79 GHz SiGe based UWB Short Range Radar - BMBF Joint Project RoCC -

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***Abstract*-- Automotive UWB (Ultra-Wideband) short range radar (SSR) is on the market as a key technology for novel comfort and safety systems. SiGe based 79 GHz UWB SRR will be a definite candidate for the long term substitution of the 24 GHz UWB SRR. This paper will give an overview of the finished BMBF joint project KOKON and the recently started successing project RoCC, which concentrate on the development of this technology and sensor demonstrators. In both projects, the responsibilities of Daimler AG deal with application based sensor specification and test & evaluation of realized sensor demonstrators. Recent UWB SRR frequency regulation approaches and activitites will be reviewed shortly. Thereafter, the BMBF KOKON successing project RoCC will be introduced in detail. Project motivation, project goals and the underlying organization will be outlined.**

***Index terms*-- Automotive Radar, SRR, UWB, SiGe-Technology, 79 GHz, BMBF, KOKON, RoCC.**

I. INTRODUCTION

Automotive radar facilitates various functions which increase the driver's safety and convenience. Exact measurement of distance and relative speed of objects in front, beside, or behind the car allows the realization of systems which improve the driver's ability to perceive objects during bad optical visibility or objects hidden in the blind spot during parking or changing lanes.

Radar technology has proved its ability for automotive applications for several years. When compared to its optical counterpart video (with image processing) or lidar, the advantages of radar are obvious:

- Direct distance and speed measurement
- Robust against weather influences and pollution
- Unaffected by light
- Measurement of stationary and moving objects on and in the vicinity of the road
- Invisible integration behind electromagnetic transparent materials (e.g. bumpers).

Meanwhile many car manufacturers use 77 GHz radar for autonomous cruise control (ACC) or recently even for pre-crash or collision mitigation. It was first introduced to the market in the Mercedes-Benz S-class under the name "Distronic" in 1998. In addition, UWB short range radar operating at 24 GHz has been developed and introduced (Mercedes-Benz S-class, Distronic Plus, 2005) and is a key enabling technology for actual and novel driver assistance and safety systems. Fig. 1 gives an overview on possible (UWB) SRR based vehicle applications.

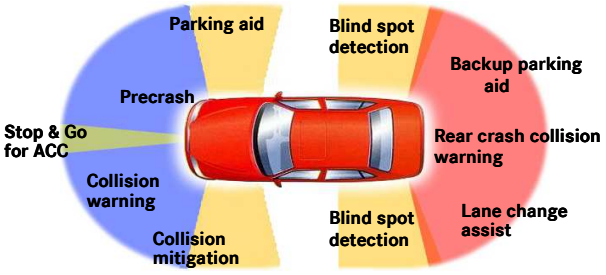

Fig. 1. SRR based assistance and safety applications.

The need for a UWB bandwith is given by the application. Especially safety applications like the prediction of a possible collision need capability of reliable object tracking and object discrimination. Thus, SRR has to have sufficiently high range resolution in the centimeter range to detect smaller objects and vulnerable road users such as motor cyclists and children.

II. UWB SRR Frequency Allocation in Europe

In 2004 and 2005, the EC and the ECC (Electronic Communications Committee of the CEPT) adopted decisions [1, 2] that regulate the temporary introduction of vehicular UWB SRR using 24 GHz spectrum in Europe until July 1, 2013 and the unlimited allocation at 79 GHz (see Fig. 2). This regulation was the basis for the worldwide first market introduction of UWB SRR in the Mercedes-Benz S-class in 2005.

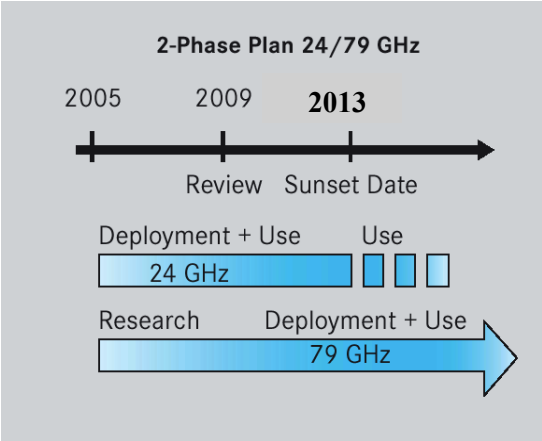

Fig. 2. European 2-Phase-Solution for 24 GHz UWB SRR frequency allocation.

The EC requested a fundamental review of its regulation, to be carried out by December 31, 2009, at the latest to verify the continuing relevance of the initial assumptions concerning the operation of vehicular SRR and development progress in the 79 GHz range technology. This process started in December 2008.

