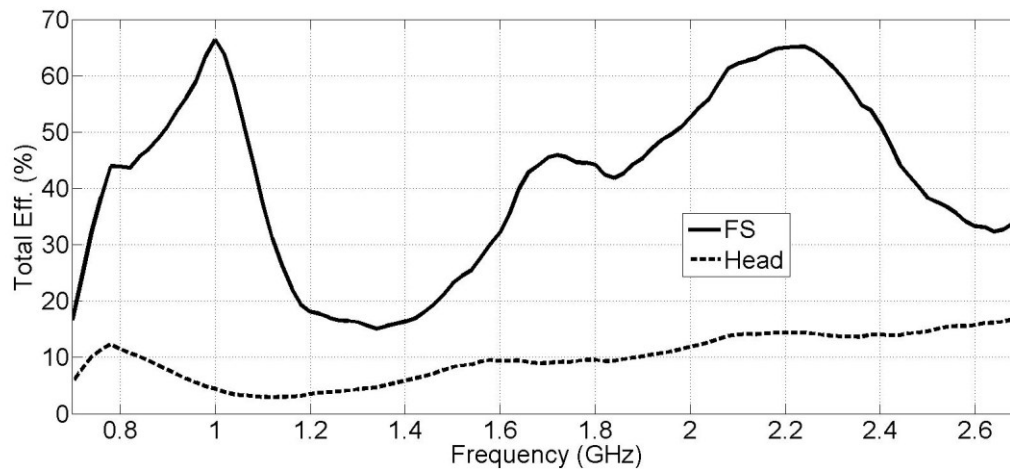
MEASUREMENTS

- Prototype-3 (CE placed behind the ear)
- MN consisting of three lumped components
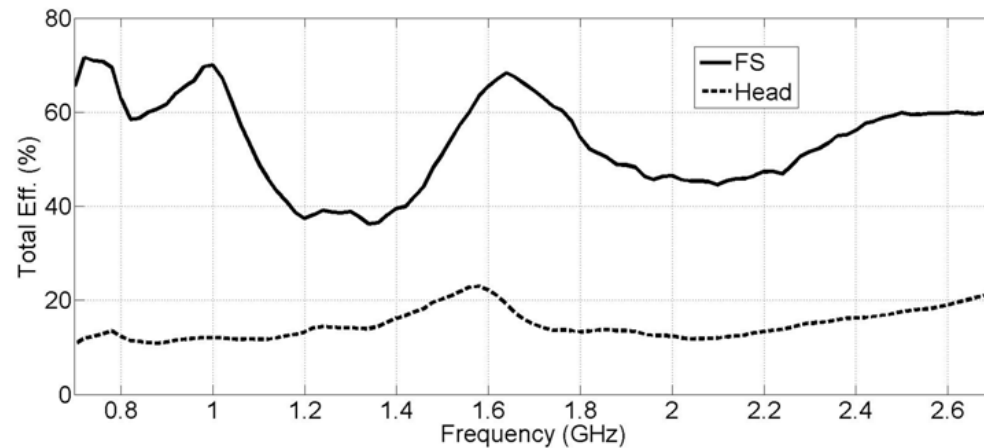
SAR SIMULATIONS

- Similar SAR trend as feasibility study in simulations
- Higher SAR than the limit for 1g and closer to the limit for 10g (for 0.25W input power)
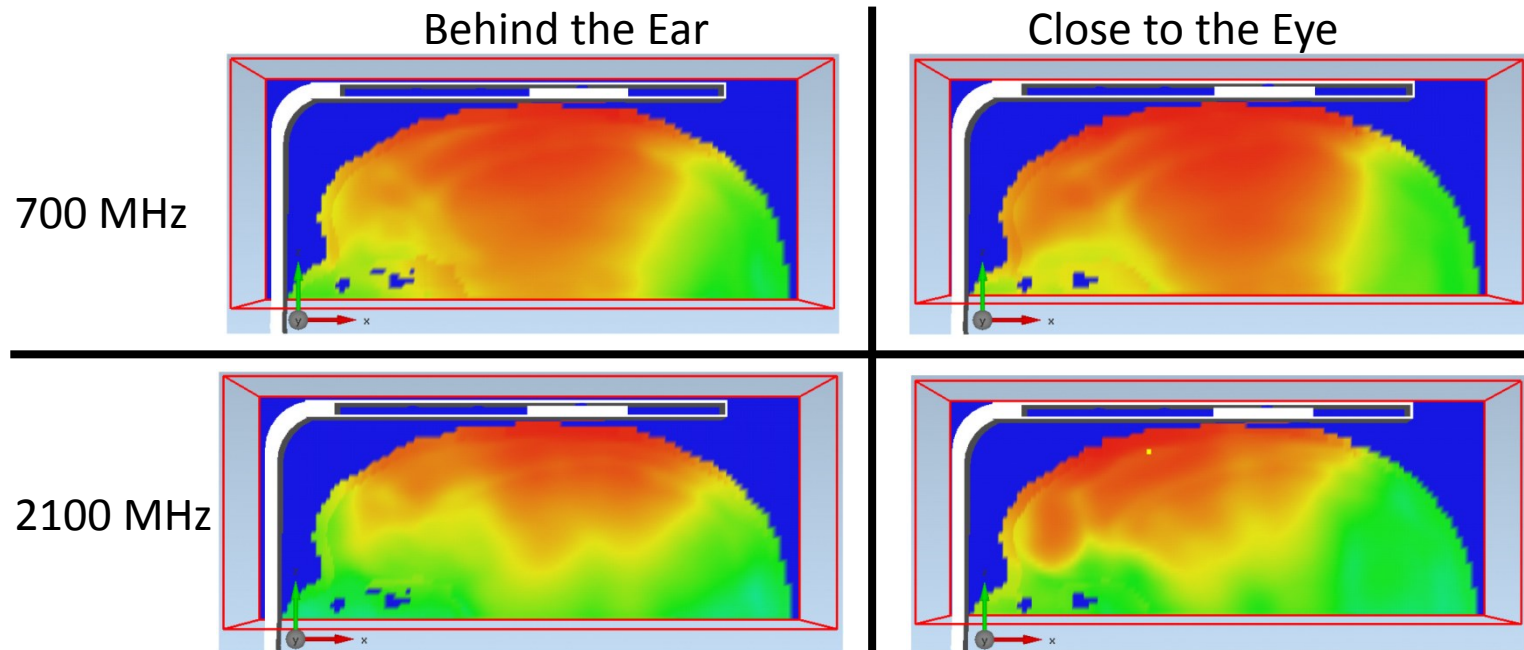- Secondary hot-spots may be observed in the eye for heterogeneous head model

