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TUTORIAL AND REVIEW PAPER

Radar on a chip for cars – the RoCC project

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I. INTRODUCTION

Radar sensors operating in the 76 81 GHz range are considered as essential parts of future vehicle safety systems and could significantly contribute in reducing the number of traffic casualties. Yet high manufacturing costs prevented their broad utilization in cars in the past. Today's SiGe processes show high potential to bring down cost of millimeter (mm)-wave systems into a range where they become attractive for mid- to low-priced cars [1, 2]. However, despite the impressing results achieved so far there is still a lot of work left to be done to achieve the final goal of "affordable radar safety for all".

On the MMIC side there is a strong need to further reduce power consumption without sacrificing high-frequency performance. At lower-power consumption heat management on board and in the sensor housing could be simplified and assembly cost could further come down. At lower power even plastic packaging and standard surface mounting of the integrated millimeter circuits would become conceivable. One measure to improve power added efficiency is to increase the cut-off frequency of the SiGe process from today's 200 GHz up to the 500 GHz range, which would allow lowering supply voltage and biasing currents of critical circuit blocks.

Other measures are higher integration levels, avoidance of mm-wave interfaces between MMIC and board (e.g. by integrating antenna structures on chip or in package) and broader deployment of integrated self-diagnosis and self-calibration circuitry.

Besides cost, ease of integration into the car (small sensor size), and the possibility for invisible integration behind bumpers are also very important factors to achieve broader acceptance on the end customer side.

II. THE RoCC PROJECT

The issues named above have been addressed in the RoCC project ("Radar on Chip for Cars"), a German research project that started in September 2008 and was successfully finished in August 2011. This 3-year project had a budget of more than 17 million Euro. It was supported by a financial grant of 8.3 million Euro from the German Federal Ministry of Education and Research (BMBF; contract number: FKZ 13N9822–13N9824), as part of the IKT 2020 support program focusing on "Innovation Alliance Automotive Electronics". This German government's high-tech strategy promotes efforts made to reduce the overall number of traffic accidents, in this case by helping to introduce innovative safety solutions into the compact and small-vehicle classes as quickly as possible which is also reflected in RoCC's overall motto "Safety for All"

The main goals of RoCC can be summarized as follows:

- Development of a cost-competitive (compared to 24/26 GHz ultra-wideband (UWB) solutions) technology platform for automotive radar sensors in the 76–81 GHz band with focus on 79 GHz UWB;
- Provision of highly integrated Silicon-based (SiGe) mm-wave semiconductors;
- Developing a low-cost assembly technology for mm-wave RF modules suitable for high-volume production;
- Investigations on the possibility of cost efficient integration of antennas;
- Characterization and investigations of optimization potentials of transmission and reflection properties of fascia materials (paints and plastic materials as used for bumpers).

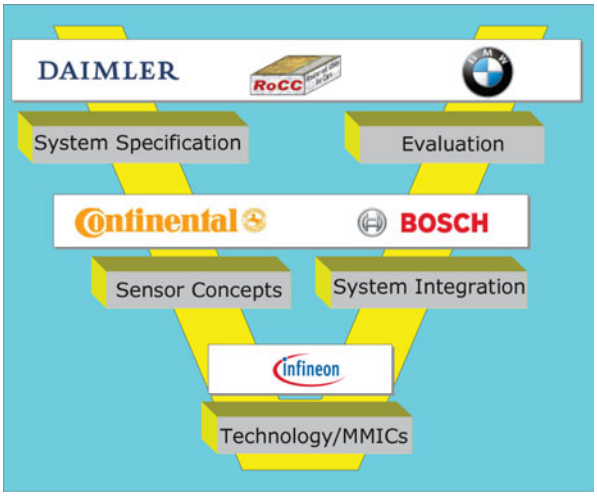

Fig. 1. Project structure and industrial participants of the RoCC project. Subcontracting research institutions were the Ferdinand Braun Institute (FBH) in Berlin, the Universities of Bochum, Bremen, Erlangen, Munich, Stuttgart, and Ulm, and the University of Applied Technology at Ulm.

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The RoCC consortium comprised the whole automotive supply chain for radar sensors covering the tier 2 level of semiconductor suppliers (Infineon), the tier 1 level of sensor and system suppliers (Bosch, Continental) and the Original equipment manufacturer (OEM) level of the car makers (BMW and Daimler). Scientific support was given by subcontracting universities and research institutes; a general project structure together with the participants is presented in Fig. 1.

Intermediate results of the RoCC project have been presented in workshops at the German Microwave Conference (Berlin, 2009) and during the European Microwave Week (Paris, 2010). In the following papers, a selection of the main achievements of the RoCC project is made available to a broader audience.

The results of the project now are being applied to actual sensor designs, and first radar products based on RoCC technology are expected to become available on the market in the 2013 time frame.

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Rudolf Lachner he received the diploma and Ph.D. degrees in physics from Technical University Munich, Germany, in 1978 and 1984, respectively. He joined Infineon Technologies in 1984, where he first was engaged in process development and integration of high speed bipolar processes. Later on he took over responsibility for the development of Infineon's leading edge Silicon and Silicon-Germanium bipolar and BiCMOS processes. As a Senior Principal in the field of RF technologies his main interests are currently in pushing the limits of SiGe technology into the Terahertz region and paving the way to broad usage of Si based mm-wave technology in new safety and communication applications. He has filed several patents and authored or co-authored many publications in this field. In the RoCC project, he was responsible for the overall project coordination.

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