Automotive manufacturers product lines have long lead times and need assured access to technology. Meanwhile, there seem to be indications that 79 GHz UWB SRR products are probably not mature enough in time for for a seamless transition from 24 GHz to 79 GHz in 2013. Thus, the EC recently mandated the CEPT to review the present 24 GHz UWB SRR regulation and to consider flexible regulatory approaches to avoid a technology gap until the availability of 79 GHz UWB SRR sensors.

III. BMBF Joint Project KOKON

In comparison to 24 GHz, the frequency range around 77-81 GHz offers different advantages, e.g.:

- one common technology platform for SRR and LRR available (frequency range 76 - 81 GHz)
- decreased dimensions and weight
- increased doppler sensitivity
- higher angular resolution with moderate antenna aperture dimensions possible.

Due to this, and as a consequence of the EU regulation, the BMBF joint project KOKON ([3, 4], 2004-2007) was launched to develop the basis technologies of 79 GHz UWB SRR and of 77 GHz advanced LRR. SiGe technology was chosen to achieve the required cost reduction and to establish the basis for highly integrated and compact radar front-ends.

KOKON was a very successful project. The feasibility of 79 GHz UWB SiGe based technology and components was clearly demonstrated. Continental realized UWB SRR demonstrators (Fig. 3) and Bosch decided to use the SiGe technology in the new LRR3 ACC-radar.

Fig. 3. 79 GHz UWB SRR demonstrator based on SiGe technology (source: Continental AG)

IV. KOKON successing Project RoCC

A. Introduction

RoCC is the follow-up project of KOKON (1/10/2004-30/9/2007). Like KOKON it is a German national funding project sponsored by the BMBF (Federal Ministry of Education and Research). The RoCC consortium spans almost the complete automotive supply chain from component manufacturer (Infineon) over Tier1 suppliers (Bosch, Continental) to OEMs (BMW, Daimler).

These companies with exemption of BMW have already collaborated very successfully within the KOKON project where they were able to

demonstrate for the first time the feasibility of low-cost Silicon-based radar technology in the 76 GHz to 81 GHz band. Commercialization of the results of the KOKON project began already. This year (2008) Infineon introduced its first SiGe radar chipset (RASIC TM) to the open market comprising a single-chip 4-channel radar transceiver for 76-77 GHz advanced ACC applications together with a 19 GHz reference oscillator. Robert Bosch GmbH utilizes these chips for its new LRR3 automotive radar system (3rd generation Long-Range-Radar) which will be launched in early 2009. It is world-wide the first automotive radar sensor in that frequency range using only silicon semiconductors (Press Release Infineon 1/12/2008 [5]). A first 79 GHz UWB SRR prototype system based on the same SiGe building blocks has been successfully demonstrated by Continental.

RoCC is targeted to further advance Silicon-based radar technology in the 76 to 81 GHz band now with special emphasis on SRR. Final goal is to bring down cost of 79 GHz automotive radar sensors significantly and make them cost-competitive to 24 GHz systems thus enabling enhanced and affordable road safety for everyone.

B. Project Organization

RoCC is lead by Infineon as project coordinator. It started on September 1, 2009, and will run until August 31, 2011. 5 work packages each of which is lead by one of the main partners comprise the organisational frame work of the project (Fig. 4):

- System Specifications: Daimler (with contributions from BMW, Bosch, Conti)
- Sensor Concept: Conti (with contributions from BMW, Bosch, Conti, Infineon)
- Technology and MMICs: Infineon (with contributions from Bosch, Conti)
- Sensor Integration: Bosch (with contributions from Conti)
- System Evaluation: BMW (with contributions from Daimler, Bosch, Conti)

The industrial partners are supported by sub-contracted Universities which will contribute with their excellent competencies in the field radar systems, antenna design or millimeter wave circuit design.

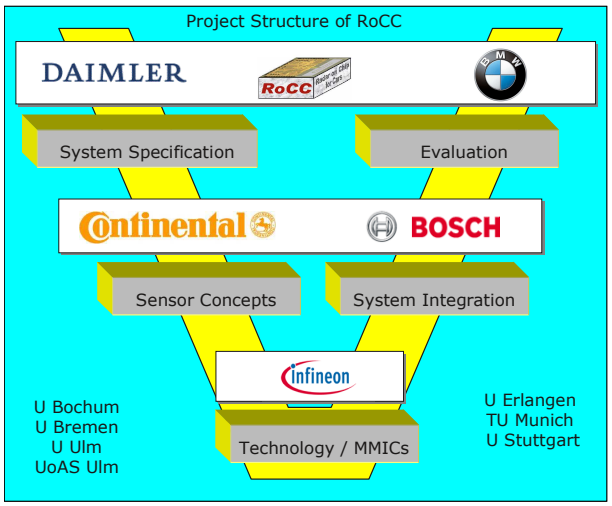

Fig. 4. Organizational structure of BMBF joint project RoCC, project partners and work packages.

