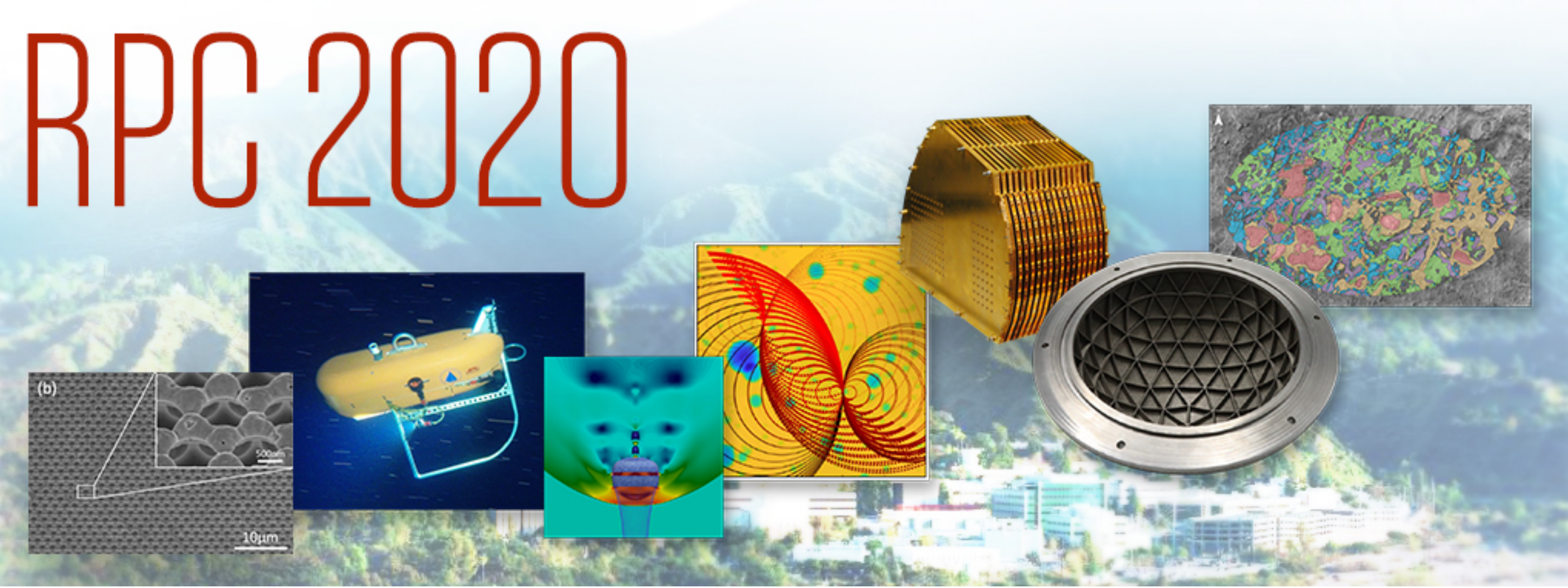

Virtual Research Presentation Conference

ALL-ACOUSTIC MONOLITHIC GAN RADIO-FREQUENCY SIGNAL PROCESSORS

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Program: Spontaneous RTD

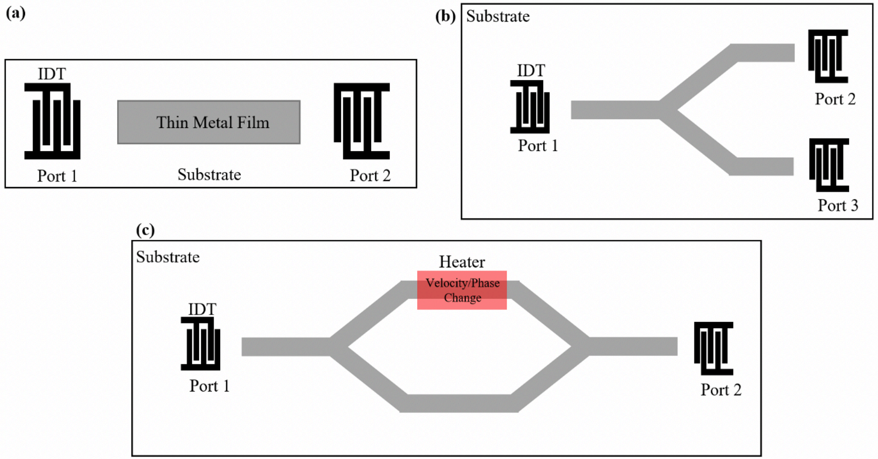
Assigned Presentation # RPC280

Jet Propulsion Laboratory
California Institute of Technology

Tutorial Introduction

Abstract

The proposed research effort will focus on the realization of all-acoustic monolithic RF signal processors based on GaN process technology. Specifically, the team will focus on the demonstration of all-acoustic waveguides, phase shifters, and couplers in this program. This novel approach based on the GaN technology platform can enable the realization of electronic (and even optical) components alongside the acoustic signal processors enabling monolithic realization of mixed-domain systems on a chip.



