

20 – 22 April 2026
Barcelona, Spain

BOOKLET

Venue & Heritage

HOSPITAL DE LA SANTA CREU I SANT PAU

The Hospital de la Santa Creu i Sant Pau in Barcelona has its origins in the medieval period and represents one of the most significant examples of Catalan Modernisme applied to a medical institution. Its historical roots date back to 1401, when several small hospitals in the city were unified to create the Hospital de la Santa Creu, which served as Barcelona's main hospital for more than five centuries. This medieval institution, located in the Raval district, played a central role not only in healthcare but also in social assistance, including the care and education of orphaned children.

By the late nineteenth century, Barcelona's rapid urban growth and the evolution of modern medicine made the old Gothic hospital obsolete. A new facility was therefore planned in the expanding Eixample district. Thanks to the legacy of the banker Pau Gil, construction of the new hospital began in 1902. The project was designed by the Catalan architect Lluís Domènech i Montaner, one of the leading figures of the Modernisme movement. His design conceived the hospital as a "garden city for healing," composed of separate pavilions surrounded by gardens and connected by underground service galleries. This layout improved hygiene, ventilation, and natural light, reflecting new ideas about hospital design and patient well-being at the beginning of the twentieth century.

The complex was built between 1901 and 1930, and after Domènech i Montaner's death in 1923, the final stages were completed by his son, Pere Domènech i Roura. When inaugurated in 1930, the hospital became one of the largest and most innovative medical complexes in Europe. Architecturally, it is considered the largest ensemble of Art Nouveau architecture in the world and one of the masterpieces of Catalan Modernisme.



The Sant Pau Modernist Site

After operating as a hospital for almost a century, healthcare services moved to a new building in 2009, allowing the historic pavilions to be restored and repurposed as a cultural and knowledge center. The complex had already been declared a Historic Monument in 1978 and, together with the Palau de la Música Catalana, was recognized as a UNESCO World Heritage Site in 1997. Today, the Sant Pau Modernist Site stands as both an architectural landmark and a symbol of the integration of architecture, medicine, and social welfare in Barcelona's history.

Welcome Messages

GREETINGS FROM THE GENERAL CHAIRS OF IC-MAM 2026



Jordi Verdú
General Chair



Jordi Mateu
General Co-Chair

Dear IC-MAM 2026 Delegates,

On behalf of the Organizing Committee, it is a profound honor and a distinct pleasure for us to welcome you to the 3rd IEEE MTT-S International Conference on Microwave Acoustics & Mechanics (IC-MAM 2026). Following the success of our previous editions in Munich and Chengdu, we are thrilled to bring this vibrant scientific community to the Mediterranean shores of Barcelona, from April 20 to 22, 2026.

Our venue, the Recinte Modernista de Sant Pau, is a UNESCO World Heritage site that perfectly embodies the spirit of our conference: a masterpiece of early 20th-century engineering and art that continues to inspire innovation. Just as this historic site redefined architectural boundaries, IC-MAM 2026 aims to push the frontiers of microwave acoustics, RF-MEMS, and advanced manufacturing processes.

The technologies we discuss here are not merely technical milestones; they are the fundamental building blocks of the digital future. From enhancing global connectivity through 6G to developing ultra-precise sensors for healthcare and environmental monitoring, the progress in microwave acoustics and mechanics has a direct and transformative impact on society, making our world more connected, efficient, and sustainable.

To address these global challenges, bringing together all key actors is crucial. This year, we are particularly proud of the deep involvement of industry leaders and major players in the sector. Their contribution goes far beyond financial sponsorship; they are an integral part of our technical soul. Many of our sessions have been co-organized by industry experts, ensuring that the content presented is not only scientifically rigorous but also commercially relevant. We firmly believe that this active synergy between academia and leading companies is the only way to accelerate the transition from the laboratory to the real world.

We would like to extend our deepest gratitude to:

- **The authors and speakers:** For sharing your groundbreaking research and industrial insights.
- **The Technical Program Committee (TPC) and Industry Partners:** For your meticulous work in building a program that bridges theory and practice.
- **Our Sponsors:** For your unwavering support and for being the engine of this event.

Beyond the technical sessions, Barcelona—a city celebrated for its cosmopolitan soul and avant-garde culture—provides the perfect backdrop for networking. We encourage you to engage with your peers, spark new collaborations, and enjoy the unique charm of our host city.

We trust that these three days will be a source of inspiration, innovation, and lasting professional relationships.

Welcome to Barcelona! Benvinguts!

General Chairs, IC-MAM 2026

Welcome Messages

GREETINGS FROM THE TECHNICAL PROGRAM CHAIRS OF IC-MAM 2026



Carlos Collado



David Molinero

**Technical Program
Chairs**

Dear IC-MAM 2026 Delegates,

We are delighted to welcome all participants, authors, keynote and invited speakers to this third edition of the conference. IC-MAM 2026 brings together researchers, academics, and professionals from around the world to share recent advances, exchange ideas, and discuss emerging challenges and opportunities in the RF-MEMS/acoustic field.

We are especially proud of the high quality and diversity of the contributions that make up this year's technical program. Thanks to the efforts of the authors, TPC members, reviewers, and session chairs, we have been able to prepare a program that reflects both scientific excellence and the latest developments in electroacoustic technologies.

Beyond the technical sessions, we hope this meeting will also provide a valuable opportunity to build new collaborations, strengthen existing connections, and inspire future research. Barcelona, with its vibrant cultural life, international outlook, and welcoming atmosphere, offers an exceptional setting for these exchanges.

We sincerely thank all contributors and participants for being part of ICMAM 2026. We hope you enjoy the conference and your stay in Barcelona.

Technical Program Chairs, IC-MAM 2026

IC-MAM 2026 STEERING COMMITTEE**General Chair:**

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Universitat Autònoma de Barcelona, Spain

General Co-Chair:

Jordi Mateu
Universitat Politècnica de Catalunya, Spain

Technical Program Chair:

Carlos Collado
Universitat Politècnica de Catalunya, Spain

David Molinero
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Amelie Hagelauer, *TUM, Germany*
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IC-MAM 2026 TECHNICAL PROGRAM COMMITTEE

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Shogo Inoue

Ryo Nakagawa

Gianluca Piazza

Richard Ruby

Lu Ruochen

Alex Shirakawa

Marc Solal

Silvan Stettler

AWARDS & RECOGNITIONS**IC-MAM 2026 Paper Awards**

*We are proud to recognize outstanding research and presentations at this year's conference.
The awards ceremony will take place during the closing session.*

General Paper Awards**■ 1st Best Paper Award**

Awarded to the most outstanding paper presented at the conference, recognizing exceptional scientific contribution and innovation.

■ 2nd Best Paper Award

Awarded to a paper of exceptional merit, recognizing a highly significant scientific contribution and innovation.

■ 3rd Best Paper Award

Awarded to a paper of outstanding quality, recognizing an excellent scientific contribution and presentation.

Student Paper Awards**■ 1st Place Student Paper Award**

Recognizing the top student-led paper and presentation.

■ 2nd Place Student Paper Award

Recognizing an excellent student-led paper and presentation.

■ 3rd Place Student Paper Award

Recognizing a highly commendable student-led paper and presentation.

Conference Information

REGISTRATION HOURS:

Registration will be open during the following times in the mezzanine foyer at:

- Monday, 20 April 2026, 07:30 - 17:00
- Tuesday, 21 April 2026, 08:00 - 17:00
- Wednesday, 22 April 2026, 08:00 - 13:00

EXHIBIT HOURS:

The joint IC-MAM Exhibition area will be open during the following times:

- Monday, 20 April 2026, 11:00 - 17:00
- Tuesday, 21 April 2026, 9:00 - 17:00
- Wednesday, 22 April 2026, 09:00 - 13:00

Please refer to the conference website at <https://icmam-ieee.org/about.html> for the latest information and details on how to become a sponsor and exhibit at IC-MAM.

SOCIAL EVENTS, NETWORKING, AND LITE RECEPTIONS:

- **Welcome Reception:** Sala hipàstila, Monday 20 April 2026, 18:00 - 19:30
- **Gala Dinner:** Restaurante El del Mar <https://www.eldelmarhermanostorres.com/ca/>, Tuesday 21 April 2026, 19:30

EXHIBITORS & SPONSORS

Platinum Sponsors



Silver Sponsors



Travel Information

VENUE AT A GLANCE

IC-MAM 2026 Venue: Recinte Modernista de Sant Pau

Address: C. Sant Antoni Maria Claret, 167, 08025 Barcelona

Nearest Metro: Sant Pau – Dos de Maig (L5)

Bus Lines: H8, 19, 47, 117, 192

RECOMMENDED PUBLIC TRANSPORT FROM BARCELONA–EL PRAT AIRPORT (T1)

Metro L9 Sud + L5

Take **L9 Sud** from **Aeroport T1**, change at **Collblanc** to **L5**, and get off at **Sant Pau – Dos de Maig**. From there, the venue is a short walk away. This is the most direct public-transport option from the airport to the conference venue.

Estimated travel time: around 45–55 minutes.

Aerobús (Airport Express Bus)

Fast connection to the city centre

The Aerobús connects **Terminal 1** with **Plaça de Catalunya**, in the heart of Barcelona. Buses run every 5 to 10 minutes and the journey takes about 35 minutes. From the city centre, continue to the venue by metro or taxi.

Metro (L9 Sud – Orange Line)

Good public-transport option from the airport

Metro line **L9 Sud** connects **Terminal 1** with Barcelona and offers convenient interchanges with other metro lines. For the conference venue, the most practical transfer is at **Collblanc** to **L5**, direction **Vall d'Hebron**, then get off at **Sant Pau – Dos de Maig**.

Train (R2 Nord Rodalies)

Useful if you prefer commuter rail

There is no direct train from **Terminal 1**. To use the **R2 Nord** line, first take the free airport shuttle bus from **T1** to **Terminal 2**. Trains run approximately every 30 minutes and connect the airport with central stations such as **Passeig de Gràcia** and **Barcelona Sants**. From there, continue by metro or taxi.

Taxi / Ride-hailing Apps

Most convenient door-to-door option

Taxis are available outside **Terminal 1** 24/7. The ride to central Barcelona usually takes about 25–35 minutes, depending on traffic, with an average fare of around EUR 30–40 including supplements. Ride-hailing services such as **Uber**, **Cabify**, and **Bolt** also operate in Barcelona, with pick-up zones generally located near the taxi area.

Private Transfers / Car Rental

Best suited for groups or onward travel

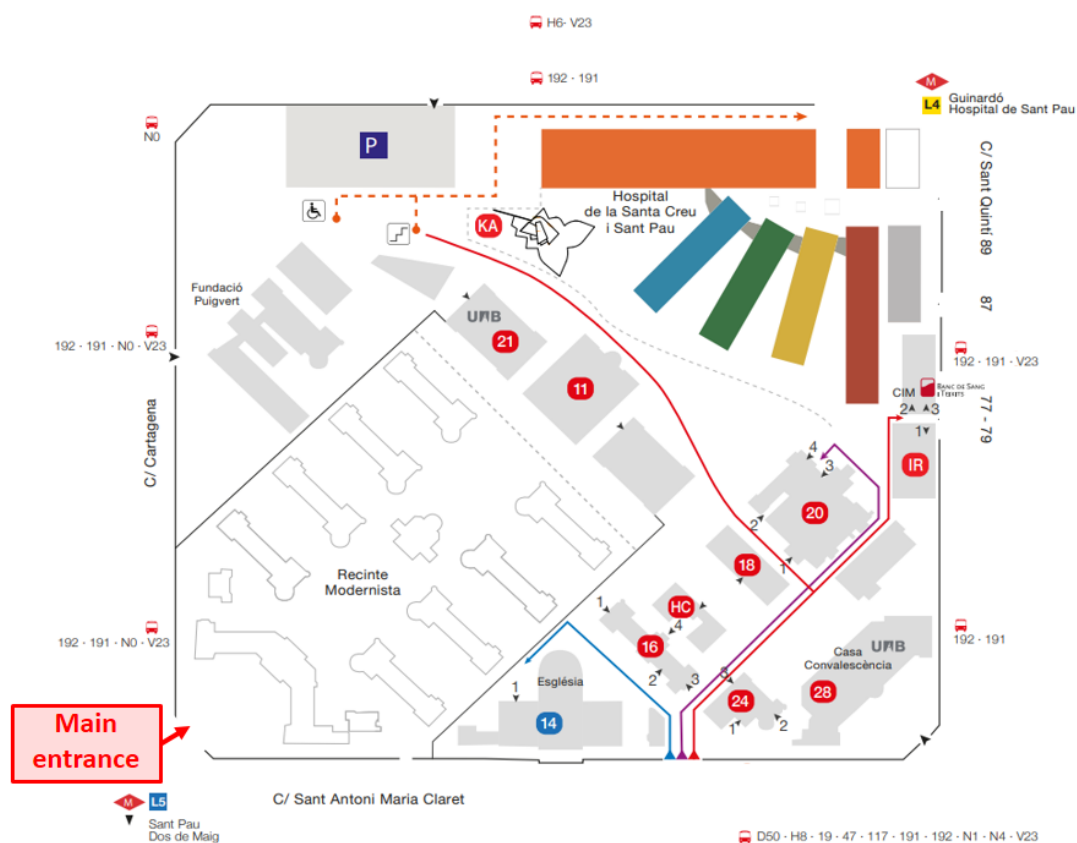
Pre-booked private transfers provide direct door-to-door service and may be especially convenient for groups, business travellers, or delegates carrying bulky luggage. Car rental is also available at **T1**, although this option is mainly recommended for participants continuing beyond Barcelona rather than travelling only to the venue.

