



A Fully Integrated Microplastic Detection SoC with 0.1–3 GHz Bandwidth and 35 dB Dynamic Range for Narrow-Band Notch RF MEMS Sensor System

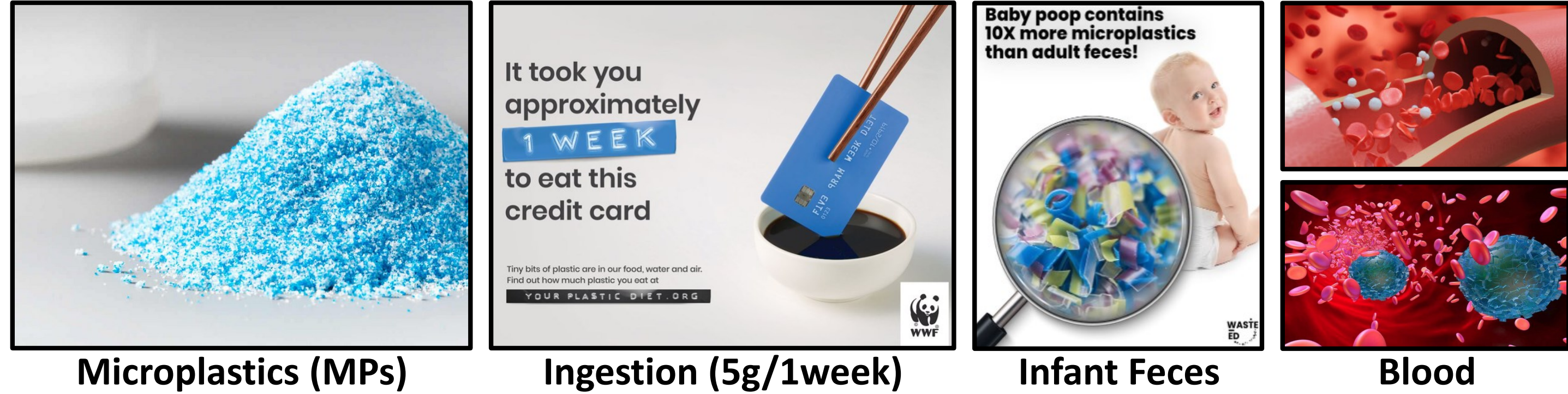
Seung-Beom Ku, Kwon-Hong Lee, Han-Sol Lee, Kyeongho Eom, Joonghoon Kang, Hyungjin Jung, and Hyung-Min Lee

