WSE (RFIC) Sunday 08:00 – 17:00 BCEC Room 154

Advanced BAW-Enabled Wireless Transceivers: from Devices to System Architectures

Full-day workshop reviewed by RFIC.

Organizer(s):

Andreas Kaiser, IEMN-ISEN.
Andreia Cathelin, ST Microelectronics.
Edgar Schmidhammer, EPCOS AG.

Bulk Acoustic Wave (BAW) resonators are now being used in functions such as filters or duplexers, namely for US-based PCS system. Key-advantages of this technology are reduced size and cost at good performance. This workshop will discuss recent advances in the technology and at the device level, such as zero temperature drift, multiple frequency bands on the same wafer, improved power durability, and increased quality factors. Combined with advanced packaging technologies, modules with high functionality can be realized. Beyond replacing other filtering technologies, BAW technology can have a significant impact on system architectures, and will allow novel approaches namely for low power radios. BAW resonators also have a strong potential as high-precision frequency references where they could advantageously replace quartz resonators for this purpose. All these points, as well as design tools and methodology, will be described by the speakers in this workshop.

Speakers:

1. Alexandre Reinhardt, CEA-LETI
"BAW Technology for Advanced RF Architectures"

New RF architectures and transmission protocols require improved RF filters with wider bandwidth, and reduced size and costs. This talk provides an overview of the impact of these new requirements on a BAW technology. Firstly, constraints put on fabrication and assembly process are summarized and some solutions presented. In particular, ways of packaging BAW filters at wafer level are discussed. Then, the impact of new materials is studied. Developments of Iridium electrodes and their impact on resonators performances are demonstrated. In a third part, the simultaneous fabrication on the same die of the two filters of a duplexer is addressed. Possible solutions are discussed and a new fabrication process is presented, which will both lead to size and cost reduction.

2. Florin Constantinescu, Politehnica University Bucharest, Romania
"Circuit and Field Models of Power BAW Resonators"

The power BAW resonators used in modern communications circuits have a nonlinear behavior. Various circuit models exhibiting this behavior are discussed together wit their implementation in commercial circuit analysis programs. Linear and nonlinear electromechanical field models are presented pointing out their use for the design of BAW resonators and filters.

3. Arto Nurmela, VTT
“Power Durability and Non-Linear Effects in BAW Resonators”

Power durability gets more and more interesting also for BAW-based devices since Crest factor of the present digital modulation schemes is pretty high (up to 10dB in W-CDMA systems). Although the average power of W-CDMA systems is 24dBm (power class 3) the peak-power can reach values up to 32dBm, and are thus in the range of current GSM-based systems. There are many ways to estimate the power durability of BAW-based devices, and one out of them is the simulation of the thermal heating of the chip at a given input power. We have been able to directly apply the methods to a complete BAW-based filter. A second part of the talk will address the problem of measuring non-linear effects of BAW devices.

4. Jean-Baptiste David, CEA-LETI
“An Operant Methodology to Handle BAW Designs: Application to a WCDMA/UMTS Duplexer”

The duplexer is one of the critical components in the European version of the WCDMA standard, due to hard specifications it should satisfy. Moreover, needs of high integration lead to investigate latest technologies developments to ensure performances and size objectives. Within MOBILIS project, such a duplexer has been prototyped, using bumping of SMR BAW filters on a glass substrate integrating high Q passive elements (IPAD technology from ST). The design of this circuit has been supported by a dedicated approach, based on an analytical tool, electric-electromagnetic co-simulations, and a splitted electromagnetic-piezolectric modeling. Acoustic models are also employed to ensure BAW technology adjustments along the design steps.

5. Eric Tournier, LAAS
“Phase Noise of FBAR/SMR Resonators - Application to Frequency Generation and Measurement”

After an overview of the use of integrated BAW resonators in transceiver and particularly in frequency sources, the focus is put on the intrinsic noise of these devices. Unlike purely passive resonators, BAW resonators generate a 1/f phase noise which is sensitive to the RF power and to the resonator geometry and technology. Various measurement systems are shown to characterize this noise. One of these measurement systems is directly integrated on-wafer, and provides a simplified characterization without the need of external devices. This integrated phase noise test bench is reconfigurable and allows characterization of the resonator itself as well as of any frequency sources. Finally, examples of FBAR/SMR-based designs are given and compared to LC-based designs.

6. Andreia Cathelin, STMicroelectronics
“BAW Enabled Advanced Digital RF Transmitter Architectures for Wireless Systems”

This talk presents a Software-Defined Radio transmitter architecture and physical implementation for a bi-band WCDMA/DCS SiP/SOC transmitter. The full transmitter implementation is enhanced with several technologies and processes such as: Silicon processes (SiGe BiCMOS, 65nm CMOS), Integrated Passive Devices on High Resistivity substrate technology (IPD) and BAW SMR technology. After a short introduction, the first part of the presentation will give highlights of the bi-band transmitter architecture. The second part will shortly present the implementation challenges for all the building blocks in the chain. A third part will detail the system co-integration for the specific case of the mono-band WCDMA transmitter. Finally, the last part will present system measurement results. Conclusions and perspectives on SiP/SoC transmitters enhanced with novel digital architectures and BAW technology will conclude this talk.

7. Alexandre Volatier, Triquint Semiconductor
“A High Performance PCS Front End Module Incorporating a BAW Duplexer and a Tri-Mode Power Amplifier for a Fully Integrated CDMA/WCDMA Transmit Module Solution”

For almost a decade now, PCS band has been the battlefield of the most advanced duplexer technologies. In this presentation, a PCS front end module will be presented. Co-integration of Power Amplifier and Duplexer provides an appealing solution in terms of performance and cost. However, it also arises significant design challenges since most of the output parameters can be measured only in the fully assembled module and with the PA powered up. A close collaboration between PA and BAW duplexer designers is mandatory for efficient module development. Module performance parameters such as gain, current consumption, ACPR, TX leakage or RX-ANT IL will be presented. The trade-offs (such as trimming, matching…) required to improve above parameters in different power modes will be discussed.

8. Rich Ruby, Avago
“Future Extensions of FBAR Technology”

There are two complimentary core technologies that created the successful FBAR Filter, Duplexer and now Multiplexer Product Lines. These two technologies are the FBAR hi-Q resonator and the chip scale package that protects the FBAR in an all-silicon hermetic microcap package. The first off-shoot of this latter technology was the all GaAs chip scale package introduced at last years' IMT. Other applications being investigated are the zero-drift resonator (ZDR) for oscillator and PLL applications. Both low power and high power applications will be covered including the natural step of integration of resonator technology with active elements.

9. Brian Otis, University of Washington - Seattle
“Innovative Use of BAW Resonators in Low-Power Transceivers”

BAW resonators have the potential to enable new transceiver design techniques. This presentation covers five brief case studies of BAW-based RF circuit topologies, with an emphasis on low power wireless connectivity. Various techniques are compared and chip measurements are provided.