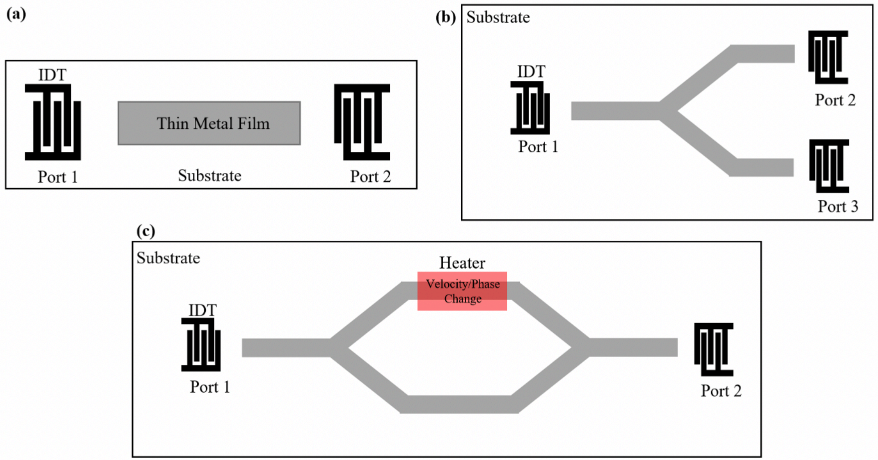
Schematic of all acoustic (a) waveguide (b) 50:50 splitter, (c) phase shifter

Problem Description

a) Context : Advancements in semiconductor fabrication technology, aka the Moore's Law, combined with innovative circuit and architecture concepts have led into complex radio frequency (RF) integrated circuits (IC). However, the form-factor and power consumption of wireless systems is still limited by the inability to realize low-noise, linear, low-power, compact, tunable RF signal processors. One major limitation stems from the fundamental trade-off between the quality factor (Q) and the size of passive electromagnetic components, such as resonators, at radio frequencies ($L_{free\text{-}space}$ ~ 30 cm at 1 GHz, Q_{EM} ~ 10 – 100 at 1 GHz). As such, nearly all commercial wireless systems utilize acoustic RF components, such as the surface acoustic wave (SAW) filters, due to the smaller acoustic wavelength ($L_{acoustic}$ ~ 3 μm at 1 GHz) that allows the realization of compact high-Q resonators for RF front-end signal conditioning. For instance, an average smartphone uses 10 – 15 acoustic filters to cover various frequency bands and wireless standards. Despite the inherent size advantage, widespread application of acoustic technology in RF signal processing has been limited to passive filtering. *Controlled interaction of phonons and electrons in a semiconductor piezoelectric material, such as gallium nitride (GaN), enables the realization of more complex acoustic devices and signal processors. We envision that monolithic acoustic integrated circuits (AIC) with a similar level of complexity and impact as photonic integrated circuits (PIC) can be developed. Such AICs have applications in not only low-power communication but also high precision sensing and in acousto-optic applications.*

b) SOA (Comparison or advancement over current state-of-the-art): SOA devices use photonic technology. With acoustic velocity several orders of magnitude slower than the speed of light, the size of the proposed all-acoustic signal processor will be proportionally smaller than SOA at few MHz to low GHz frequencies.

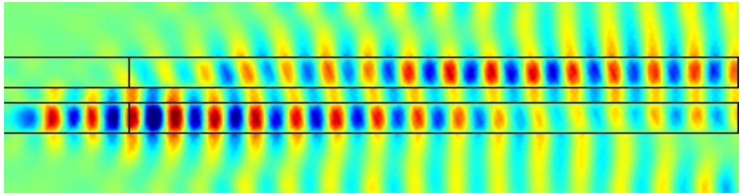
Methodology



Schematic of all acoustic (a) waveguide (b) 50:50 splitter, (c) phase shifter

Results

a) Accomplishments versus goals: In collaboration with the USC team we designed the all-acoustic devices. The USC team then fabricated and measured the first batch of devices right before the COVID-19 closure.



COMSOL simulations of an acoustic coupled-line coupler.

b) Next steps: We will seek future funding to continue working on this task that was interrupted by the COVID-19 outbreak

c) Significance: Such devices will be drastically smaller than SOA while offering competitive performance resulting in reduced SWaP+C.

Publications and References

None.