School of Electrical Engineering, Korea University, Seoul, Korea



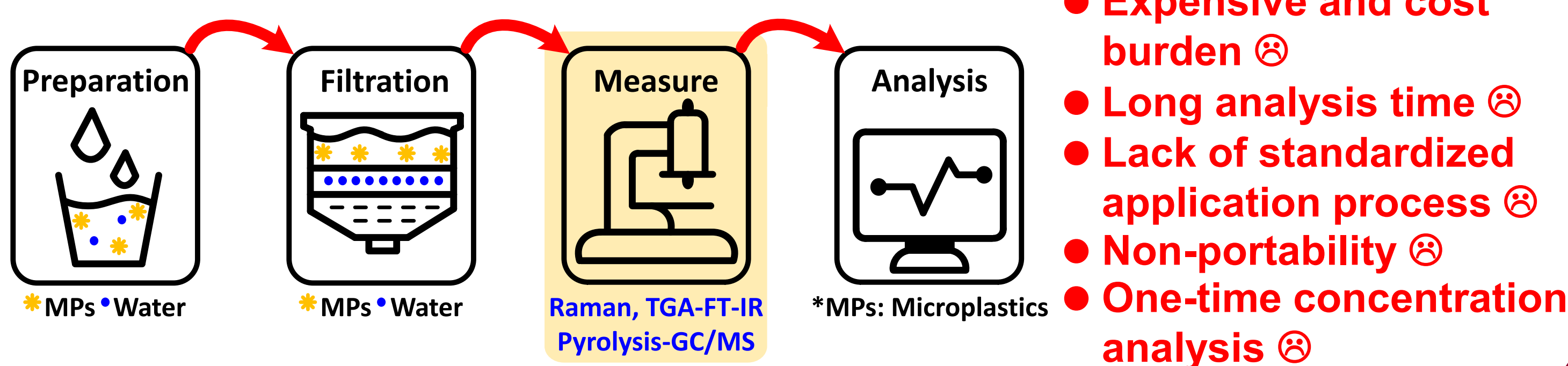
Motivation & Previous MP Det. Method

Motivation



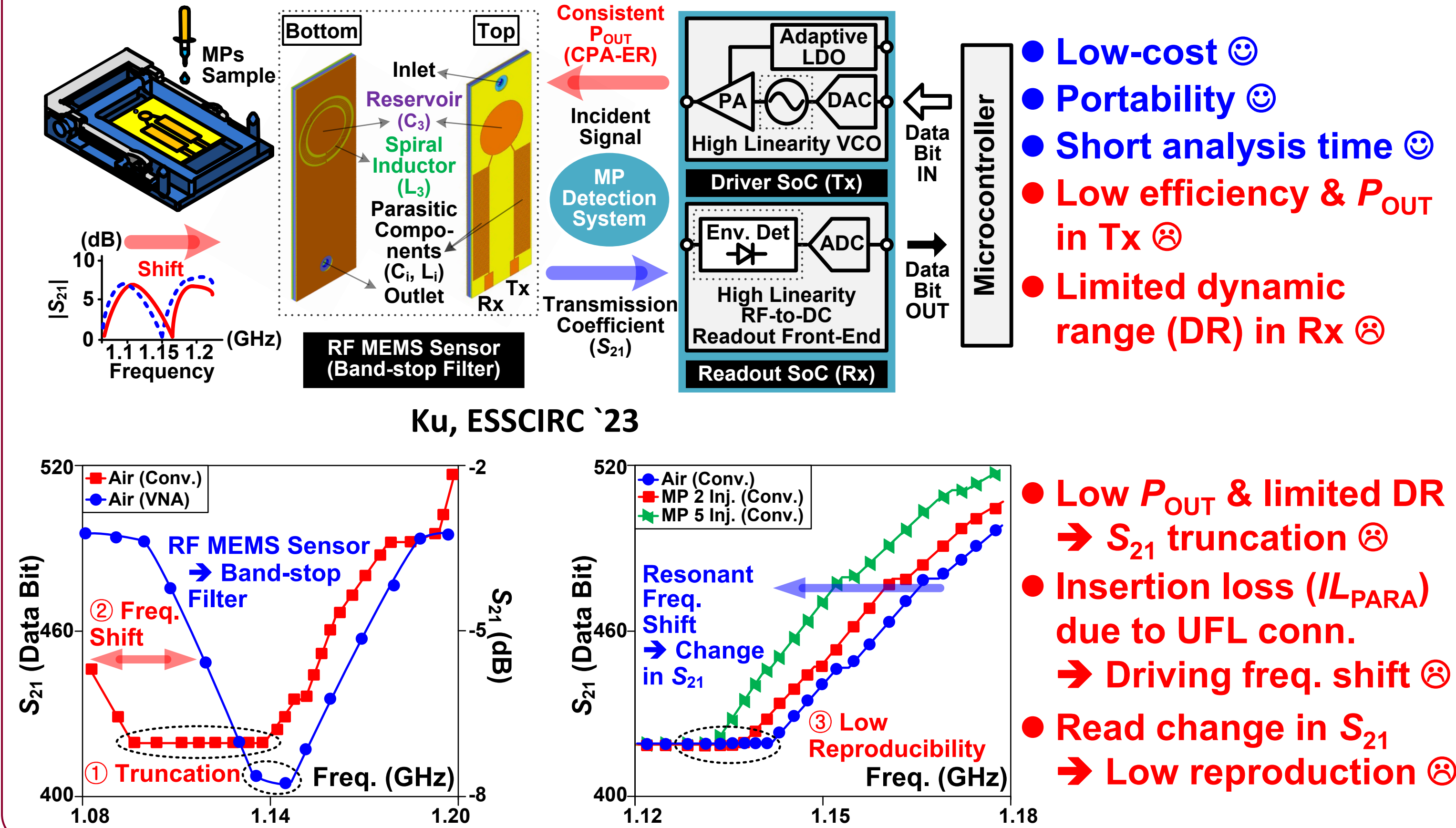
- MPs pose a **threat to human health** by causing damage.
- Research on **MP detection system** is essential and necessary.