PRACTICAL NOTE

Barcelona has an extensive public-transport network, and both metro and airport bus services are frequent. For the latest fares, operating times, and route updates, participants are encouraged to check the official websites of **TMB**, **Rodalies**, and **Aerobús** before travelling.

VENUE MAP

Map of the Recinte Modernista de Sant Pau



Plan of the conference venue and surrounding buildings.

Keynote Speakers

Acoustic RF Filters Powering Emerging Wireless Systems



Alexandre Shirakawa

Vice President of Engineering at Skyworks Solutions

Short Biography: Alexandre Shirakawa is Vice President of Engineering at Skyworks Solutions, where he leads the acoustic RF filter technologies. His work spans bulk acoustic wave (BAW) and surface acoustic wave (SAW) platforms, with a focus on enabling future connectivity applications. With over two decades of experience in RF and acoustic technologies, Alexandre has held senior engineering leadership roles at Skyworks, Qualcomm, and Broadcom (Avago Technologies), driving technology roadmaps from early research through high-volume manufacturing. He began his career at CEA-Leti, working at the intersection of device physics and system integration.

Abstract: Future wireless systems—including low earth orbit satellite networks, sixth generation cellular, next generation Wi Fi, autonomous vehicles, smart cities, and robotics—are driving unprecedented demands on radio frequency front ends. As bandwidth, coexistence complexity, power density, and reliability requirements intensify, acoustic RF filters are no longer passive components but critical architectural enablers. This keynote examines how acoustic filter technologies are evolving to power these emerging wireless systems. It explores the complementary roles of bulk acoustic wave (BAW) and thin film surface acoustic wave (TF-SAW) technologies, including the growing importance of integration strategies such as die size reduction strategies. By connecting system level requirements to materials, device physics, and integration challenges, the talk highlights why the future of wireless communication depends on continued innovation in acoustic RF filter technology.

Enabling next generation Filter technology



Markus Lörner

Segment Manager at Rohde & Schwarz

Short Biography: Markus Lörner is a Market Segment Manager at Rohde & Schwarz focusing on the RF and Microwave Component market looking at the test requirements today and tomorrow. Markus has 25 years plus experience in the test & measurement industry. Before moving into the market segment role, Markus worked as a product manager for signal generators and power meters at Rohde & Schwarz where he was looking at different application areas including the mobile industry, positioning, satellite and EW applications. He received his Dipl.-Ing. degree from the University Erlangen-Nuremberg, Germany.

Abstract: RF filters are a key enabler of new technologies and ensure coexistence of many active systems in the same environment. As applications extends in frequencies, so do the requirements on the next generation of RF filters. The speech will start from an overview of today's and tomorrow's market needs and business opportunities. As we look into filter validation and design phase, focus will be on the T&M aspect to support new enhancements in technical performance, higher level of integration and complexity of filter structures and systems. Following the complete value chain, we emphasize the need for efficiency and throughput in mass production.

AI needs RF - Power, Edge Intelligence, and the Role of RF Hardware



Gernot Fattinger

Vice President and Chief Technology Officer of Global Operations at Qorvo

Short Biography: Gernot Fattinger is Vice President and Chief Technology Officer of Global Operations at Qorvo, where he defines and drives technology strategy across the company's semiconductor platforms and engineering ecosystem. His technology ownership spans BAW, Interconnects, GaAs, SAW, Silicon, and Packaging. He also leads Software Development, Electronic Design Automation (EDA), and Cross-Technology Design, enabling scalable innovation from early research to high-volume manufacturing. With more than two decades of experience, Dr. Fattinger has built and led global engineering organizations, shaping technology roadmaps and aligning innovation with business strategy. He has a strong track record of translating advanced technologies into manufacturable, high-performance RF solutions that power next-generation connectivity across mobile, 5G, Wi-Fi, and aerospace markets. Dr. Fattinger began his career at Infineon Technologies as a BAW R&D engineer. He holds a Ph.D. in Semiconductor Physics from Johannes Kepler University in Linz, Austria, and is a recognized contributor to the field through publications and intellectual property.

Abstract: As artificial intelligence moves toward the edge, its physical realization is increasingly constrained by power, latency, and system efficiency. While local processing reduces reliance on centralized compute, the high energy consumption of modern AI hardware and limited battery scaling fundamentally reshape system-level trade-offs. This keynote argues that, rather than reducing the importance of communication, edge intelligence re-emphasizes the need for fast, efficient, and adaptable RF links between edge devices and datacenters. It highlights how emerging RF front-end requirements place new demands on selectivity, integration, and reconfigurability, and how advances in acoustic wave technologies—spanning mm-Wave operation, mode engineering, and reconfigurable architectures—are transforming RF components into flexible building blocks for distributed AI systems.

Invited Speakers

Monday, April 20th

Session M1 | 09:00 – 09:22

An Overview of SAW Technology as the Industry Transition from TCSAW to Thin Film SAW

Rei Goto

Skyworks, USA

Surface Acoustic Wave (SAW) filters are widely employed in wireless systems. In the early years, SAW filters employed LiTaO₃ based SH mode SAW technology (standard SAW), then transitioned to SiO₂/LiNbO₃ based Rayleigh mode temperature compensation (TC-SAW) technology, and has now transitioned to LiTaO₃ base Thin Film (TF) SAW technology. TF-SAW technology innovation continues as new structures and materials are investigated. The history of this breakthrough technology evolution, which has enabled increasingly wider passband coverage, and has improved temperature stability and loss reduction, will be reviewed along with the benefits and drawbacks of each.

Session M4 | 16:15 – 16:37

Remote-Resonator for Improved Multiplexer Performance

Yiliu Wang

Skyworks Solutions, Inc., USA

For the 5th generation (5G) user experience, coverage and capacity are the key elements. Carrier Aggregation (CA) is the foundation for 5G and an effective tool to extend the coverage. When two filters are connected at the common node and working simultaneously, like in CA, each filter insertion loss (IL) will degrade slightly compared to its standalone (SA) operation mode, due to a loading loss. In other words, one filter was not an ideal open at the other filter's passband frequency, leading to signal partially leaking into the other path. In a multiplexer case, e.g., in the MHBPAD (Mid-High Band Power Amplifier and Duplexer) or TxDSM (Transmitter Diversity Switch Module) module, where multiple filters are connected at the antenna port (also called multiplexer, MUX), minimizing the loading of filters to other bands is the key to achieve overall good in-band performance.

Tuesday, April 21st

Session T2 | 11:30 – 11:52

Modeling the Broadband Nonlinear Behavior of a Bulk Acoustic Wave (BAW) Resonator

Renfeng Jin, David Molinero, Dave Feld*(Skyworks Solution, inc, USA)*

A broadband second harmonic (H2) emissions model of a Bulk Acoustic Wave (BAW) resonator is presented. The model is both physically grounded and is ready to be used in filter design. We review the fundamental properties of the nonlinear resonator response by partitioning the broadband response into four sub-band regions from low to high frequency as follows: (i) the subharmonic region, (ii) the lateral mode region, (iii) the in-band main (TE_1) mode region, and (iv) the overtone region. For the sub-band region we identify the dominant physical mechanisms and the key modeling challenges, e.g., rapid H2 phasor rotation, modal crowding, and nonlinear parameter extraction. We synthesize cutting edge modeling techniques including nonlinear Mason, nonlinear FEM, and perturbation models using an EBVD multi branch model capturing lateral modes into a hybrid approach that captures the entire H2 response across all four sub bands using a single, portable model. Finally, we extend the hybrid model to filter level H2 suppression topologies, namely the anti series cascade and anti-parallel split configurations that are widely used in modern filter designs. The extended model predicts residual H2 emissions in these configurations due to small frequency imbalances and trace parasitics. These results provide a practical path to meeting ever stricter H2 emission specifications, enabling robust, phasor aware design closure for next generation RF filters.

Wednesday, April 22nd

Session W1 | 9:00 – 9:22

XBAR Technology: Methods for Development and Mass Production

Taishi Kimura*Resonant Inc.*

RF filters leveraging a new class of high frequency acoustic device, laterally excited shear mode bulk acoustic wave resonators (XBARs) have recently transitioned to volume manufacturing. Owing to their large electromechanical coupling coefficient and robust high frequency operation, XBAR devices are well suited to wireless communication systems above 3 GHz, including current 5G deployments, prospective 6G bands, and Wi-Fi applications. This talk begins by outlining the XBAR architecture and device characteristics, clarifying its advantages and trade-offs in filter design. Next, key simulation techniques that enable smooth mass production are also discussed.

Session W2 | 11:30 – 11:50

SAW sensors and their applications for multi-parameters sensing: gas, icing, magnetic field, and temperature

Wang Wen*Institute of Acoustics, Chinese Academy of Sciences, China*

Surface acoustic waves (SAWs) are mechanical acoustic waves that propagate along the surface of a piezoelectric medium, generated by micro-nano interdigitated electrodes deposited on the surface of the piezoelectric medium using the piezoelectric effect. Due to the high frequency, excellent reciprocity and symmetry of the interdigitated electrodes, as well as the simplicity and flexibility of the design, and the use of semiconductor planar lithographic technique, SAW devices, as key components in signal processing, have become crucial analog components in fields such as mobile communications and radar, with an annual market application scale exceeding tens of billions. Additionally, because acoustic energy is concentrated on the surface of the medium, it is extremely sensitive to surface loads, forming another important development direction of SAW technology, namely intelligent sensing. Compared to other sensing technologies, SAW sensors have technical advantages such as high sensitivity, fast response, wide measurement range, and high reliability. In particular, they can provide a novel sensing method that is passive (senses without power supply), and transmits wirelessly, which has attracted widespread attention and great interest. After nearly 30 years of development, a large number of SAW sensors have been successfully applied in special fields such as national defense, power, intelligent manufacturing, aerospace, and more, for in-situ detection of multiple parameters such as temperature, mechanics, and gas, demonstrating significant application value. This present will focus on reporting the research and sensor applications of SAW multi-parameter sensing effects, mechanisms, devices, and system integration, including gas, icing, magnetic field, and temperature sensing, based on the research results of the laboratory team.

Session W2 | 11:50 – 12:10

Monolithically Integrated Frequency-Modulated Acoustic Sensors via Piezoelectric Layer Transfer

Azadeh Ansari

Georgia Institute of Technology, USA

Frequency modulated (FM) sensors benefiting from high-Q resonant devices offer numerous advantages compared to their amplitude modulated (AM) counterparts. Such advantages include improved signal-to-noise ratio, inherent immunity to amplitude drift, enhanced linearity, and faster response times. These attributes make FM sensing particularly attractive for precision acoustic detection in noisy and thermally fluctuating environments. In this talk, I will present a novel monolithically integrated acoustic sensing platform based on piezoelectric resonators realized through a layer transfer process. High sensitivity FM pressure and temperature sensors are realized in Aluminum (scandium) nitride (Al(Sc)N) material systems. The Al(Sc)N piezo-stack is then transferred on to a sapphire substrate, where the III-nitride electronics for signal readout are fabricated. This work demonstrates a new monolithically integrated sensing platform that is capable of operation in high temperature environments up to 800C.

Program at a Glance

Time	Monday April, 20th	Tuesday April, 21st	Wednesday April, 22nd
09:00 – 10:30	M1 Advanced electro-acoustic technologies I	T1 Advanced filtering structures	W1 Advanced electro-acoustic technologies III
10:30 – 11:00	Coffee break	Coffee break TP1 Student award posters Industrial Talk: Rohde Schwarz	Coffee break WP1 Posters Industrial Talk: SAL
11:00 – 11:30	OS Opening Session	T2 Non-linear characterization and modelling	W2 Sensors and Interrogation Techniques
11:30 – 13:00			
13:00 – 14:00	Lunch Break		
14:00 – 15:30	M3 Simulation and modeling I	T3 Advanced electro-acoustic technologies II	W3 Measurement improvements
15:30 – 16:15	Coffee break	Coffee Break TP2 Student award posters Industrial Talk: Scia	Coffee Break WP2 Posters
16:15 – 17:45	M4 Filter synthesis and design	T4 Simulation and modeling II	W4 Materials and emerging applications

Technical Program Schedule

Monday

M1: Advanced electro-acoustic technologies I (High Performance Resonators)

Chairs:

C. Huck (Qorvo, Inc, Germany), L. G. Villanueva (École Polytechnique Fédérale de Lausanne, Switzerland)

Tuesday

T1: Advanced filtering structures

Chairs:

R. R. Mansour (University of Waterloo, Canada), A. Tag (Qorvo, Inc)

Wednesday

W1: Advanced electro-acoustic technologies III (High performance resonators)

Chairs:

R. Aigner (Qorvo, USA), A. Link (Qorvo, Germany)

09:00

An Overview of SAW Technology as the Industry Transitions from TCSAW to Thin Film SAW

Authors: R. Goto

Design of Acoustic Wave Multiplexers with Frequency-Dependent Source Impedance: A Synthesis-Based Approach

Authors: M. Faura, S. Cano, J. Mesas, L. Garcia, J. Verdu, P. A. de Paco Sanchez

XBAR Technology: Methods for Development and Mass Production

Authors: T. Kimura, P. Turner, B. Willemssen, G. Moreno

09:20

Multilayer SAW Resonators with Split-Electrode Busbar Topology

Authors: V. Yantchev, Y. Ji, T. Daiping, K. Han

Tunable Ferroelectric Acoustic Resonators in Monolithic Thin-Film Barium Titanate