C. Project Goals

The main technical, scientific and socio-political goals of the RoCC project are (Fig. 5.):

- affordable vehicle and road safety for everyone
- strengthening of technological leadership in automotive high frequency products and processes
- application based sensor specifications, test and evaluation of realized 79 GHz SiGe UWB SRR sensors
- investigation and optimization of conditions of covered sensor packaging and sensor operation in the vehicular environment
- further enhancement of sensor performance and reliability (e.g. noise reduction, angular resolution)
- development of a cost-competitive radar sensor technology in the 76 to 81 GHz range with special emphasis to 79 GHz SRR and evaluation beyond 100 GHz
- foundation of a sound technology base for migration from 24 GHz SRR to 79 GHz SRR
- development of highly integrated universally applicable radar MMIC demonstrators (RoCC: “Radar-on-Chip for Cars”)
- improvement of energy efficiency of SiGe-MMICs
- demonstration of radar sensors with superior signal to noise ratio (S/N)

- adaptive (smart) sensors from short range to long range (multi-mode, multi-range)
- pave way to SMD-Package for SiGe-MMICs in the frequency range of 76 to 81 GHz
- benchmarking versus 24 GHz solutions
- demonstration of feasibility of 500 GHz SiGe technology for automotive radar applications
- extended self-test, diagnosis and –calibration features.

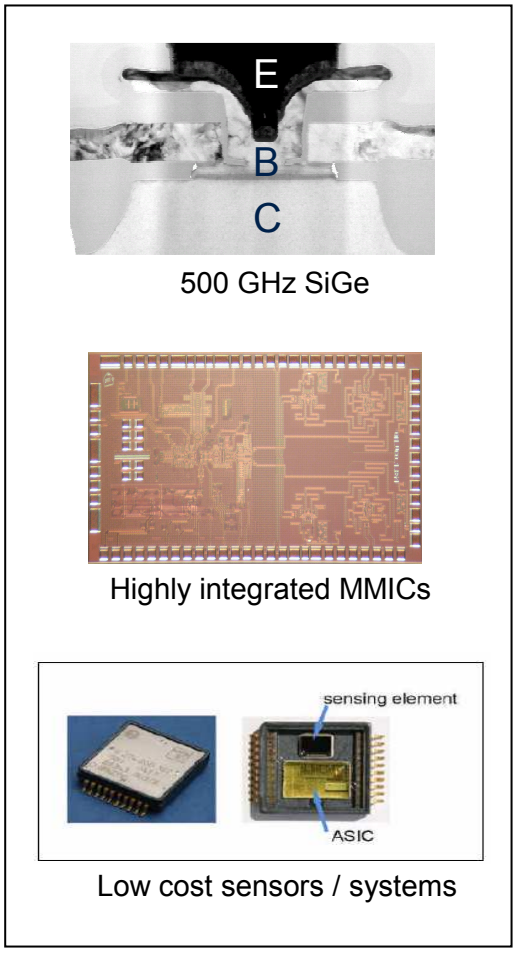

Fig. 5. Main BMBF RoCC goals.

V. Conclusion

Automotive short range radar is an important sensor technology for present and future automotive active safety and comfort functions. The UWB approach provides a real-time high range resolution, which is of particular importance for the time critical safety functions, e.g. pre-crash. The European frequency regulation for UWB automotive SRR requires the shift from 24 GHz to the 79 GHz band in 2013. Beneath this, the 79 GHz frequency range offers application of the same technology platform for LRR and UWB SRR. Furthermore, frequency dependent parameters as angular and velocity resolution, are improved significantly. SiGe technology has been chosen to realize low-cost sensors. Within the BMBF public funded joint project KOKON, the feasibility of SiGe based SRR/LRR has been shown successfully. The successing project RoCC has been started recently to commercialize the technology developed within KOKON and to support the availability of cost efficient and reliable 79 GHz UWB SRR products after 2013.

VI. Acknowledgement

The authors wish to thank the German Federal Ministry of Education and Research (BMBF) for the funding of the KOKON and RoCC joint projects.

VII. References

[1] The ECC Decisions ECC/DEC(04)10 (24 GHz SRR) and ECC/DEC(04)03 (79 GHz SRR) are available in the Internet: ERO-Homepage (http://www.ero.dk/deliverables/decisions)

[2] The EC Decisions 2005-50-EC (24 GHz SRR) and 2004-545-EC (79 GHz SRR) are available in the Internet: EC-Homepage: (http://www.europa.eu.int/eur-lex)

[3] Proceedings of the BMBF joint project KOKON final meeting (Workshop WSW5 of the EuMW 2007), Munich, October, 2007.

[4] Final reports of the KOKON project partners, German National Library of Science and Technology (online ressource); http://tiborder.gbv.de/psi/DB=2.63/LNG=DU/SID=1ea59db2-3b/CMD?ACT=SRCHA&IKT=1016&SRT=YOP&TRM=kokon

[5] http://www.infineon.com/cms/en/corporate/press/news/releases/2008/INFATV200812-015.html