Traditional MP Detection Method



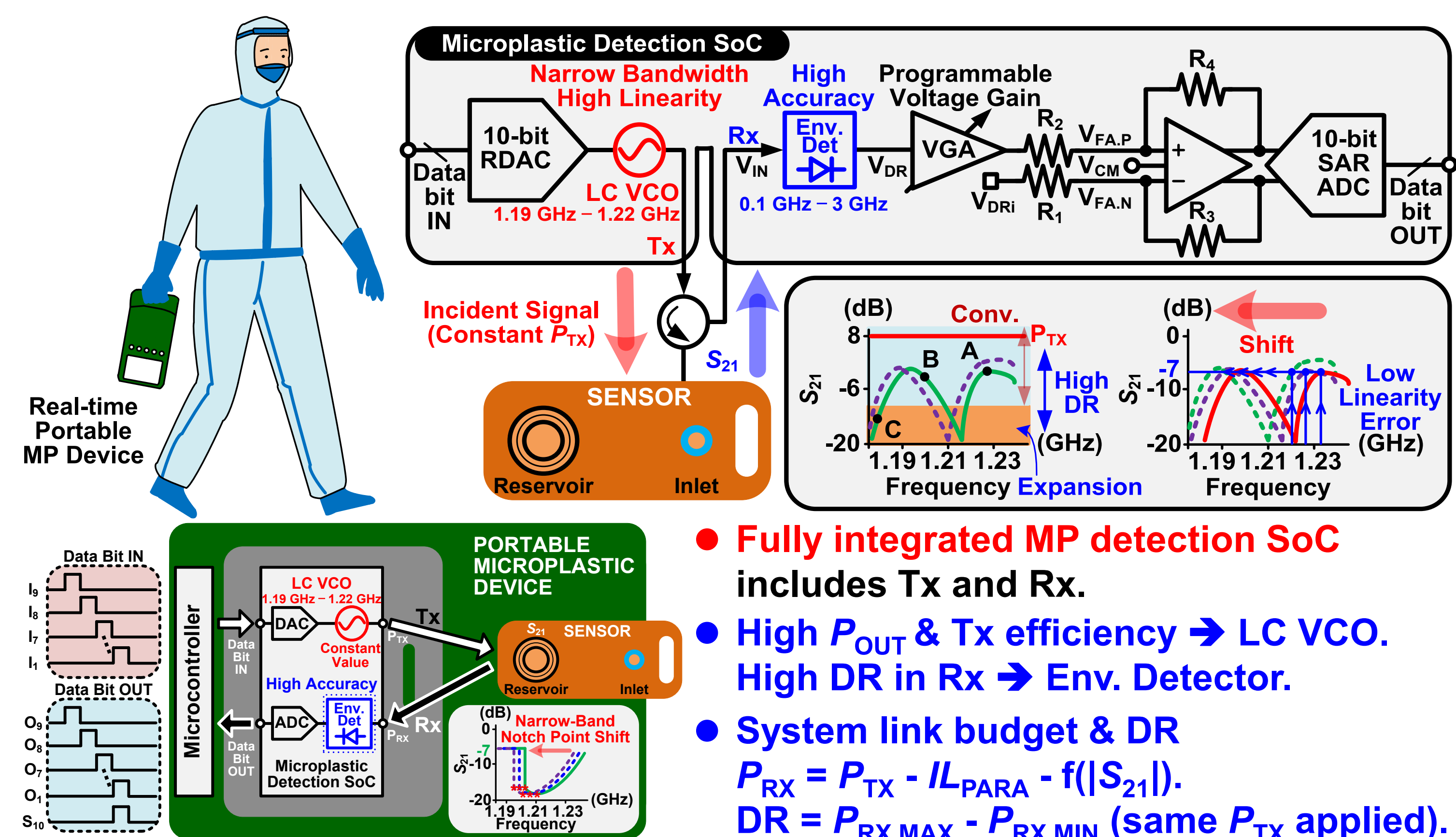
Problems of Previous MP Det. System

Conventional MP Detection System



