2021

ESTIMATED RESULTS

2nd stage:

- Simulations of the pressure and temperature behaviour for SAW devices supported on membranes and metalized membranes;
- Fabrication of the SAW devices supported on membranes and metalized membranes;
- Tests of the membrane supported SAW devices packaging;
- Characterization and analysis of the pressure sensitivity for the fabricated SAW devices;
- Dissemination of the results.

OBTAINED RESULTS

Simulations of the pressure and temperature behaviour for SAW devices supported on membranes and metalized membranes

The resonance frequency variation as function of the pressure (in the range of 1 – 7 Bar), for different temperatures (between 25 and 150°C), was extracted from coupled simulations (FEM+COM) for both propagation modes (Rayleigh and Lamb). **This type of simulation is used for the first time for SAW structures supported on membranes.** The variation of the resonance frequency versus pressure at different temperatures (Fig. 1), as well as versus temperature for different pressures (Fig. 2), can be linear approximated, confirming that this type of SAW structure can be used as dual sensor.

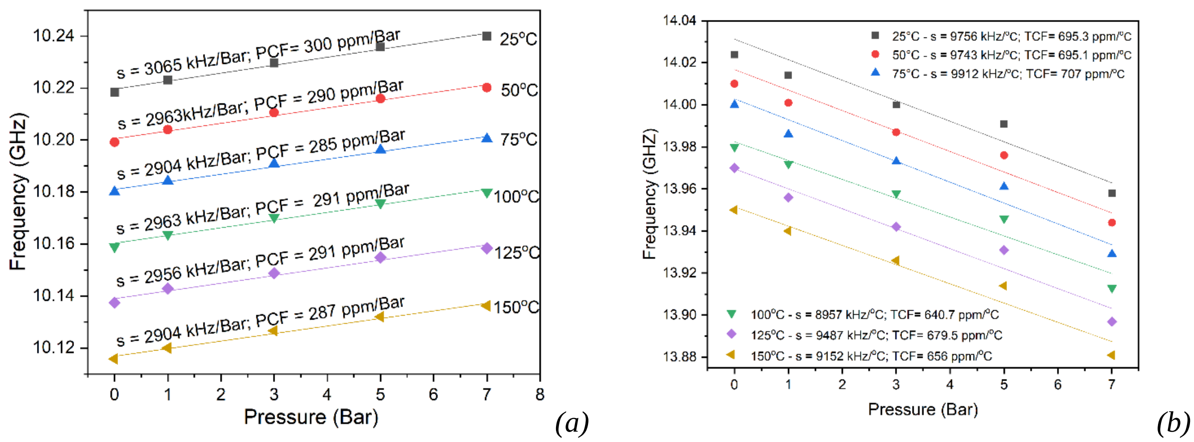


Fig. 1 The simulated resonance frequency vs. pressure, at different temperatures for the SAW device supported on GaN membrane (1.3 μm thin) for Rayleigh propagation mode (a) Lamb propagation mode (b)

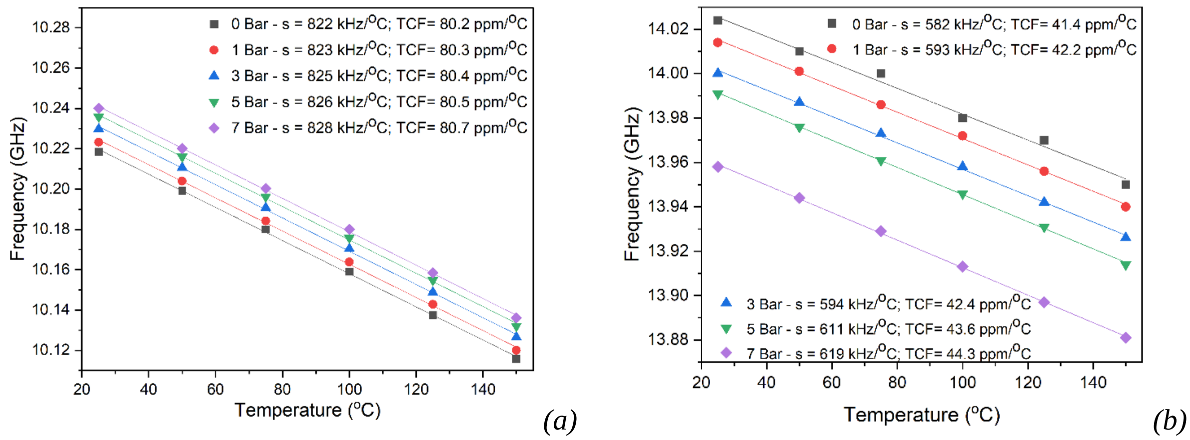


Fig. 1 The simulated resonance frequency vs. temperature, at different pressures for the SAW device supported on GaN membrane (1.3 μm thin) for Rayleigh propagation mode (a) Lamb propagation mode (b)

Fabrication of the SAW devices supported on membranes and metalized membranes

First SAW structures having IDTs with digit/interdigit width of 100 nm and 120 nm have been manufactured on GaN membranes. Three types of membranes have been etched: (i) 1.3 μm thin GaN membrane, (ii) 1.3 μm/10 μm thin GaN/Si membrane and (iii) 3 μm/10 μm/30 nm GaN/Si/Mo membrane.