Authors: I. Anderson, A. Posadas, A. Demkov, L. Ruochoen

Transversal Rayleigh Type SAW Filter Using Periodically Polarization Inverted ScAlN Films

Authors: Y. Hidaka, N. Shimazaki, T. Yanagitani

09:37

Design and Analysis of Solidly Mounted Lamé-Mode MEMS Resonator and Spurious-Mode Mitigation

Authors: V. Pashchenko, T. Terzic, J. Streque, D. Solonenko

On the Way of Systematic Exploration of Novel Hybrid BAW-SMR Filter Topologies

Authors: J. Mesas, M. Faura, S. L. de Pablo Oya, L. Garcia, A. Valdivieso, S. Cano, J. Verdu, P. A. de Paco Sanchez

AlScN-on-SiC Surface Acoustic Wave Resonators and Filters Above 4 GHz

Authors: S. Stettler, M. Liffredo, L. G. Villanueva

09:55

Multilayer AlN Polarity-Reversed BAW Resonators

Authors: N. Suzuki, D. Taniguchi, A. Hanai, T. Yanagitani

Cascaded CRF SAW Filters. Synthesis and Design

Authors: E. Navarro-Gessé, A. Valenzuela-Pérez, J. Mateu, C. Collado, M. Gonzalez Rodriguez, S. Huebner

Influence of Geometric Parameters on the Performance of Lamé Mode Resonators

Authors: T. Terzic, V. Pashchenko, D. Solonenko, J. Streque

10:12

Design and Fabrication of New Architectures for Surface Acoustic Wave Filters on Piezoelectric on Insulator Substrates

Authors: S. Karmous Jedaa, B. Aurélie, T. Richard, W. Daniau, V. Soumann, T. Baron, T. Makdissy, E. Courjon, S. J. Ballandras

Resonant Gap Surface Acoustic Wave: A Flexible Architecture Based on POI Suited for RF Integration

Authors: L. Rolland du Roscoat, T. Laroche, T. Makdissy, E. Courjon, F. Bernard, A. Clairet, S. NDiaye, G. Aspar, A. Raveski, A. Alami-Idrissi, S. J. Ballandras

High-Frequency Fundamental Operation in Fin-Type Quartz Resonators Fabricated by HF Gas-Phase Catalyst Etching

Authors: K. Sano, Y. Kataoka, Y. Ono, Y. Hayashi, T. Yanagitani

10:30

Coffee Break

Coffee Break

Student Award Posters

Coffee Break

WP1 Posters

Chairs: C. Collado, D. Molinero

OS: Opening Session

T2: Non-linear characterization and modelling
Chairs:
 D. Feld (Skyworks Solutions, USA), M. Gonzalez Rodriguez (Qorvo Inc, Munich)

W2: Sensors and interrogation techniques
Chairs:
 O. Elmazria (Université de Lorraine & CNRS, France), M. Koohi (Texas AM University, USA)

11:00

Welcome Opening
Jordi Verdu & Jordi Mateu (Conference Chairs)
Nuno Borges Carvalho (IEEE-MTT)
Barcelona City Hall representative

Modeling the Broadband Nonlinear Behavior of a Bulk Acoustic Wave (BAW) Resonator
Authors: R. Jin, D. Feld, D. Molinero

11:30

Monolithically Integrated Frequency-Modulated Acoustic Sensors via Piezoelectric Layer Transfer
Authors: A. Ansari

11:15

Acoustic RF Filters Powering Emerging Wireless Systems
A. Shirakawa, Skyworks Solutions, USA

Unique Parameter for in-Band Third-Order Nonlinearities in TC-SAW Resonators and Filters
Authors: M. Gonzalez Rodriguez, A. Balust, C. Collado, J. Mateu, S. Huebner

11:50

Automated Reconstruction of Dispersion Relations and Bandgap Optimization in Topological Device
Authors: A. Marella, N. S. Pantuso, T. Maggioli, C. Cassella, L. Colombo, M. Rinaldi

11:50

Enabling Next Generation Filter Technology
M. Loerner, Rhode & Schwarz

Experimental Investigation of Nonlinearity in Longitudinal Leaky SAW Resonators on LiNbO₃/SiO₂/SiC Substrate
Authors: X. Guo, P. Zheng, X. Fang, J. He, M. Sun, D. Sui, D. Ling, K. Huang, S. Zhang, X. Ou

12:10

High Sensitivity Magnetic Field SAW Sensors Based on Love Waves and Operating in the GHz Range
Authors: L. Meistersheim, Y. Yang, C. Floer, I. Cinar, S. Hage-Ali, S. Petit-Watelot, D. Ba, M. Hehn, O. Elmazria

12:25

AI Needs RF – Power, Edge Intelligence, and the Role of RF Hardware
G. Fattinger, Qorvo, Inc.

Thevenin Theorem Application for a One-Nonlinear Source Model Accounting for Distributed Nonlinearities of SAW Devices
Authors: M. Carmona López, C. Collado, V. M. Garcia Martinez, J. Mateu, M. Gonzalez Rodriguez, S. Huebner

12:28

Wireless SAW Delay Line Resonance Sensor
Authors: V. Yantchev, P. Z. Petkov

13:00

Wavelet Analysis of Nonlinear Second-Order Harmonic Responses in RF-SAW Resonators
Authors: T. Omori, N. Tsutsui

12:42

13:00

Lunch Break

M3: Simulation & Modelling I**Chairs:**

D. A. Kiefer (Institut Langevin, ESPCI Paris, Université PSL, CNRS, France), R. Perea (Spectron Microsystems, Italy)

T3: Advanced electro-acoustic technologies II (High performance resonators)**Chairs:**

S. Gong (University of Illinois at Urbana-Champaign, USA), T. Kimura (Resonant/Murata, Japan)

W3: Measurement improvements**Chairs:**

K. Kokkonen (Qualcomm, USA), J. C. Booth (NIST, Boulder, USA)

14:00

Equivalent Circuit Analysis of Double Mode Surface Acoustic Wave Resonator Filters

Authors: K.-Y. Hashimoto, Z. Yang, F. Zhang, T. Wu, B. Jingfu

Spurious Signal Control for SAW Devices on POI Substrates

Authors: L. Rolland du Roscoat, S. J. Ballandras, E. Courjon, T. Laroche, F. Bernard, T. Makdissy, A. Clairet, S. NDiaye, G. Aspar, A. Alami-Idrissi, T. Hilt, G. Martin, R. Salut, L. Capello

Linear Response of BAW Resonators by Vibrometer Measurements

Authors: D. Molinero Giles

14:18

Distributed Circuit Modeling and FEM Validation of Thermoelastic Damping in BAW Resonators

Authors: A. Valenzuela-Pérez, E. Navarro-Gessé, J. Mateu, C. Collado

Thin-Film Lithium Niobate on Insulator SH-SAW Ladder Filter with Fractional Bandwidth > 35%

Authors: Z.-Q. Lee, T.-H. Hsu, L. Ruo Chen, M.-H. Li

Characterization of Temperature Coefficients in Piezoelectric Film Using Substrate-Supported-Film Resonators

Authors: N. Shimazaki, Y. Wada, W. Oda, T. Yanagitani

14:36

Evaluating the Ybus Method Efficiency into the Mason Model for Simulating BAW Resonators

Authors: A. Valdivieso, L. Garcia, J. Mesas, R. Loscertales, J. Verdu, P. A. de Paco Sanchez

Investigation of Polarization-Inverted Double-Layer BAW Resonators Fabricated by MOCVD and Sputtering Deposition

Authors: Y. Hidaka, N. Shimazaki, N. Shimoji, T. Kimura, T. Yanagitani

Air-Coupled Through-Transmission Characterization of Porous Membranes Using a Dual-Frequency PMUT Array

Authors: T. Xu, Z. Da, G. A. E. Tomás

14:54

Material-Device Co-Optimization of Langasite-Family SAW Resonators via Multiscale Modeling

Authors: M. Gigauri, R. Desai, J. Hakimi, A. Strachan, D. Weinstein

Line-Type Orthogonal-Shear Bulk Acoustic Wave Resonator (LiBAR) on Thin Film LiNbO₃

Authors: D. Sui, S. Shao, K. Dai, J. He, Y. Li, X. Ke, K. Huang, P. Zheng, S. Zhang, X. Ou

KNN Thick Film Transducer with High kt^2 and Q_m and KNN Thin Film Self-Standing Resonator

Authors: N. Suzuki, T. Yanagitani, C. Zhang, Y. Shimano, C. Mita, H. Uchida

15:12

BAW TCF Vs Quality Factor in Sputter-Silica Glass Film

Authors: N. Shimazaki, T. Yanagitani

Experimental Realization of Sub-Mm Wavelength Hybrid SAW/BAW for RF and Sensing Applications

Authors: T. Terzic, D. Solonenko, V. Pashchenko, H. Campanella, F. Hörich, A. Dadgar, A. Strittmatter

Benchmarking Low-Cost Vector Network Analyzers for FBAR Sensing

Authors: A. Rodríguez Alhambra, T. Mirea, E. Jaldo Serrano, R. García-Francisco, R. Hervás, J. Olivares, M. Clement

15:30

Afternoon Coffee Break**Afternoon Coffee Break**

Student Award Posters

Afternoon Coffee Break

WP2 Posters

Chairs: C. Collado, D. Molinero

M4: Filter synthesis and design**Chairs:**

L. Acosta (Qorvo Inc., Spain), Y. Wang (Skyworks Solutions, Inc., USA)

T4: Simulation and Modelling II**Chairs:**

K. Hashimoto (University of Electronic Science & Technology of China, China), Y. Yang (Hong Kong University of Science and Technology, Hong Kong)

W4: Materials and emerging applications**Chairs:**

M. Domínguez (Technical University of Catalonia (UPC), Spain), X. Zhu (Menlo Micro, USA)

Remote-Resonator for Improved Multiplexer Performance

Authors: Y. Wang, T. Komatsu

Dispersion Computation of Microwave Acoustic Resonators with Spectral Elements

Authors: D. A. Kiefer, C. Grünsteidl

RF MEMS Switch for AI Chip Testing

Authors: X. Zhu, S. Yang, N. Yost

16:15

Cascading Hybrid BAW-Assisted Filters to Achieve Broadband Responses for 5G Applications

Authors: S. Cano, E. Guerrero, A. R. Gimenez, M. Faura, L. Garcia, J. Mesas, J. Verdu, P. A. de Paco Sanchez

Spurious-Resistant Parameter Estimation for mBVD Modeling of SAW/BAW Resonators

Authors: F. Zhang, Z. Yang, T. Wu, B. Jingfu, K.-Y. Hashimoto

High-Strength, Low-Damage Direct Bonding of LiNbO₃/Glass Wafers for the Fabrication of Glass-Based SAW Resonators

Authors: S. Nagai, K. Nakao, Y. Hayashi

16:33

Lattice XBAR Filters in Thin-Film Lithium Niobate

Authors: T. Anusorn, B. Kim, I. Anderson, Z. Yao, L. Ruochen

Identification of Electromagnetic Layout Effects by Recovering a Distorted Acoustic Wave Filter Response

Authors: L. Garcia, J. Mesas, S. Cano, A. Valdivieso, M. Faura, J. Verdu, P. A. de Paco Sanchez

Small Mode-Volume Lateral Field Excited Bulk Acoustic Wave Resonators as a Potential Platform for Quantum Microwave to Optical Photon Transduction

Authors: E. Shokati, K. C. Balram

16:51

Acoustic Wave Star-Junction Multiplexers with Complex Terminating Impedances

Authors: G. Reixach, M. Faura, J. Verdu, P. de Paco

A General WLP Platform for BAW and TF-SAW Filters with TSV on Device Wafer

Authors: D. Feng, W. Hu, J. Liang, C. Han, J. Zou

Implementing Microwave Interferometry Using Piezoelectric Phononic Integrated Circuits

Authors: M. Bicer, A. F. Malik, K. C. Balram

17:09

Multilayer Ferroelectric Devices for Programmable Acoustic Wave Filters

Authors: A. Hammami, A. K. Hamdan, M. Koohi

Comparative Study of Optimization Algorithms for mBVD Fitting of SAW/BAW Resonators

Authors: Z. Yang, F. Zhang, T. Wu, B. Jingfu, K.-Y. Hashimoto

17:27

18:00 WELCOME RECEPTION

19:30 GALA DINNER

18:00

Student Paper Contest Finalists

*The following papers have been selected as finalists for the Student Paper Contest.
The winners will be announced during the closing and awards ceremony.*

Design of Acoustic Wave Multiplexers with Frequency-Dependent Source Impedance: A Synthesis-Based Approach

M. Faura, S. Cano, J. Mesas, L. Garcia, J. Verdu, P. A. de Paco Sanchez

Lattice XBAR Filters in Thin-Film Lithium Niobate

T. Anusorn, B. Kim, I. Anderson, Z. Yao, L. Ruochen

Cascading Hybrid BAW-Assisted Filters to Achieve Broadband Responses for 5G Applications

S. Cano, E. Guerrero, A. R. Gimenez, M. Faura, L. Garcia, J. Mesas, J. Verdu, P. A. de Paco Sanchez

Distributed Circuit Modeling and FEM Validation of Thermoelastic Damping in BAW Resonators