Proposed MP Detection System

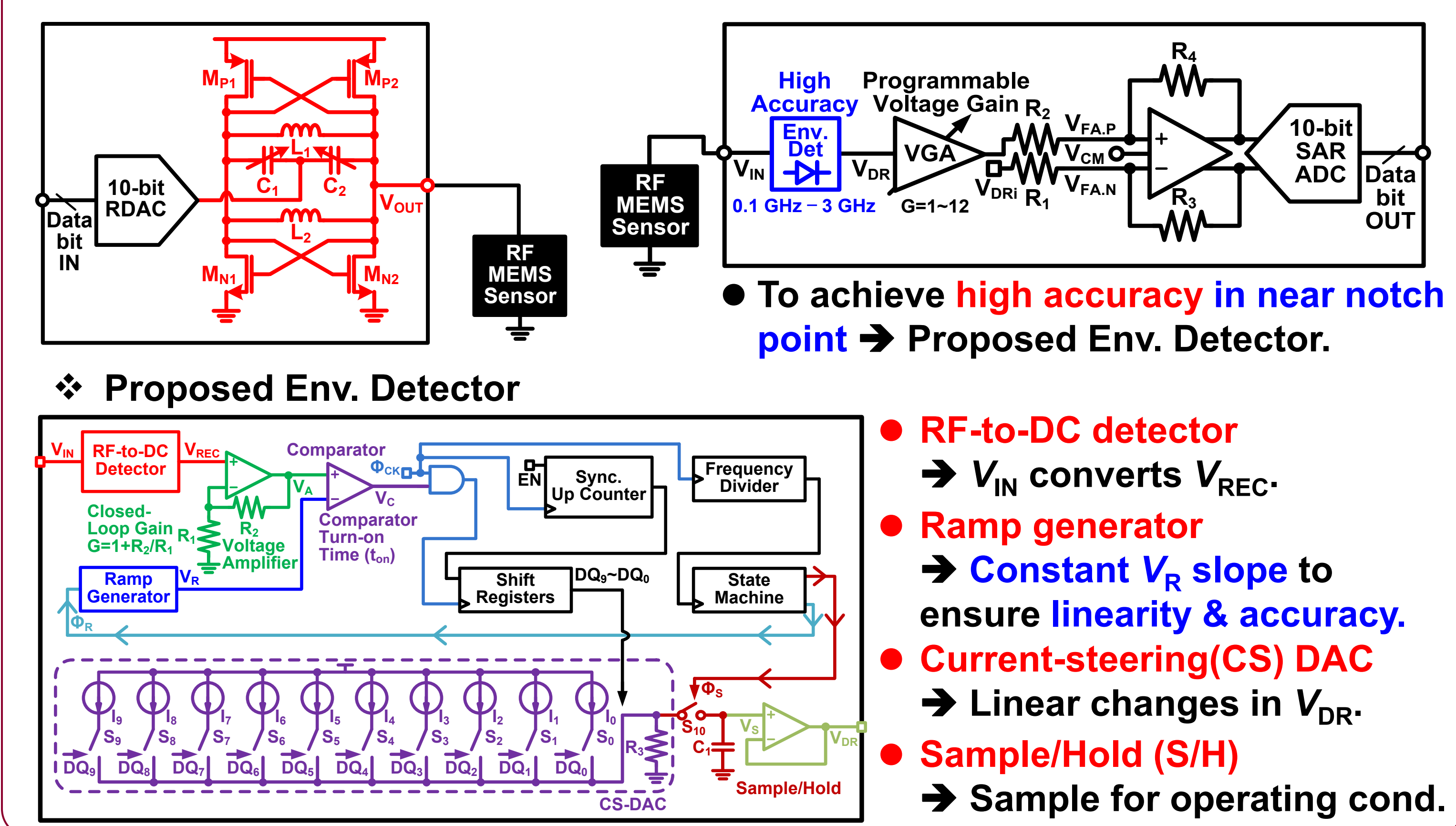
Proposed MP Detection SoC (System-on Chip)