	Behind the Ear	Close to the Eye
700 MHz		
2100 MHz		

SAR MEASUREMENTS

- SAR measurements planned to be done soon
- DASY4 SAR measurement system
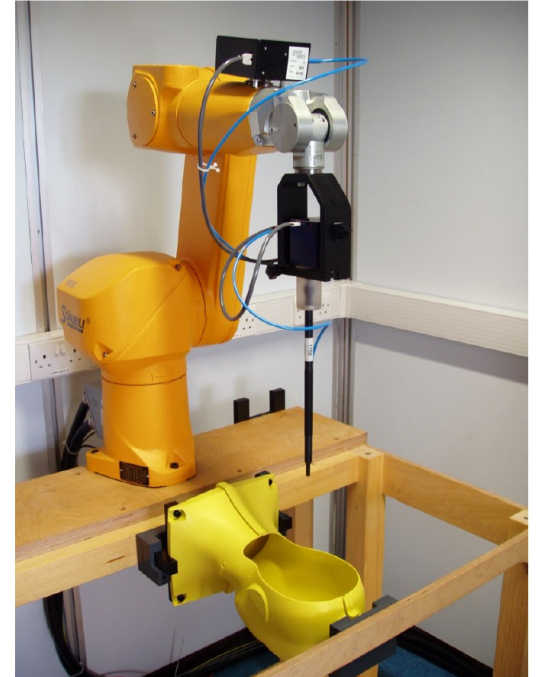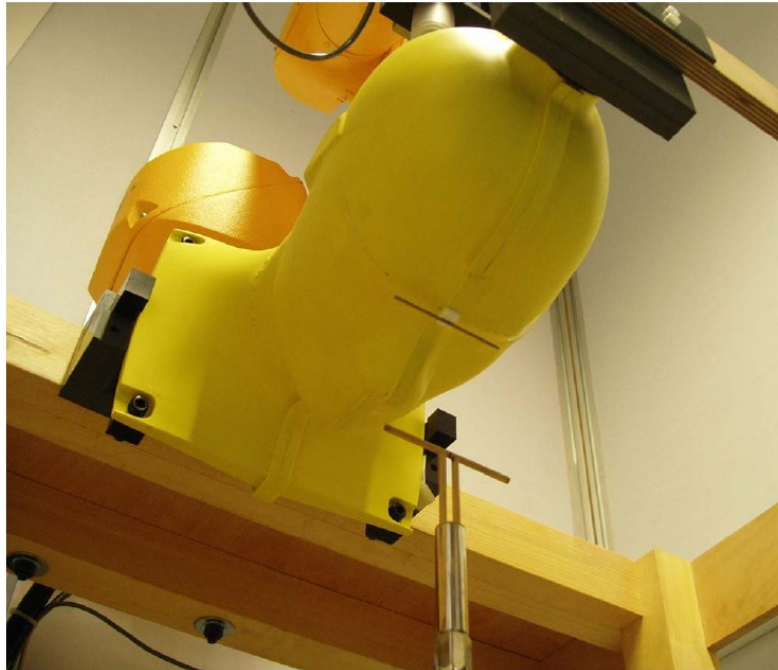
CONCLUSION

- LTE antenna designs using CEs for eyewear applications

- Feasibility study
  - BW Potential enough to obtain dual-band coverage
  - SAR levels exceeding or close to the limit !

- Realistic prototypes with a dielectric frame
  - Good agreement with simulations
  - S-Parameter and efficiency measurements

- SAR measurements planned to be done soon

- MIMO implementation to be presented in AP-S 2014 conference

THANK YOU FOR LISTENING

ANY QUESTIONS ?