A. Valenzuela-Pérez, E. Navarro-Gessé, J. Mateu, C. Collado

Structure Design Analysis of Tilted Electrode for Transverse Mode Suppression in POI-SAW

J. He, P. Zheng, C. Song, K. Liu, D. Ling, X. Fang, D. Sui, M. Sun, J. Xiao, X. Guo, Y. Yao, S. Zhang, X. Ou

Cascaded CRF SAW Filters. Synthesis and Design

E. Navarro-Gessé, A. Valenzuela-Pérez, J. Mateu, C. Collado, M. Gonzalez Rodriguez, S. Huebner

Benchmarking Low-Cost Vector Network Analyzers for FBAR Sensing

A. Rodríguez Alhambra, T. Mirea, E. Jaldo, R. García-Francisco, R. Hervás, J. Olivares, M. Clement

Design and Fabrication of New Architectures for Surface Acoustic Wave Filters on Piezoelectric on Insulator Substrates

S. Karmous Jedaa, A. Broussier, R. Thomas, W. Daniau, V. Soumann, T. Baron

Poster Session: WP1 & WP2

Wednesday, April 22nd | 10:30 – 11:30 & 15:30 – 16:15

BALUN-FREE TRANSVERSAL ACOUSTIC FILTER USING ELECTROACOUSTIC RESONATORS

E. Navarro-Gessé, J. Mateu, C. Collado

Abstract: Electroacoustic filters must keep up with new RF needs such as wider bandwidth, higher operating bands, and more demanding multiplexing. These trends expose the limits of conventional acoustic topologies, mainly due to the intrinsic electroacoustic coupling and the reduced freedom to place transmission zeros. Transversal acoustic networks are attractive because they can provide wideband responses and allow transmission zeros to be placed where needed, without being constrained by the electroacoustic coupling in the same way as ladder-type solutions. A key practical drawback, however, is that transversal implementations often require a 180° phase inversion between some signal paths, which is usually obtained with a BALUN. For standard BAW/SAW resonators, this requirement is not naturally satisfied by the resonator configuration, and the BALUN increases loss, area, and integration complexity. This work proposes a transversal filter configuration based on conventional BAW/SAW resonators that avoids the BALUN by meeting the phase-cancellation requirement through the use of series and shunt branches in the transversal paths. The method starts from a synthesized low-pass prototype and applies circuit transformations using matrix-rotation techniques to obtain an equivalent transversal network in which the out-of-phase coupling terms are removed by construction. After transformation to the bandpass domain, limitations related to out-of-band phase compensation appear; these can be reduced by introducing a small number of external components. Several example designs are presented to validate the approach and to highlight the practical bandwidth limits and trade-offs. The results show that the proposed BALUN-free transversal topology preserves the main advantages of transversal filtering-flexible transmission-zero placement and reduced dependence on electroacoustic coupling-while simplifying the implementation for BAW/SAW technologies.

COMPACT SAW RESONATORS ON POI USING ETCHED SIDE-WALL REFLECTORS

B. Aurélie, T. Richard, V. Soumann, S. Karmous Jedaa, W. Daniau, T. Baron, D. Belharet, S. J. Ballandras

Abstract: The development of Piezoelectric-On-Insulator - POI - wafers based on single crystal layers bonded on Silicon offers many opportunities for innovative surface acoustic wave filter structures. The extreme confinement of Shear Horizontal waves in the POI top layers allows for considering new types of resonators for the development of compact filters. This paper particularly discusses a novel technique for manufacturing single-port resonators using pure shear guided waves on POI substrates at 1GHz equipped with etched side-wall reflectors. The devices based on deep-etched reflective grooves are being compared to standard resonators equipped with Bragg mirrors. The paper focuses on technological development achieved in that purpose. Experimental measurements demonstrate the efficiency of the proposed approach, yielding figures of merit compatible with effective impedance element SAW filters.

EXPERIMENTAL REALIZATION OF SUB-MM WAVELENGTH HYBRID SAW/BAW FOR RF AND SENSING APPLICATIONS

T. Terzic, D. Solonenko, V. Pashchenko, H. Campanella, F. Horich, A. Dadgar, A. Strittmatter

Abstract: In this work, the experimental realization of hybrid SAW/BAW resonators based on AlN thin films on Si(111) substrates with sub micrometre wavelengths are reported. Methods of having both main propagating modes of the hybrid SAW/BAW being located outside the cut-off region, where the velocity of the propagating wave surpasses the velocity of leaky substrate waves, leading to suppression of high velocity modes, are discussed using FEM simulations, which are then investigated experimentally. Concept verification was carried out using electron-beam lithography (EBL) in combination with dry etching of the top electrode and the AlN thin film.

STRUCTURE DESIGN ANALYSIS OF TILTED ELECTRODE FOR TRANSVERSE MODE SUPPRESSION IN POI-SAW

J. He, P. Zheng, C. Song, K. Liu, D. Ling, X. Fang, D. Sui, M. Sun, J. Xiao, X. Guo, Y. Yao, S. Zhang, X. Ou

Abstract: In this work, we analyze the structure design of tilted interdigital transducers (IDT), which are commonly employed to suppress transverse modes in surface acoustic wave (SAW) resonator on piezo-on-insulator (POI) substrates. Based on the velocity profile and the simulated electrical performances, the design rules are summarized as follows: 1) smaller air gap is preferred; 2) a higher acoustic barrier at the air gap and busbar necessitates a larger tilt angle; 3) an over-tilted IDT leads to main mode leakage. The simulated electrical performance and the full-3D vibrating diagram agree well with the proposed guidelines. Experimental validation is then carried out, corroborating the theoretical analysis. The optimized resonator on X-10°Y LiNbO₃/SiC exhibits spurious-free smooth admittance response, achieving a k_t^2 of 32.5%, Q_{\max} of 507 and a figure-of-merit (FOM) of 165 at 3.5 GHz. This work establishes a valuable methodology for the IDT design, which is crucial for realizing low-loss, spurious-free POI-SAW filters.

PHYSICS-INFORMED NEURAL NETWORK-ENHANCED MODELING OF A 923 MHZ THIN-FILM ACOUSTIC RESONATOR USING SCIKIT-RF

T. Deeka, B. Deeka

Abstract: Thin-film acoustic resonators operating in thickness-extensional bulk acoustic wave (BAW) modes are key components in microwave and sub-GHz RF front-end systems, where performance is governed by acoustic resonance, electromechanical coupling, and energy dissipation mechanisms. Accurate prediction of resonant frequency, quality factor, and insertion loss is essential for device design but typically relies on computationally intensive multiphysics simulations or iterative circuit-based analysis. This paper presents a physics-informed surrogate modeling framework for a 923 MHz thin-film acoustic resonator. A Butterworth–Van Dyke (BVD) equivalent circuit is implemented using the open-source scikit-rf library to generate electrically measurable responses that capture the dominant acoustic resonance behavior. A Physics-Informed Neural Network (PINN) is then trained using simulated data while enforcing electromechanical resonance constraints directly within the loss function, ensuring physically consistent predictions. The proposed model predicts resonant and anti-resonant frequencies, quality factor, and insertion loss with errors below 2% relative to circuit-based simulations, while reducing computation time by nearly two orders of magnitude. The framework provides an efficient and physically interpretable approach for rapid exploration of thin-film acoustic resonator designs and demonstrates the potential of physics-informed learning for microwave acoustics and electromechanical device modeling.

TOWARDS BROADBAND ALSCN PMUTS ARRAYS

A. Shabeer, Y. Wang, Z. Hui, A. Uranga, F. Torres, N. Barniol

Abstract: This paper reports CMOS compatible multi-frequency PMUTs arrays which will allow, for the first time, achieving operational relative bandwidths (BW) larger than 100% for AlScN PMUT's in the MHz range. Three different PMUTs arrays systems with different sizes and gaps operating at different frequency ranges are designed. The array at 2.7 MHz central frequency provides the best results, with a relative BW as large as 148% (the larger reported until now for PMUTs). This opens the way for using PMUTs with axial distance resolutions not limited by the ring-down response and consequently getting closer to their intrinsic spatial resolution limits and facilitating faster ultrasound imaging systems.

SERIES RESISTANCE MODELING OF ARBITRARY SHAPED ELECTRODES IN CAPACITIVE STRUCTURES FOR BAW-ORIENTED DESIGN

X. Mir, L. Garcia, A. Valdivieso, J. Verdu, P. de Paco

Abstract: We present a conformal-transformation-based method to estimate the electrode series resistance of BAW resonators. At first glance, we deal with the device as a capacitor with finite-conductivity electrodes. Two van der Pauw resistances are interpreted through the Montgomery method to extract an equivalent aspect ratio G that captures the geometry-dependent current-spreading behaviour, which is then used in a closed-form series-resistance expression. The approach enables sub-0.1s geometry/feed exploration and is validated against full 3-D EM simulations.

A UNIFIED SYNTHESIS AND PHYSICAL MODELING FRAMEWORK FOR DOUBLE-MODE SAW FILTERS

A. Romero, R. Pampliega, J. Verdu, P. de Paco, A. K. Das, R. R. Mansour

Abstract: The demand for high-selectivity RF filters in 5G/6G networks has exposed the limitations of ladder-type SAW architectures in achieving wide bandwidths and strong OoB rejections. DMS filters enable improved OoB rejection through strategically placed transmission zeros (TZs) far from the passband. However, the lack of a systematic and automated synthesis methodology has limited the efficient design of DMS filters, requiring extensive optimization and empirical adjustments. This work presents a closed-loop synthesis methodology that enables the automated design of DMS filters with tunable characteristics, linking theoretical models to physical implementations via the coupling matrix (CM) and the COM model.

Abstracts

The abstracts below are presented in the same overall day/session sequence as the technical program. Detailed scheduling information (day, room, and presentation time) is already provided in the *Technical Program Schedule*; here the emphasis is placed on the title, authors, and abstract text for each contribution.

Monday, April 20th

Session M1

Advanced electro-acoustic technologies I (High Performance Resonators)

AN OVERVIEW OF SAW TECHNOLOGY AS THE INDUSTRY TRANSITIONS FROM TCSAW TO THIN FILM SAW

Rei Goto

Abstract: Surface Acoustic Wave (SAW) filters are widely employed in wireless systems. In the early years, SAW filters employed LiTaO₃ based SH mode SAW technology (standard SAW), then transitioned to SiO₂/LiNbO₃ based Rayleigh mode temperature compensation (TC-SAW) technology, and has now transitioned to LiTaO₃ base Thin Film (TF) SAW technology. TF-SAW technology innovation continues as new structures and materials are investigated. The history of this breakthrough technology evolution, which has enabled increasingly wider passband coverage, and has improved temperature stability and loss reduction, will be reviewed along with the benefits and drawbacks of each.

MULTILAYER SAW RESONATORS WITH SPLIT-ELECTRODE BUSBAR TOPOLOGY

Ventsislav Yantchev, Yuancheng Ji, Tang Daiping, Ke Han

Abstract: In this work we present a multilayer SAW resonator topology specifically designed for operation in the mid band with suppressed spurious transverse modes. This design employs a split-electrode feature in the busbar. Similar design approach has been recently demonstrated for low band resonators and is extended here towards higher frequencies keeping in mind the technological limitations. The presented topology promotes a good wave confinement throughout the resonance to antiresonance frequency range, while enabling a piston mode of operation.

DESIGN AND ANALYSIS OF SOLIDLY MOUNTED LAMÉ-MODE MEMS RESONATOR AND SPURIOUS-MODE MITIGATION

Vladimir Pashchenko, Tamara Terzic, Jeremy Streque, Dmytro Solonenko

Abstract: This paper presents a piezoelectric RF MEMS resonator based on Lamé-mode excitation in an AlScN piezoelectric film deposited on silicon substrate. The fabricated devices exhibit an effective electromechanical coupling coefficient of 14% and an antiresonance quality factor of 494 at 1.75 GHz. Several design configurations were implemented to suppress spurious modes. The proposed device is promising for applications in 5G telecommunication systems.

MULTILAYER ALN POLARITY-REVERSED BAW RESONATORS

Nanami Suzuki, Daisuke Taniguchi, Ayaka Hanai, Takahiko Yanagitani

Abstract: Demand for bulk acoustic wave (BAW) filters operating in the high-frequency band is increasing because wireless communication like 5G and 6G shifts toward higher frequency ranges where conventional filters often underperform. Polarity-reversed multilayer structures are attracting attention because they can excite specific higher-order modes while maintaining a practical total film thickness. Sputtered AlN typically grows with an Al-face plane, but achieving non-conventional N-face sputter growth is challenging. This study focuses on the in-situ control of AlN growth polarity by precisely modulating the sputtering gas flow ratio. We attempted to fabricate three-layer and 10-layer polarity-reversed structures by adjusting the sputtering gas flow ratio (Ar: N₂ = 4: 1 and pure N₂ atmosphere). Furthermore, we evaluated the piezoelectric properties and polarity of the fabricated resonators. Both resonators demonstrated 3rd-order and 10th-order resonance thus achieving a polarity-reversing multilayer structures.