Proposed Idea & Circuit Design

Proposed Sensor Driver IC (Tx)

Proposed RF Readout IC (Rx)

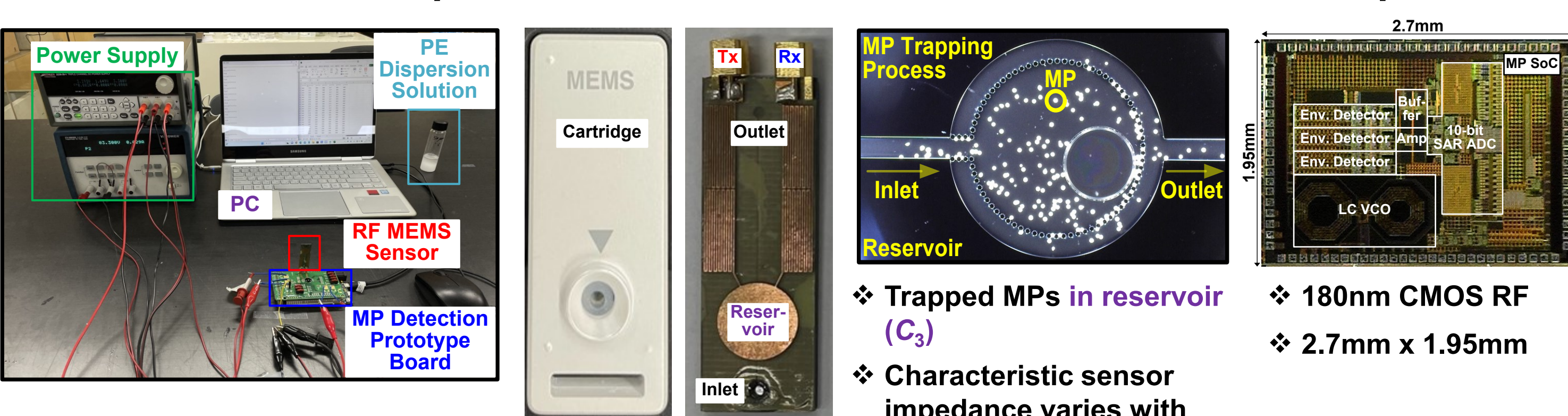


Measurement Results

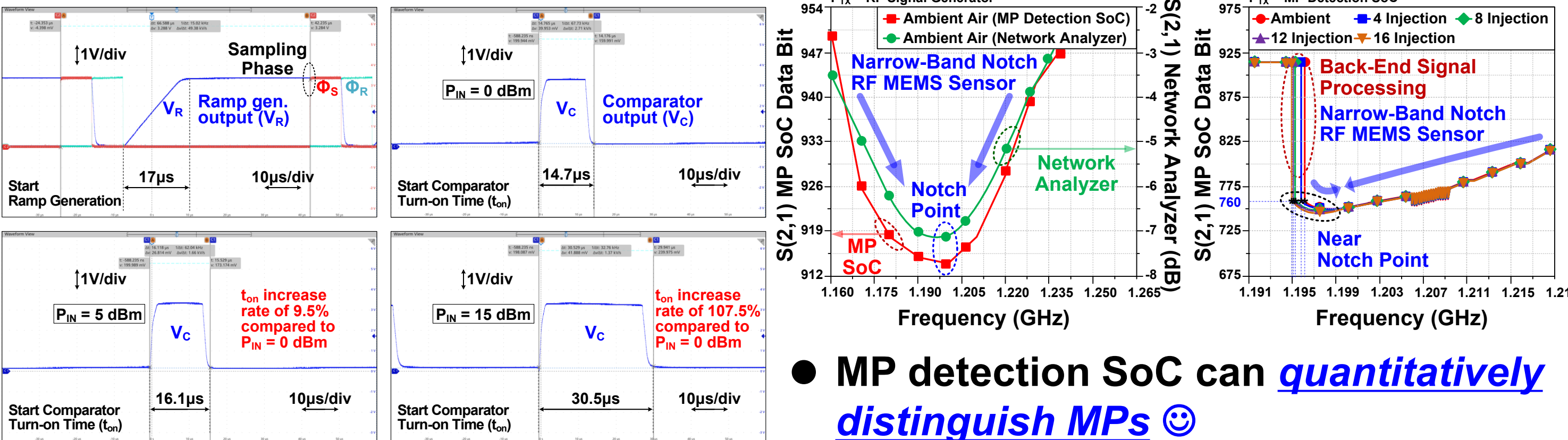
Measurement Setup

Fabricated RF MEMS Sensor

Chip Die



Measurement Transient Response



Performance Comparison

State-of-the-art Comparison Tables

Publication	This Work	IEEE ESSCIRC 2023 [9]	IEEE Sensor J. 2023 [8]	IEEE Sensor J. 2023 [7]	IEEE MTT-S IMS 2022 [6]	IEEE Sensor J. 2020 [5]	TRAC Tr. Anal. Chem. 2015 [4]	Mar. Pollut. Bull. 2015 [3]
Sensor Type	MEMS Resonator	MEMS Resonator	MEMS Resonator	RLC Resonator	Dual Resonator	LC Resonator	Infrared Beam	Laser Beam
Readout SoC	O (SoC)	O (SoC)	X (VNA)	X (VNA)	X (VNA)	X (PNA)	X (FT-IR)	X (Raman)
Cost	Low	Low	Low	Low	Low	Low	High	High
Portability	O	O	Δ	Δ	Δ	Δ	X	X
Real-time	O	O	Δ	Δ	O	O	X	X
Analysis Time	4 min	7 min	N.A.	30 min	105 min	N.A.	N.A.	N.A.
Measured Parameter	S_{11}	S_{21}	S_{21}	N.A.	S_{21}	S_{11}	N.A.	N.A.
Notch Depth	-8 dB	-8 dB	-17 dB	N.A.	-15 dB	-26 dB	N.A.	N.A.
Detect. Limits	25 μm	25 μm	30 μm	10–20 μm	63–75 μm	50–500 μm	10–20 μm	1–2 μm
Freq. Shift	1.17 MHz	10 MHz	14.3 MHz	4.87 kHz	700 kHz	120 MHz	N.A.	N.A.

Conclusion

- A fully integrated MP detection SoC can distinguish the narrow-band notch point of the RF MEMS sensor crafted as the narrow-band notch filter in 1.19–1.22 GHz range ☺️
- The proposed MP detection SoC can improve the output performance metrics related to the driving and sensing capabilities with a smaller chip area ☺️
- The proposed MP detection SoC can be a viable portable solution to detect MPs while significantly reducing the analysis time and cost ☺️

Acknowledgment

The chip fabrication and EDA tool were supported by the IC Design Education Center (IDEC), Korea. This work was supported by the Technology Innovation Program (20016289) funded by the Ministry of Trade, Industry & Energy (MOTIE), Korea.