Introduction to the Special Issue on the 2020 IEEE International Solid-State Circuits Conference (ISSCC)

I. Introduction

IT IS an annual tradition ever from the start of the IEEE JOURNAL OF SOLID-STATE CIRCUITS (JSSC) in 1966 to publish extended manuscripts of a selected set of papers presented at the annual International Solid-State Circuits Conference (ISSCC). In this November issue, you will find selected papers from the Imagers, Medical, MEMS, and Displays (IMMD) and the Technology Directions (TD) sessions. Most of the bio-related papers are covered in these topics. Next month, the sessions of Analog, Power Management, Data Converters, RF, and Wireless will be covered, and in January, you will find the selected papers from the Wireline, Digital Circuits, Digital Architectures and Systems, Memory, and Machine Learning subcommittees.

II. Imagers, Medical, MEMS, and Displays

This section includes six papers selected from the IMMD sessions presented at the ISSCC 2020. The selection contains three papers that report the latest advances in CMOS image sensors, automotive LiDAR systems-on-chip (SoCs), and CMOS X-ray detectors. The other three papers report on biomedical electronics for a wide range of applications, including closed-loop neural recording, heartbeat detection, and therapeutic drug monitoring. The first paper reports a 320 $\times$ 240 indirect time-of-flight CMOS image sensor with background light cancelation to eliminate depth error in outdoor mobile applications. This design uniquely employs a pseudo-four-tap demodulation scheme with alternate-phase driving using a conventional two-tap pixel structure with a high fill factor of over 43% for on-chip motion artifact suppression. The second paper reports a 40-channel, high-resolution, automotive LiDAR SoC that uniquely features a dual-data converter analog front end (AFE) to combine the two functions of analog-to-digital and time-to-digital conversion for highly accurate acquisition of both voltage and time information with 5$\times$ smaller AFE area. The third paper reports a 5.2-Mpixels, 12-in wafer-scale, CMOS X-ray detector consisting of 169 sub-chips. The detector employs a 3T pixel with 16-b, column-parallel, continuous-time, incremental $\Delta\Sigma$ analog-to-digital converters for pixel readout to concurrently achieve high resolution and low power consumption while maintaining uniformity across the 12-in wafer. The fourth paper reports a low-power, continuous-time, second-order, $\Delta\Sigma$ modulator that employs feedback-assisted G_m-linearization technique for resiliency against large stimulus artifacts in closed-loop neural recording applications. This work is further validated through *in vivo* experiments in a mouse model. The fifth paper presents a batteryless SoC for heartbeat detection that is powered by human body heat. The self-powered SoC employs a thermoelectric generator along with power-management circuitry for energy harvesting from body heat and generates an adaptive threshold using a pulsewidth-locked loop for heartbeat detection from the electrocardiogram (ECG) signal with motion artifact resiliency. Finally, the last paper presents a chronoamperometry-based electrochemical sensor with sample-and-hold circuitry for quantifying therapeutic drug levels using structure-switching aptamers. The sensor is validated in human whole blood samples by measuring the changes in electron-transfer kinetics from the aptamers at different kanamycin concentrations.

III. Technology Directions

This section includes three papers selected from the TD sessions presented at the ISSCC 2020. The selection presents a mix of topics from electronics for quantum computing to millimeter-scale dosimeters to novel communication systems. The first paper describes a cryo-CMOS controller for spin qubits and transmons (superconductive qubits). The chip, fabricated in Intel 20-nm FinFET CMOS technology, comprises a digital signal processing section for DDS and a front-end for arbitrary single sideband (SSB) signals centered around 2–20 GHz. The qubit controller achieves an SNR of 48 dB and an SFDR of 45 dB in a 1-GHz data bandwidth when operating at 3 K; it comprises a 4-kb instruction memory to control up to 4 $\times$ 32 qubits by means of FDMA. The chip successfully demonstrates coherent control of a spin qubit at 14 and 18 GHz. The second paper presents an array of 64 $\times$ 64 single-charged-particle radiation detectors for beam cancer radiotherapy. The size of the detector (1 mm^2) makes it amenable to *in vivo* implants for monitoring the dose a patient receives during a radiation therapy session. This measurement is extremely important in radiation therapy to optimize the therapeutic effects on tumor cells. The chip is fabricated in a 65-nm LP CMOS process node, dissipating an average static power of 0.535 mW. The system is verified in a clinical 67.5-MeV proton beam setup. The third paper demonstrates a chip that receives a series of packets generated from a Wi-Fi access point and determines whether to initiate backscatter communication. When this happens, the antenna receiving the next incident Wi-Fi packet is terminated by dynamically

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varying complex impedances that perform SSB quadrature QPSK modulation with frequency translation to a separate Wi-Fi channel for reception by a second access point, thus establishing the communication link. The measured range is as high as 90 m, consuming up to 28 μW with 17 dB of image rejection.

The Guest Editors would like to express their sincere appreciation to all the authors and anonymous reviewers for contributing their efforts and time to ensure high-quality manuscripts under a tight schedule and the highly unusual circumstances brought on by the global COVID-19 pandemic. They would also like to thank all the members of the IMMD and TD international technical program subcommittees (ITPCs) and the session chairs for their help in scoring the papers for selection. Finally, they would like to thank the Editor-in-Chief, Pavan Hanumolu, for his guidance, and Danielle Marinese and the JSSC staff for their invaluable assistance in publishing this Special Issue.

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Dr. Mohseni was a member of the Technical Program Committee (TPC) of the IEEE Radio Frequency Integrated Circuits Symposium from 2012 to 2015 and the IEEE Custom Integrated Circuits Conference from 2012 to 2019. He has been a member of the TPC of the International Solid-State Circuits Conference since 2017. He has been a member of the IEEE Solid-State Circuits, Circuits and Systems, and Engineering in Medicine and Biology Societies. He was a member of the Administrative Committee of the IEEE Sensors Council from 2014 to 2017. He was a recipient of several awards, including the National Science Foundation CAREER Award, the Case School of Engineering Research Award, the First-Place Prize of the Medical Device Entrepreneur's Forum at the 58th Annual Conference of the American Society of Artificial Internal Organs, and the ECSE Mihajlo "Mike" Mesarovic Award for Extraordinary Impact. He was the TPC Co-Chair of the IEEE BioCAS Conference in 2017 and the General Co-Chair of the conference in 2018. He has been an associate editor and a guest editor of several IEEE journals since 2008.

Edoardo Charbon (Fellow, IEEE) received the Diploma degree from ETH Zurich in 1988, the M.S. degree from the University of California at San Diego, La Jolla, CA, USA, in 1991, and the Ph.D. from the University of California at Berkeley, Berkeley, CA, USA, in 1995, all in electrical engineering and EECS.

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