DESIGN AND FABRICATION OF NEW ARCHITECTURES FOR SURFACE ACOUSTIC WAVE FILTERS ON PIEZOELECTRIC ON INSULATOR SUBSTRATES

Sarah Karmous Jedaa, Broussier Aurélie, Thomas Richard, William Daniau, Valérie Soumann, Thomas Baron, Tony Makdissy, Emilie Courjon, Sylvain J Ballandras

Abstract: The evolution of modern telecommunication standards imposes significant challenges on passive filters, particularly those based on SAW technology, which is extensively deployed in mobile communication systems. In particular, ultracompact filters are needed in the so-called Front-End Modules, including several bands in confined packages combining amplification, switching, and filtering functions. In this paper, we introduce an innovative type of resonator architecture particularly adapted to piezoelectric-on-insulator substrates devoted to radio-frequency operation. The paper presents an approach based on the combination of etched grooves and interdigitated transducers, yielding ultimately compact resonators that can be advantageously implemented in filters, as demonstrated in the dedicated section. We demonstrate that this approach allows taking advantage of all the remarkable features of SAW on piezoelectric-on-insulator, with improved filter characteristics.

Session M3

Simulation & Modelling I

EQUIVALENT CIRCUIT ANALYSIS OF DOUBLE MODE SURFACE ACOUSTIC WAVE RESONATOR FILTERS

Ken-Ya Hashimoto, Zijiang Yang, Fuxian Zhang, Ting Wu, Bao Jingfu

Abstract: This paper describes equivalent circuit analysis of double mode surface acoustic wave (DMS) filters. Detailed discussions are given on derivation of an equivalent circuit from the measured admittance matrix [Y] and how to determine LCR values in the equivalent circuit from [Y]. First, the admittance matrix is decomposed to three parts, and they are expressed by the mBVD model including multiple mechanical branches. Then, measured data of a DMS resonator filter are used as an example, and the fitting procedure is explained step by step.

DISTRIBUTED CIRCUIT MODELING AND FEM VALIDATION OF THERMOELASTIC DAMPING IN BAW RESONATORS

Ana Valenzuela-Pérez, Edgar Navarro-Gessé, Jordi Mateu, Carlos Collado

Abstract: Thermoelastic damping (TED) is a source of losses in mechanical structures, arising from the irreversible coupling between elastic deformation and heat transport. While Multiphysics Finite Element Methods (FEM) effectively quantify TED in eigenvalue problems, there is a lack of simple circuitual models capable of emulating these effects in Bulk Acoustic Wave (BAW) resonators. In this work, a distributed circuit model is introduced, as an extension of the Mason equivalent circuit. The proposed model captures the interaction between the electrical, acoustical, and thermal domains, enabling the analysis of Quality Factor (Q) degradation due to ambient temperature and material properties. The model is validated through extensive comparison with FEM simulations for both Film Bulk Acoustic Resonators (FBAR) and Solidly Mounted Resonators (SMR), demonstrating high accuracy in predicting thermoelastic losses.

EVALUATING THE YBUS METHOD EFFICIENCY INTO THE MASON MODEL FOR SIMULATING BAW RESONATORS

Aleix Valdivieso, Laia Garcia, Joel Mesas, Raül Loscertales, Jordi Verdu, Pedro Antonio de Paco Sanchez

Abstract: With the increasing performance requirements of mobile RF devices, fast and accurate simulation is essential for efficient design and optimization. Therefore, execution time is a critical factor. This work reviews and compares two approaches for computing the Mason model: the traditional sequential method and the admittance bus method for obtaining the input impedance of a structure, with a focus on execution time. While the sequential method is fast and simple to implement, the admittance bus method offers greater easier generalization and more flexibility in design studies and, through optimizations such as Kron reduction and sparse matrices, can achieve comparable computational performance. Although the sequential method remains the fastest overall, the optimized admittance bus method matches its performance in specific applications such as optimization routine, making it a viable alternative for Mason model.

MATERIAL-DEVICE CO-OPTIMIZATION OF LANGASITE-FAMILY SAW RESONATORS VIA MULTISCALE MODELING

Mariam Gigauri, Rushik Desai, Jeremy Hakimi, Alejandro Strachan, Dana Weinstein

Abstract: Langasite (lanthanum gallium silicate - LGS) has emerged as a top contender for high-temperature applications requiring high-performance piezoelectricity for sensors and wireless communication. In this work, we present a multiscale material-device co-optimization framework for LGS-family (trigonal crystals with general formula $A_3BC_3D_2O_{14}$) acoustic resonators that links first-principles materials discovery to wave physics and device-level performance. Density functional theory (DFT) calculations are used to extract anisotropic elastic, dielectric, and piezoelectric tensors for candidate compositions. These properties are then used to compute surface acoustic wave (SAW) phase velocity, electromechanical coupling coefficient k^2 , and power flow angle (PFA) as functions of crystal orientation. Selected configurations are subsequently evaluated using periodic finite-element analysis (FEA) simulations to quantify dispersion, electrode mass-loading effects, and device-level trade-offs between k^2 and quality factor Q. This workflow enables systematic exploration of a coupled material and design space, providing physically guided criteria for RF-relevant property selection. While demonstrated here for SAW devices, the framework is scalable to other acoustic modes, including thickness-shear and bulk acoustic wave (BAW) resonators, and to broader material and compositional studies.

BAW TCF VS QUALITY FACTOR IN SPUTTER-SILICA GLASS FILM

Nana Shimazaki, Takahiko Yanagitani

Abstract: In RF front-end filters for next-generation mobile communication systems (5G/6G), a high mechanical quality factor of resonators is essential to achieve steep out-of-band attenuation. In temperature-compensated devices such as TC-SAW and TC-FBAR, acoustic loss originating from amorphous thin films such as silica glass is a major source of performance degradation. However, conventional characterization methods based on device prototyping struggle to distinguish intrinsic material loss from structural parasitic losses. This study proposes a non-destructive evaluation method using Fourier-transform analysis to directly quantify GHz longitudinal acoustic properties of wafers prior to device processing. Silica glass thin films deposited under ten different process conditions were evaluated, revealing for the first time a moderate statistical interdependence between mechanical loss and the temperature coefficient of frequency (TCF) ($R^2 = 0.59$), suggesting a potential linkage between these parameters. The results further indicate that these parameters represent intrinsic material properties independent of structural factors such as film thickness. This study shows that by utilizing TCF as a more readily measurable proxy for the mechanical quality factor, high-Q materials can be probabilistically screened at the pre-process stage. Specifically, when TCF exceeds $90 \text{ ppm}/^\circ\text{C}$, high mechanical quality factor (>1300) are obtained with a probability exceeding 80%. This methodology enables a transition from conventional retrospective verification to a predictive process based on intrinsic material potential, thereby enabling predictive design of low-loss, high-selectivity BAW filters for next-generation RF front-end modules.

Session M4

Filter synthesis and design

REMOTE-RESONATOR FOR IMPROVED MULTIPLEXER PERFORMANCE

Yiliu Wang, Tomoya Komatsu

Abstract: For the 5th generation (5G) user experience, coverage and capacity are the key elements. Carrier Aggregation (CA) is the foundation for 5G and an effective tool to extend the coverage. When two filters are connected at the common node and working simultaneously, like in CA, each filter insertion loss (IL) will degrade slightly compared to its standalone (SA) operation mode, due to a loading loss. In other words, one filter was not an ideal open at the other filter's passband frequency, leading to signal partially leaking into the other path. In a multiplexer case, e.g., in the MHBPAD (Mid-High Band Power Amplifier and Duplexer) or TxDSM (Transmitter Diversity Switch Module) module, where multiple filters are connected at the antenna port (also called multiplexer, MUX), minimizing the loading of filters to other bands is the key to achieve overall good in-band performance.

CASCADING HYBRID BAW-ASSISTED FILTERS TO ACHIEVE BROADBAND RESPONSES FOR 5G APPLICATIONS

Santi Cano, Eloi Guerrero, Alfred R Gimenez, Mario Faura, Laia Garcia, Joel Mesas, Jordi Verdu, Pedro Antonio de Paco Sanchez

Abstract: Bulk acoustic wave (BAW) filters play a key role in 5G wireless communication systems to satisfy the stringent specifications of modern radio-frequency (RF) front-end modules. However, the increasing demand for wider frequency bands limits the use of conventional BAW ladder filters. This work proposes cascading hybrid BAW-assisted filters to achieve a broadband response with a fractional bandwidth (FBW) of 33%. The proposed filters employ low-pass (LPF) and high-pass (HPF) bridge-T (BT) topologies using Sc-doped AlN BAW resonators, designed to operate together with a laminate incorporating on-chip capacitors and inductors on which the filter die is mounted. Insertion loss levels below 2.5 dB are achieved across the entire passband. The results demonstrate that symmetric BT topologies with shunt BAW resonators require lower electromechanical coupling coefficients (k_{2t})

LATTICE XBAR FILTERS IN THIN-FILM LITHIUM NIOBATE

Taran Anusorn, Byeongjin Kim, Ian Anderson, Ziqian Yao, Lu Ruochen

Abstract: This work presents the demonstration of lattice filters based on laterally excited bulk acoustic resonators (XBARs). Two filter implementations, namely direct lattice and layout-balanced lattice topologies, are designed and fabricated in periodically poled piezoelectric film (P3F) thin-film lithium niobate (TFLN). By leveraging the strong electromechanical coupling of XBARs in P3F TFLN together with the inherently wideband nature of the lattice topology, 3-dB fractional bandwidths (FBWs) of 27.42% and 39.11% and low insertion losses (ILs) of 0.88 dB and 0.96 dB are achieved at approximately 20 GHz for the direct and layout-balanced lattice filters, respectively, under conjugate matching. In addition, the first ladder-lattice hybrid XBAR filter is experimentally demonstrated. The matched hybrid filter exhibits an IL 1.62 dB, a 3-dB FBW of 15.93%, and a close-in rejection exceeding 30 dB. Notably, all prototypes feature compact footprints smaller than 1.3 mm².

ACOUSTIC WAVE STAR-JUNCTION MULTIPLEXERS WITH COMPLEX TERMINATING IMPEDANCES

Guillem Reixach, Mario Faura, Jordi Verdu, Pedro de Paco

Abstract: Acoustic wave multiplexers are key enablers of carrier aggregation in modern handset RF front-end modules, but their design is particularly challenging due to strong inter-channel loading effects and the need to interface with non-ideal RF stages. Analytical synthesis techniques provide an efficient starting point for multiplexer design by implicitly accounting for filter interactions; however, existing methods are limited to purely real port impedances, restricting integration with practical amplifier terminations and requiring additional matching networks. This paper presents an extension of analytical multiplexer synthesis that enables prescribed complex termination impedances by appropriately redistributing terminal nodes and adjusting the computation of the multiplexer response. The proposed approach allows direct co-design of acoustic wave ladder filters with their preceding and succeeding RF stages, reducing circuit complexity and enabling compact, low-loss multiplexer implementations suitable for RF front-end applications.

MULTILAYER FERROELECTRIC DEVICES FOR PROGRAMMABLE ACOUSTIC WAVE FILTERS

Abdullah Hammami, Abdelmajeed K. Hamdan, Milad Koohi

Abstract: Multilayer ferroelectric acoustic stacks can offer more freedom during the design process: configuration assignment, where different pin assignments realize different transfer-function topologies (i.e., different pole/zero structure), and bias programmability, where DC voltage magnitude and polarity reconfigure the response within a chosen configuration by controlling the polarization in ferroelectric layers. This paper uses a three pin device as a concrete example of multilayer ferroelectric programmable concept, which can be generalized to additional pins and layers to provide greater design freedom for acoustic wave filter synthesis. The three pin device is studied under multiple pin configurations that map the same physical stack to switched-mode bulk acoustic wave (BAW) resonator, K^2 reconfiguring, and stacked crystal filter (SCF) behaviors. Within these configurations, voltage programming enables interband and intra band resonance frequency switching, phase modulating, and ON/OFF operation. Experimental demonstrations are implemented in a bilayer BST stack, with targeting the fundamental and second-harmonic frequency near 2.0 GHz and 3.6 GHz. Example designs including a single three pin device, higher-order (2-pole and 4-pole), and a hybrid ladder network using mixed configuration to illustrate the potential of multi-pin technology to reduce component count and footprint while maintaining strong rejection and isolation.

Tuesday, April 21st

Session T1

Advanced filtering structures

DESIGN OF ACOUSTIC WAVE MULTIPLEXERS WITH FREQUENCY-DEPENDENT SOURCE IMPEDANCE: A SYNTHESIS-BASED APPROACH

Mario Faura, Santi Cano, Joel Mesas, Laia Garcia, Jordi Verdu, Pedro Antonio de Paco Sanchez

Abstract: One of the main challenges in network synthesis is handling frequency-dependent source and load impedances, which commonly arise when acoustic wave (AW) filters and multiplexers are connected to antenna switch modules or active devices. This paper presents an analytical multiport synthesis methodology capable of incorporating dispersive impedances at a common node. The proposed approach relies on an iterative solution of rational function relationships, enabling accurate modeling of both dispersive impedance effects and loading from adjacent channels. The validity of the method is demonstrated through the synthesis of an AW duplexer example.

TUNABLE FERROELECTRIC ACOUSTIC RESONATORS IN MONOLITHIC THIN-FILM BARIUM TITANATE

Ian Anderson, Agham Posadas, Alexander Demkov, Lu Ruo Chen

Abstract: The increasing development of wireless communication bands has motivated the development of compact, low-loss, and frequency adjustable RF filtering technologies. Acoustic resonators are the ideal solution to these requirements, and tunable implementations offer a path toward reconfigurable front ends. In this work, we investigate epitaxial barium titanate (BTO) grown on silicon as a platform for tunable acoustic resonators operating in the sub-GHz regime. We demonstrate lateral excitation of symmetric lamb (S₀) modes in X-cut BTO membranes, in contrast to prior thickness-defined ferroelectric resonators. Devices are designed using finite-element simulations and fabricated with laterally patterned electrodes that enable overtone coupling to multiple resonant modes. Under applied DC bias, ferroelectric domains align, allowing electrical excitation, frequency tuning, and quality-factor enhancement of acoustic modes. Resonances near 300 MHz and 700 MHz exhibit electromechanical coupling up to 8% and bias-dependent frequency tuning, with a distinct transition in behavior near 20 V. These results highlight monolithic BTO on silicon as a promising material system for laterally excited, tunable acoustic resonators for reconfigurable RF applications.

ON THE WAY OF SYSTEMATIC EXPLORATION OF NOVEL HYBRID BAW-SMR FILTER TOPOLOGIES

Joel Mesas, Mario Faura, Sergio Lopez de Pablo Oya, Laia Garcia, Aleix Valdivieso, Santi Cano, Jordi Verdu, Pedro Antonio de Paco Sanchez

Abstract: Conventional filter design workflows are predominantly based on sequential synthesis algorithms, in which the target network is constructed through a prescribed sequence of analytically defined steps. While highly effective for well-established configurations, this paradigm intrinsically limits the synthesis to a restricted family of known network topologies. In contrast, this paper demonstrates how numerical synthesis techniques enable the systematic exploration and realization of non-conventional acoustic-wave filter topologies. Starting from a fully general network representation, a constrained numerical solver is employed to systematically navigate the space of feasible solutions while preserving the target frequency response. This results in an automated process that is systematic, generalizable, and scalable, enabling the discovery of unconventional AW filter configurations without reliance on predefined similarity transformations or topology-specific analytical circuit analysis. As a representative example, a broadband hybrid filter based on a ladder topology is introduced, combining solidly mounted bulk acoustic wave (BAW) resonators with reactive elements to decouple transmission-zero placement from fractional bandwidth, thereby overcoming a key limitation of classical BAW ladder filters.

CASCADED CRF SAW FILTERS. SYNTHESIS AND DESIGN

Edgar Navarro-Gessé, Ana Valenzuela-Pérez, Jordi Mateu, Carlos Collado, Marta Gonzalez Rodriguez, Sebastian Huebner

Abstract: This paper presents the synthesis and design of cascaded CRF SAW structures. Conventional CRF SAW structures are based on coupled IDT configurations in which several modes are excited inside each IDT. This requires non-uniform pitch distributions along the IDTs, making the control of each mode -and thus the filter response- a very complicated task. By cascading CRF SAW structures, high-order filters can be obtained using simpler IDT configurations. The circuit models describing the cascaded structures are introduced and synthesized from initial characteristic polynomials. The design process is also outlined, and detailed examples of fourth- and sixth-order filters are provided. The designed filters are simulated using the Coupling-of-Modes (COM) model.

RESONANT GAP SURFACE ACOUSTIC WAVE: A FLEXIBLE ARCHITECTURE BASED ON POI SUITED FOR RF INTEGRATION

Laure Rolland du Roscoat, Thierry Laroche, Tony Makdissy, Emilie Courjon, Florent Bernard, Alexandre Clairet, Saly NDiaye, Gabrielle Aspar, Alexandre Raveski, Aziz Alami-Idrissi, Sylvain J Ballandras

Abstract: The evolution of wireless communication systems toward 5G Advanced and Non-Terrestrial Networks is driving stringent requirements on radiofrequency (RF) front-end filters, which must offer high selectivity, low insertion loss, excellent linearity and minimal footprint. This paper presents the development of a flexible generation of RF Surface Acoustic Wave (SAW) filter architecture designed to address these emerging challenges. Leveraging advanced substrate engineering, with the POI stacks, the proposed new electro-elastic filter architecture achieves enhanced frequency performances while ensuring scalability for multiple frequencies, bandwidth and standard integration. The approach paves the way for high-performance SAW filtering solutions suitable for future RF system-on-chip and module-level integration, enabling compact and cost-efficient designs for upcoming mobile, navigation and satellite platforms.

Session T2

Non-linear characterization and modelling

MODELING THE BROADBAND NONLINEAR BEHAVIOR OF A BULK ACOUSTIC WAVE (BAW) RESONATOR

Renfeng Jin, Dave Feld, David Molinero

Abstract: A broadband second harmonic (H2) emissions model of a Bulk Acoustic Wave (BAW) resonator is presented. The model is both physically grounded and is ready to be used in filter design. We review the fundamental properties of the nonlinear resonator response by partitioning the broadband response into four sub-band regions from low to high frequency as follows: (i) the subharmonic region, (ii) the lateral mode region, (iii) the in-band main (TE_1) mode region, and (iv) the overtone region. For the sub-band region we identify the dominant physical mechanisms and the key modeling challenges, e.g., rapid H2 phasor rotation, modal crowding, and nonlinear parameter extraction. We synthesize cutting edge modeling techniques including nonlinear Mason, nonlinear FEM, and perturbation models using an EBVD multi branch model capturing lateral modes into a hybrid approach that captures the entire H2 response across all four sub bands using a single, portable model. Finally, we extend the hybrid model to filter level H2 suppression topologies, namely the anti series cascade and anti-parallel split configurations that are widely used in modern filter designs. The extended model predicts residual H2 emissions in these configurations due to small frequency imbalances and trace parasitics. These results provide a practical path to meeting ever stricter H2 emission specifications, enabling robust, phasor aware design closure for next generation RF filters.

UNIQUE PARAMETER FOR IN-BAND THIRD-ORDER NONLINEARITIES IN TC-SAW RESONATORS AND FILTERS

Marta Gonzalez Rodriguez, Aleix Balust, Carlos Collado, Jordi Mateu, Sebastian Huebner

Abstract: This paper demonstrates the validity of a distributed model for accounting for the nonlinear effects occurring in surface acoustic wave resonators. The circuit model has been shown to accurately emulate the third-order intermodulation products (IMD3) and third harmonics (H3) observed in many resonators and test filters centered around 1 GHz. The filter and the resonators comprising it were manufactured and subsequently characterized with respect to their nonlinear behavior. The measured IMD3 and H3 responses are consistent with a single parameter value that is independent of the in-plane geometry, namely the second-order derivative of the elastic constant. This implies that the same parameter value can explain different manifestations of nonlinearity across various devices. This finding is crucial for determining the origin of the nonlinearities since there are many potential sources of the nonlinearities in electroacoustic devices. We also demonstrate, through simulations and measurements, that while the IMD3 remains nearly unchanged when the input and output ports are swapped, the H3 response changes significantly. Such simulations could enable the prediction of optimal configurations for minimizing nonlinearity in more complex filter designs.

EXPERIMENTAL INVESTIGATION OF NONLINEARITY IN LONGITUDINAL LEAKY SAW RESONATORS ON LINBO3/SIO2/SIC SUBSTRATE

Xinyu Guo, Pengcheng Zheng, Xiaoli Fang, Juxing He, Mijing Sun, Dongchen Sui, Dan Ling, Kai Huang, Shibin Zhang, Xin Ou

Abstract: This study presents a systematic experimental investigation into the nonlinear characteristics of longitudinal leaky surface acoustic wave (LL-SAW) resonators on the LiNbO₃/SiO₂/SiC substrate, specifically targeting 5G N79 band applications. The nonlinear responses of three interdigital transducer (IDT) structures—standard with dummy, tilted, and piston mode (edge-thickened)—are compared. The results demonstrate that while both tilted and piston mode designs effectively suppress transverse modes, the piston mode configuration is superior due to its higher admittance ratio (AR) and comparable harmonic performance. In the entire 5G N79 band, the peak values of second harmonic (H2) and third harmonic (H3) are -61.9 dBm and -62.0 dBm, respectively. Furthermore, the impact of key structural parameters, including nonstandard reflector (NSR) period (λ_r), airgap width (W_g), aperture length (L_a), and the number of IDT pairs (NIDT), on harmonic levels is quantified. H2 and H3 exhibit distinct sensitivities to these parameters, which is attributed to their different generation mechanisms. Notably, while reducing the aperture length or the number of IDTs leads to increased harmonic levels at lower frequencies, a convergence phenomenon is observed above 5 GHz, which cannot be easily explained by linear small signal responses. Additionally, H2 ripples are generally more severe than H3 ripples, a trend that is sensitive to variations in the W_g . These experimental findings offer critical insights for optimizing LL-SAW resonators under high-power conditions and contribute to the development of high-performance filters for future mobile communication systems.

THEVENIN THEOREM APPLICATION FOR A ONE-NONLINEAR SOURCE MODEL ACCOUNTING FOR DISTRIBUTED NONLINEARITIES OF SAW DEVICES

Marcos Carmona López, Carlos Collado, Victor Manuel Garcia Martinez, Jordi Mateu, Marta Gonzalez Rodriguez, Sebastian Huebner

Abstract: This article presents a new simulation methodology for analyzing nonlinearities in Surface Acoustic Wave (SAW) resonators. Accurate nonlinear modeling is essential for high-performance system design. However, modeling resonator nonlinearity is challenging because the behavior is inherently distributed; harmonic and intermodulation products are generated along the structure and coupled to the electrical ports. Conventional distributed nonlinear models, which require thousands of internal nonlinear sources, are computationally prohibitive to simulate complex filter schemes. To address this, we propose a method that aggregates distributed nonlinear sources at device electrical terminals. This approach significantly reduces model complexity while preserving physical accuracy, enabling fast and scalable simulations for advanced electroacoustic systems.

WAVELET ANALYSIS OF NONLINEAR SECOND-ORDER HARMONIC RESPONSES IN RF-SAW RESONATORS

Tatsuya Omori, Naoya Tsutsui

Abstract: A time-frequency analysis using the continuous wavelet transform (CWT) is introduced to analyze the nonlinear second-order harmonic (H2) response generated by an RF-SAW resonator. The complex amplitude of H2, measured by a highly sensitive vector measurement system, is mapped onto the time-scale plane using the CWT with the Morlet wavelet. The proposed method successfully decomposed the main response, which is concentrated in the time-scale plane. Reconstructions after picking up and excluding the main response in the time-scale plane reveal the clear behavior of the main response and two sharp peaks hidden by it, respectively. Therefore, the proposed method is expected to provide a clearer and more flexible decomposition than the conventional time-gating technique.

Session T3

Advanced electro-acoustic technologies II (High performance resonators)

SPURIOUS SIGNAL CONTROL FOR SAW DEVICES ON POI SUBSTRATES

Laure Rolland du Roscoat, Sylvain J Ballandras, Emilie Courjon, Thierry Laroche, Florent Bernard, Tony Makdissy, Alexandre Clairet, Saly NDiaye, Gabrielle Aspar, Aziz Alami-Idrissi, Thierry Hilt, Gilles Martin, Roland Salut, Luciana Capello

Abstract: Piezo-On-Insulator (POI) wafers are gaining more and more popularity for the design of Long Term Evolution and 5G telecommunication filters on a spectral range spreading from 600 MHz to 3.5 GHz and even above. For all these applications, a critical need for spectral purity control is imposed by the coexistence of the multiple bands composing the communication modules. The POI wave guide structure naturally induces the possible existence of spurious elastic wave contributions which can be minimized according to the various stack parameters. We demonstrate in this paper the possibility to define POI composition to limit these contributions and to comply with spectral standard specifications. We focus on S band applications (2-3 GHz).

THIN-FILM LITHIUM NIOBATE ON INSULATOR SH-SAW LADDER FILTER WITH FRACTIONAL BANDWIDTH > 35%

Zhi-Qiang Lee, Tzu-Hsuan Hsu, Lu Ruo Chen, Ming-Huang Li

Abstract: This work investigates the design trade-offs associated with implementing ultra-wide fractional-bandwidth (FBW) RF filters on a thin-film lithium-niobate-on-insulator (LNOI) platform. By appropriately selecting the wavelength ratio between the series and shunt resonators in a ladder topology, an ultra-wide FBW approaching 40% can be achieved using shear-horizontal surface acoustic wave (SH-SAW) resonators with a large electromechanical coupling coefficient (k_{eff}^2). The fabricated 2-stage ladder filter achieves a maximum FBW of 37.4% with an insertion loss (IL) of 1.5 dB at 1.2 GHz, in good agreement with the predicted performance. A numerically synthesized 3.5-stage ladder filter further demonstrates an FBW of 36% at 1.2 GHz with sub-3 dB IL and 25 dB out-of-band rejection, underscoring the promise of acoustic-wave technology for wideband RF filter design.

INVESTIGATION OF POLARIZATION-INVERTED DOUBLE-LAYER BAW RESONATORS FABRICATED BY MOCVD AND SPUTTERING DEPOSITION

Yuichiro Hidaka, Nana Shimazaki, Noriyuki Shimoji, Takashi Kimura, Takahiko Yanagitani

Abstract: High-frequency 5G/6G wireless systems demand Bulk Acoustic Wave (BAW) resonators with nano-meter order thin films. To overcome the design bottleneck of reduced electrode area at high frequencies due to thin piezoelectric layer, this study investigates polarization-inverted double-layer structures with second-order mode excitation. This approach doubles the effective layer thickness for a given frequency, allowing for a larger electrode area and reduced lateral acoustic energy leakage. We developed a hybrid fabrication process combining Metal Organic Chemical Vapor Deposition (MOCVD) to grow N-polar AlN and RF magnetron sputtering for Al-polar films. The opposing polarities of these films were confirmed through piezoelectric voltage responses in press tests. Three specific stacks-AlN/AlN, AlN/ SiO₂/AlN, and ScAlN/AlN-were evaluated. By applying Mason's equivalent circuit model to calculate theoretical curves and fitting them with experimental insertion loss data, we assessed the electromechanical coupling coefficient (kt^2) and transition layer between the polarity inverted double layer. The results demonstrated that while the AlN/AlN structure exhibited a transition layer with 300 nm thickness due to an inheritance of polarity of underlayer, the introduction of a SiO₂ intermediate layer prevent from inheriting the polarity of underlayer. The ScAlN/AlN double-layer resonator exhibited kt^2 of 3.5%. This superior performance is attributed to the formation of Al-Sc bonds at the interface, which promotes a facile transition to Al-polarity even on N-polar AlN under layers, unlike the gradual transition observed in non-doped AlN stacks.

LINE-TYPE ORTHOGONAL-SHEAR BULK ACOUSTIC WAVE RESONATOR (LIBAR) ON THIN FILM LiNbO₃

Dongchen Sui, Shuai Shao, Kejin Dai, Juxing He, Yang Li, Xinjian Ke, Kai Huang, Pengcheng Zheng, Shibin Zhang, Xin Ou

Abstract: This work presents a novel line-type orthogonal-shear bulk acoustic wave resonator (LiBAR) on an X-cut LiNbO₃ thin film platform for high-frequency and wide-bandwidth applications. The proposed device features a slender near-square LiNbO₃ bar sandwiched between top and bottom electrodes. Exploiting the e_{35} piezoelectric coefficient of X-cut LiNbO₃, the vertical electric field excites a unique cross-sectional orthogonal-shear mode. With the Euler angle optimized to (117°, 90°, -90°), the orthogonal-shear mode exhibits over 50% electromechanical coupling together with a spectrally clean frequency response in simulations. In LiBARs, the operating frequency depends on both the bar thickness and its width, permitting lithographic frequency tuning. Macroscale prototypes on a bulk X-cut LiNbO₃ wafer operating in the MHz range confirm the fundamental performance, achieving a kt^2 of 47.4% and a quality factor (Q) of 700, which results in a high figure of merit (FoM) of 332. Furthermore, microscale demonstrators operating around 5 GHz are fabricated, exhibiting a high kt^2 of 37.1% and validating the frequency scalability of the LiBARs. These results validate the LiBAR as a compelling technology for next-generation ultra-wideband RF filters.

EXPERIMENTAL REALIZATION OF SUB-MM WAVELENGTH HYBRID SAW/BAW FOR RF AND SENSING APPLICATIONS

Tamara Terzic, Dmytro Solonenko, Vladimir Pashchenko, Humberto Campanella, Florian Hörich, Armin Dadgar, André Strittmatter

Abstract: In this work, the experimental realization of hybrid SAW/BAW resonators based on AlN thin films on Si(111) substrates with sub micrometre wavelengths are reported. Methods of having both main propagating modes of the hybrid SAW/BAW being located outside the cut-off region, where the velocity of the propagating wave surpasses the velocity of leaky substrate waves, leading to suppression of high velocity modes, are discussed using FEM simulations, which are then investigated experimentally. Concept verification was carried out using electron-beam lithography (EBL) in combination with dry etching of the top electrode and the AlN thin film.

Session T4

Simulation and Modelling II

DISPERSION COMPUTATION OF MICROWAVE ACOUSTIC RESONATORS WITH SPECTRAL ELEMENTS

Daniel A. Kiefer, Clemens Grünsteidl

Abstract: Surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices consist of layered media, including piezoelectric layers for transduction. We present a method for efficient and reliable computation of guided modes in these structures, which is a valuable tool for device design. Details on implementing mixed piezoelectric, dielectric and metallic layers are discussed. Our open-source software "GEWtool" (<https://doi.org/10.5281/zenodo.10114243>) implements these methods and is also presented. The applicability is demonstrated by solving for the dispersion spectra of realistic BAW structures.

SPURIOUS-RESISTANT PARAMETER ESTIMATION FOR MBVD MODELING OF SAW/BAW RESONATORS

Fuxian Zhang, Zijiang Yang, Ting Wu, Bao Jingfu, Ken-Ya Hashimoto

Abstract: This paper proposes an auto-fitting algorithm to evaluate mBVD parameters for RF SAW/BAW resonators effective even for situations where strong spurious responses are overlapped. Deviations of fitted Bode Q, resistance, impedance, conductance and admittance from the original data are considered in the objective function, and their weights are adjusted following to volatility of the original data for each frequency point. Namely, the weight sets small when the volatility is large since the original data at the point is unreliable due to inclusion of spurious responses. The fitting software is applied for two SAW resonators with strong spurious responses, and its effectiveness is demonstrated.

IDENTIFICATION OF ELECTROMAGNETIC LAYOUT EFFECTS BY RECOVERING A DISTORTED ACOUSTIC WAVE FILTER RESPONSE

Laia Garcia, Joel Mesas, Santi Cano, Aleix Valdivieso, Mario Faura, Jordi Verdu, Pedro Antonio de Paco Sanchez

Abstract: In ladder-type microwave acoustic filters, the physical layout introduces parasitic effects that can lead to deviations from the ideal synthesized response. Accurate extraction of the coupling matrix from the inversion of S-parameter measurements requires the use of a sufficiently wide frequency window to capture the relevant physical information of the structure, together with the definition of a topology that incorporates the analyzed layout effects. This paper shows that the filter layout has a significant impact on the measured response and must be explicitly accounted for during the inversion process. Layout-dependent parasitic effects, if neglected or improperly windowed, can severely distort the extracted model and compromise diagnostic accuracy. The importance of appropriate frequency windowing is demonstrated through a representative case study involving a ground inductor, in which its influence on the inversion results is clearly observed.

A GENERAL WLP PLATFORM FOR BAW AND TF-SAW FILTERS WITH TSV ON DEVICE WAFER

Duan Feng, Weiwei Hu, Ji Liang, Chao Han, Jie Zou

Abstract: This paper demonstrates a general wafer level packaging (WLP) platform for bulk acoustic wave (BAW) and thin-film surface acoustic wave (TF-SAW) filters, which innovatively routes signals via through-silicon vias (TSVs) fabricated on the device wafer instead of the cap wafer. Adopting a proprietary organic bonding material and a non-patterned cap wafer, this platform effectively mitigates cap wafer stress-induced defects such as breakage and debonding, while unifying the manufacturing supply chain for BAW and SAW filter packaging via process compatibility. The proposed solution features flexible cap wafer material selection, enhanced device reliability and electrical performance, as well as a cost-effective fabrication flow. Experimental results show the packaged BAW/TF-SAW filters achieve ultra-low insertion loss with stable bonding strength, verifying the platform's broad application prospects.

COMPARATIVE STUDY OF OPTIMIZATION ALGORITHMS FOR MBVD FITTING OF SAW/BAW RESONATORS

Zijiang Yang, Fuxian Zhang, Ting Wu, Bao Jingfu, Ken-Ya Hashimoto

Abstract: This paper compares the use of Bayesian optimization, simulated annealing, and genetic algorithm for automatic mBVD fitting of RF SAW/BAW devices from two key aspects: robustness and computational speed. It is shown that the Bayesian algorithm with the iterative boundary shrink method is the fastest. This is mainly owed to not only convergence efficiencies but also suitability for parallel computing. In addition, the applicability of graphic processor units (GPU) is also discussed. Even when a high-end GPU is employed, the acceleration in calculation speed was limited. Namely, GPU can accelerate the calculation in limited routines in the mBVD fitting software, and major parallel calculation can be performed in the current multi-core CPU.

Wednesday, April 22nd

Session W1

Advanced electro-acoustic technologies III (High performance resonators)

XBAR TECHNOLOGY: METHODS FOR DEVELOPMENT AND MASS PRODUCTION TED KIMURA, PATRICK TURNER, BALAM WILLEMSSEN, GUILLERMO MORENO RESONANT INC. A MURATA COMPANY SAN MATEO, CA, USA

Tetsuya Kimura

Abstract: RF filters leveraging a new class of high frequency acoustic device, laterally excited shear mode bulk acoustic wave resonators (XBARs) have recently transitioned to volume manufacturing. Owing to their large electromechanical coupling coefficient and robust high frequency operation, XBAR devices are well suited to wireless communication systems above 3 GHz, including current 5G deployments, prospective 6G bands, and Wi-Fi applications. This talk begins by outlining the XBAR architecture and device characteristics, clarifying its advantages and trade-offs in filter design. Next, key simulation techniques that enable smooth mass production are also discussed.

TRANSVERSAL RAYLEIGH TYPE SAW FILTER USING PERIODICALLY POLARIZATION INVERTED SCALN FILMS

Yuichiro Hidaka, Nana Shimazaki, Takahiko Yanagitani

Abstract: As we prepare for the introduction of 6G around 2030, it has become urgent to support high-frequency bands above 5 GHz in modern wireless communications. However, conventional ladder-type SAW filters face physical limits. Reducing the line width of the Interdigital Transducer (IDT) leads to reduced power durability and a lower Q-factor. To fundamentally resolve this bottleneck, we propose a new acoustic wave excitation structure that combines a periodically poled ScAlN structure with solid electrodes. This design eliminates the need for traditional IDT. First, FEM simulations confirmed that the proposed solid electrode structure excites Rayleigh-type SAWs with resonance characteristics equivalent to conventional IDT-SAW resonators. We fabricated a transversal-type SAW filter using RF magnetron sputtering and a polarization reversal process at 250°C. The sputtered ScAlN thin films demonstrated high piezoelectric quality, with an electromechanical coupling coefficient (kt^2) for BAW estimated at 15.2%. In experimental evaluations, the fabricated transversal filter showed a clear SAW response at 0.75 GHz. The measured electromechanical coupling coefficient (K^2) for the SAW was 2.3%. Furthermore, numerical impedance matching using MATLAB improved the initial insertion loss of -13.7 dB by approximately 3 dB. These results verify that the combination of periodically poled structures and solid electrodes is a viable and effective alternative to conventional IDTs. This research provides a critical foundation for high-performance acoustic wave devices in next generation 6G communication systems.

ALSCN-ON-SIC SURFACE ACOUSTIC WAVE RESONATORS AND FILTERS ABOVE 4 GHZ

Silvan Stettler, Marco Liffredo, Luis Guillermo Villanueva

Abstract: With the continuous rise of the carrier frequencies in wireless systems, new material and design strategies enabling frequency scaling for surface acoustic wave resonator technology are required. We report AlScN-on-SiC Sezawa SAW resonators with resonances above 4 GHz. In previously demonstrated AlScN-based SAW resonators, the effective electromechanical coupling coefficient (k_{2eff}) limited the bandwidth potential. We show that by integrating a patterned floating bottom electrode, the transduction efficiency can be enhanced compared to standard, IDT-only architectures. With a floating bottom electrode, we demonstrate Sezawa SAW resonators achieving a k_{2eff} of 10.8%. In addition, we experimentally demonstrate filters with center frequencies in the 5-6 GHz range with 4-5% fractional bandwidth and a minimum insertion loss of 1 dB.

INFLUENCE OF GEOMETRIC PARAMETERS ON THE PERFORMANCE OF LAMÉ MODE RESONATORS

Tamara Terzic, Vladimir Pashchenko, Dmytro Solonenko, Jeremy Streque

Abstract: This paper presents experimental results on the influence of geometric parameters on the performance of AlScN based solidly mounted Lamé mode resonators. Different device configurations, based on sets of design variables such as the wavelength, the metallization ratio and the number of the interdigitated transducers (IDTs) as well as the aperture were investigated. Their effect on performance metrics, being the electromechanical coupling, quality factor and the shape of the frequency response are demonstrated at wafer-scale in order to assess device uniformity, providing guidelines for optimal device design and fabrication.

HIGH-FREQUENCY FUNDAMENTAL OPERATION IN FIN-TYPE QUARTZ RESONATORS FABRICATED BY HF GAS-PHASE CATALYST ETCHING

Ko-hei Sano, Yusuke Kataoka, Yoshitaka Ono, Yasuo Hayashi, Takahiko Yanagitani

Abstract: Quartz crystal resonators for next-generation electronic devices are required to achieve miniaturization and high-frequency operation. However, high-frequency operation using thin quartz substrates reduces mechanical strength. This study proposes a mechanically strong fin-type quartz resonator fabricated by vertical microfabrication via gas-phase catalyst etching. The resonator structure has electrodes placed on the fin sidewalls, and the frequency can be controlled because of the photolithographic precision of catalyst etching. Additionally, the handling of the resonator is easy because the fin is supported by the substrate. We demonstrated high-frequency operation at 260 MHz and 970 MHz using fabricated prototypes of the fin resonator. This resonator design will contribute to the advancement of quartz resonators because it combines mechanical strength and high-frequency operation.

Session W2

Sensors and interrogation techniques

MONOLITHICALLY INTEGRATED FREQUENCY-MODULATED ACOUSTIC SENSORS VIA PIEZOELECTRIC LAYER TRANSFER

Azadeh Ansari

Abstract: Frequency modulated (FM) sensors benefiting from high-Q resonant devices offer numerous advantages compared to their amplitude modulated (AM) counterparts. Such advantages include improved signal-to-noise ratio, inherent immunity to amplitude drift, enhanced linearity, and faster response times. These attributes make FM sensing particularly attractive for precision acoustic detection in noisy and thermally fluctuating environments. In this talk, I will present a novel monolithically integrated acoustic sensing platform based on piezoelectric resonators realized through a layer transfer process. High sensitivity FM pressure and temperature sensors are realized in Aluminum (scandium) nitride (Al(Sc)N) material systems. The Al(Sc)N piezo-stack is then transferred on to a sapphire substrate, where the III-nitride electronics for signal readout are fabricated. This work demonstrates a new monolithically integrated sensing platform that is capable of operation in high temperature environments up to 800C.

AUTOMATED RECONSTRUCTION OF DISPERSION RELATIONS AND BANDGAP OPTIMIZATION IN TOPOLOGICAL DEVICE

Alessio Marella, Niccolò Scalise Pantuso, Tommaso Maggioli, Cristian Cassella, Luca Colombo, Matteo Rinaldi

Abstract: Topological piezoelectric metamaterials enable robust and highly controllable wave manipulation, offering defect-tolerant operation and enhanced sensitivity that are attractive for next-generation sensing applications. However, the design of topological structures typically relies on extensive Finite Element Method (FEM) parameter sweeps to tune the operating frequency and maximize bandgap-induced localization. This work presents a data-driven workflow that reconstructs dispersion relations directly from FEM eigenfrequency sweeps and optimizes device geometry to maximize the bandgap while preserving the targeted mode family. The considered structure is based on the Su-Schrieffer-Heeger (SSH) model. For optimization, a genetic algorithm explores the geometric parameter space. Topological mode recognition is enforced through an envelope-based similarity metric combining Pearson correlation with an asymmetric log-ratio penalty to discourage spatial misalignment. Bandgaps are automatically identified using an adaptive threshold applied to nearest-neighbor eigenfrequency spacings, ensuring robust detection. The proposed framework fully automates dispersion reconstruction and geometry tuning, significantly accelerating the design cycle of topological acoustic devices.

HIGH SENSITIVITY MAGNETIC FIELD SAW SENSORS BASED ON LOVE WAVES AND OPERATING IN THE GHZ RANGE

Laurine Meistersheim, Yang Yang, Cécile Floer, Ibrahim Cinar, Sami Hage-Ali, Sebastien Petit-Watelot, Demba Ba, Michel Hehn, Omar Elmazria

Abstract: A single-port surface acoustic wave (SAW) resonator based on a CoFeB/ SiO₂/(X+90°) ST-quartz multilayer structure is presented for high-sensitivity magnetic field sensing, targeting industrial and medical applications where wireless interrogation is required. The achieved performance relies on the excitation of a Love wave mode, the optimization of CoFeB/SiO₂ bi-layer thicknesses through numerical simulations, and a high-frequency design operating in the 2.45 GHz ISM band. Experimental results demonstrate an absolute sensitivity of 1200 Hz/ μ T.

WIRELESS SAW DELAY LINE RESONANCE SENSOR

Ventsislav Yantchev, Peter Z Petkov

Abstract: This work presents the first conceptual study of a new class of wireless SAW sensing device simultaneously employing a discrete time delay together with a discrete frequency interrogation. It can offer a lower loss operation combining the advantages of delay line type SAW sensors and SAW resonators. Here we preliminary characterize the proposed SAW delay line resonance sensor (DLRS) configurations and propose potential practical applications. With this we set the beginning of investigations related to the practical implementation of the DLRS in wireless sensing applications.

Session W3

Measurement improvements

LINEAR RESPONSE OF BAW RESONATORS BY VIBROMETER MEASUREMENTS

David Molinero Giles

Abstract: This paper presents a detailed characterization of Bulk Acoustic Wave (BAW) resonators using combined optical and electrical setup. An integrated and fully automated Laser Doppler Vibrometer (LDV) integrated with electrical acquisition is presented with detailed explanation of the characterization procedure. The LDV is used to acquire multiple points across the surface of the BAW resonator and infer the equivalent electrical performance. This technique allow us to isolate regions of the resonator active area and identify the location of undesired electrical response.

CHARACTERIZATION OF TEMPERATURE COEFFICIENTS IN PIEZOELECTRIC FILM USING SUBSTRATE-SUPPORTED-FILM RESONATORS

Nana Shimazaki, Yuto Wada, Wataru Oda, Takahiko Yanagitani

Abstract: With the transition to 5G and 6G mobile communication systems, the demand for RF filters with improved temperature stability continues to grow. However, evaluating the intrinsic Temperature Coefficient of Frequency (TCF) of emerging piezoelectric materials remains a significant challenge. Conventional characterization typically requires the fabrication of free-standing Film Bulk Acoustic Resonators (FBARs) through backside substrate removal, which is a destructive, complex, and time-consuming process that creates a measurement gap between film deposition and device evaluation. To address this limitation, this study proposes a rapid material screening framework based on substrate-supported-film resonators. This approach eliminates the need for substrate removal by employing digital signal processing to suppress acoustic reflections from the substrate through a virtual boundary concept. A key finding of this work is the distinct behavior of resonance modes in composite resonator structures. The short-circuit resonance mode (f_r) was found to be relatively robust against acoustic energy leakage and impedance mismatch with the substrate, depending solely on the temperature characteristics of the piezoelectric thin film. Meanwhile, the antiresonance mode (f_a) showed higher sensitivity to these environmental factors, reflecting composite temperature characteristics. By selectively tracking the temperature shift of f_r , the thermal properties of the thin film can be evaluated with reduced substrate influence. Experimental demonstrations using sputtered aluminum nitride and zinc oxide thin films indicated the feasibility of the proposed framework. The aluminum nitride films exhibited TCF values comparable to previously reported FBAR-based results, while the zinc oxide films showed noticeable variations (-51.0 to -66.6 ppm/°C) depending on deposition conditions. Furthermore, the zinc oxide films exhibited sample-to-sample variations, which may be associated with differences in film quality at the as-deposited wafer level. This substrate-supported-film resonators evaluation approach has the potential to accelerate the exploration of next-generation filter materials and to support in-line process control monitoring in manufacturing environments.

AIR-COUPLED THROUGH-TRANSMISSION CHARACTERIZATION OF POROUS MEMBRANES USING A DUAL-FREQUENCY PMUT ARRAY

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Abstract: In this work, an air-coupled, non-destructive ultrasonic inspection approach for porous polymer membranes is presented using a dual-frequency piezoelectric micromachined ultrasonic transducer (PMUT) array and non-linear frequency mixing in the air, targeting industrial filtration and separator-type applications. Characterization of porous membranes using air-coupled ultrasound is challenged by strong acoustic attenuation and frequency-dependent insertion loss. To address this, a dual-frequency PMUT array operating at $f_1 = 125$ kHz and $f_2 = 175$ kHz is designed and fabricated, enabling non-linear frequency mixing in the air that generates a frequency comb that makes possible frequency-selective through-transmission measurements optimized for porous materials over the frequency range 50-700 kHz. Experimental validation is performed on commercial porous polymer membranes. The measured transmission coefficients at the two frequency bands show improved sensitivity and robustness compared to single-frequency operation, allowing discrimination between membranes with different structural properties. Benchmark results using a conventional broadband air-coupled ultrasonic transducer are also provided. The results demonstrate the feasibility of dual-frequency PMUT-based air-coupled ultrasonic inspection for rapid and high-precision membrane characterization, with potential for inline industrial non-destructive testing.

KNN THICK FILM TRANSDUCER WITH HIGH kt_2 AND Q_m AND KNN THIN FILM SELF-STANDING RESONATOR

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Abstract: (K, Na) NbO_3 (KNN) is known for its high piezoelectric properties. It has been reported that KNN thin film with $Na/(K+Na) = 0.55$ exhibit high piezoelectric constants. The material (K, Na) NbO_3 (KNN) possesses high piezoelectric constants, making it a candidate for applications such as sensors, actuators and MEMS. Therefore, the behavior of kt_2 in KNN thick films was measured and its response under DC bias voltage. Additionally, the Q_m value in the high-frequency range was evaluated using the pulse-echo method. The kt_2 of the KNN thin film resonator with substrate was evaluated as 21.9%. For KNN thick film, when the damping constant a/f^2 was 2.3×10^{-15} (dB-s²/m), the Q_m in the longitudinal wave at 3 GHz was 440. Furthermore, self-standing resonator (FBAR) using KNN thin films we fabricated and evaluated. The kt_2 of the self-standing KNN resonator after substrate etching (11.3%) was higher than that of the resonator before etching (3.5%).

BENCHMARKING LOW-COST VECTOR NETWORK ANALYZERS FOR FBAR SENSING

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Abstract: High-frequency electroacoustic resonators, such as Film Bulk Acoustic Wave Resonators (FBAR) have traditionally relied on laboratory-grade Vector Network Analyzers (VNAs) for high-precision characterization. While these instruments provide gold-standard dynamic range, their prohibitive cost and lack of portability hinder field-deployable applications. This paper evaluates the metrological validity of a new generation of ultra-low-cost VNAs (LibreVNA and NanoVNA) as scalable alternatives for multimodal sensing. Unlike simplified frequency-tracking front ends, these portable VNAs enable complete S11 spectrum read-out across wide frequency ranges (up to 6 GHz), facilitating advanced data analysis and multi-resonance characterization. We perform a comparative stability study of the anti-resonance frequency (f_a) against a high-end industrial VNA (Keysight P9371A). To overcome the hardware constraints of low-cost architectures, such as fixed Intermediate Frequency Bandwidth (IFBW), a computational fitting method is applied to the impedance curve to mitigate the noise floor and enhance peak detection stability. Our results demonstrate that, through adequate post-processing, cost-effective VNAs can achieve the precision required for high-frequency acoustic sensing, offering a versatile and accessible solution for both research and decentralized field measurements.

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Materials and emerging applications

RF MEMS SWITCH FOR AI CHIP TESTING

Xu Zhu, Stewart Yang, Nicholas Yost

Abstract: This paper presents the evolution of RF MEMS ohmic-contact switch technology across three generations, targeting high-performance digital integrated circuit (IC) testing. Through successive design iterations, the fully hermetically sealed devices demonstrate a significant expansion of 1dB insertion-loss bandwidth, increasing from 16GHz in the first generation to beyond 50GHz in the third generation, while maintaining return loss approaching 20dB. The inherent DC-to-millimeter-wave bandwidth of ohmic contact MEMS switches enables unique advantages for wireline applications. This work focuses on the application for high-speed digital chip testing, where ultrawide bandwidth, low insertion loss, and stable impedance characteristics are critical.

HIGH-STRENGTH, LOW-DAMAGE DIRECT BONDING OF LINBO3/GLASS WAFERS FOR THE FABRICATION OF GLASS-BASED SAW RESONATORS

Sho Nagai, Keisuke Nakao, Yasuo Hayashi

Abstract: Heterogeneous acoustic layer (HAL) structures that integrate LiNbO₃ (LN) with glass material are promising for surface acoustic wave (SAW) devices requiring both wide bandwidth and high thermal stability. Glass substrates offer low cost and tunable thermo-mechanical properties. However, direct bonding of amorphous glass to single-crystal LN remains challenging because conventional activation methods using atom beam or low-pressure plasma can yield insufficient bond strength and induce damage of bonded interface. Here, we demonstrate a low-temperature, low-damage LN/glass bonding technique based on atmospheric-pressure NH₃ plasma activation. LN and various glass substrates (fused silica, borosilicate, alkali-free aluminosilicate, and Na-containing aluminosilicate) were successfully bonded. High bonding strength was achieved between LN and glass ($Glc > 1.6 \text{ J/m}^2$), and the LN/fused-silica pair exhibited bulk fracture during the strength test, indicating an exceptionally strong bonding interface. Transmission electron microscopy revealed that the proposed method reduced the thickness of the damaged layer on LN compared with conventional low-pressure plasma-activated bonding (3.1 nm \rightarrow 1.4 nm). Moreover, the bonded LN/glass samples were successfully diced into 1 x 1 mm² chips without delamination. These results demonstrate that atmospheric-pressure NH₃ plasma bonding is an effective approach for fabricating glass-based HAL-SAW devices.

SMALL MODE-VOLUME LATERAL FIELD EXCITED BULK ACOUSTIC WAVE RESONATORS AS A POTENTIAL PLATFORM FOR QUANTUM MICROWAVE TO OPTICAL PHOTON TRANSDUCTION

Elnaz Shokati, Krishna C Balram

Abstract: Efficient microwave to optical photon transducers (MW-OT) are critical for networking future remote superconducting qubit based processors using optical fibers. MW-OTs have traditionally been designed around 1D photonic crystal cavities, but they face both performance and scalability limitations. Here, we consider an alternative approach built around small mode volume MEMS based bulk acoustic wave resonators where we demonstrate phonon trapping to reduce cavity mode volume and improve mechanical quality factors by $\sim 4x$. We also discuss some of the key bottlenecks that need to be overcome to implement efficient MW-OT using this approach.

IMPLEMENTING MICROWAVE INTERFEROMETRY USING PIEZOELECTRIC PHONONIC INTEGRATED CIRCUITS

Mahmut Bicer, A Fahad Malik, Krishna C Balram

Abstract: Microwave interferometry underpins a range of applications from radio astronomy and remote sensing to precision measurements. Here, we consider the implementation of such interferometers in chip-scale platforms by demonstrating tunable microwave interference using a Mach-Zehnder interferometer built using a gallium nitride on silicon carbide phononic integrated circuit (PnIC). We quantify the interferometer performance and discuss potential improvements with a view towards enabling applications in signal processing and sensing.