The technological flow consists of 4 main steps: (1) the patterning of the CPW line – RF connection pads; (2) the fabrication of the interdigitated transducer (IDT) by nanolithography, the width of the digit/interdigit being 100 nm for one type of SAW structures and 120 nm for the second type; (3) supplementary metallization of the CPW line in order to ensure the thickness necessary for RF measurements and a good contact with the IDT area; (4) etching 500 x 500 μm area membranes under IDTs by dry etching (Reactive Ion Etching - RIE) of the silicon substrate.

SEM photos of SAW structures having IDTs with w_{IDT} = 100 nm, supported on GaN/Si membrane are presented in Fig. 3.

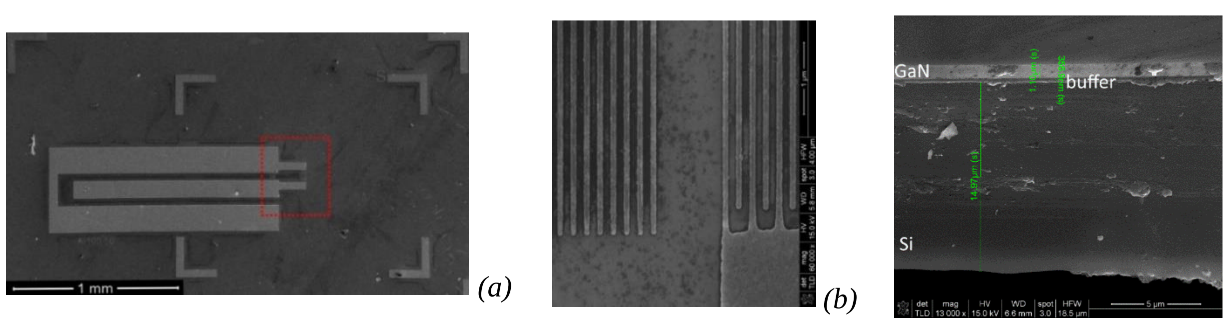
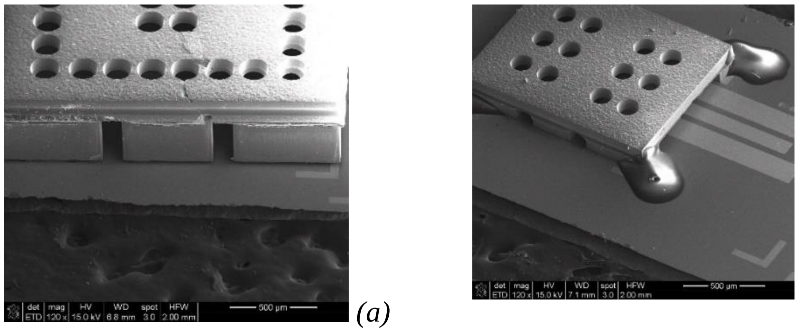


Fig. 3 SEM photos of SAW manufactured devices: (a) SAW device having 100 nm width of the IDTs, the membrane area is marked in red; (b) detail of the IDT and reflectors; (c) detail with the composition of the GaN/Si membrane

Packaging of the SAW sensors

In order to ensure a minimum protection against the environment, a zero-level packaging was considered for the fabricated SAW structures, allowing in the same time the possibility to perform pressure and temperature measurements. The packages were fabricated by dry etching of Si wafers. SEM photos presents the junction between the package and the SAW structures through AZ 4500 photoresist (Fig. 4a) and epoxy adhesive (Fig. 4b).

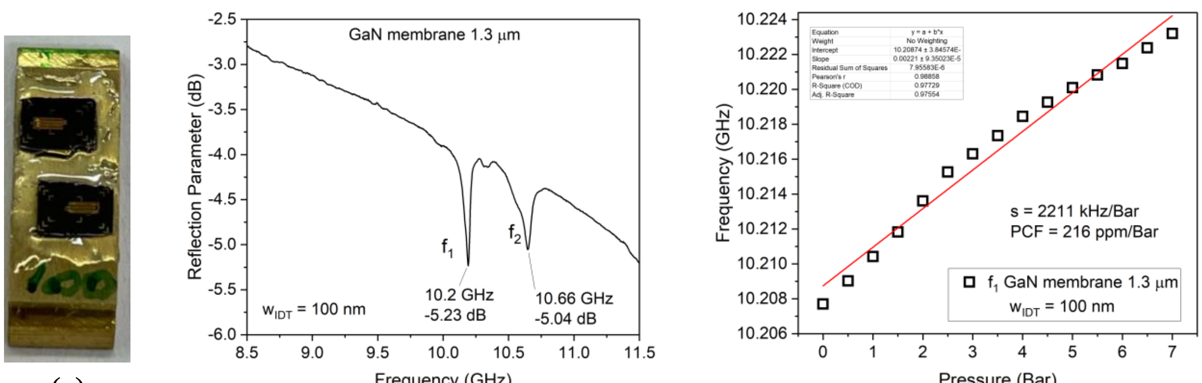


(a) *(b)*

Fig. 4: SEM photos of packaged SAW structures sticked with: AZ 4500 photoresist (a) and epoxy adhesive (b)

Pressure characterization

- SAW structures have been diced into chips and then hermetically soldered on a metallic carrier (Fig. 5a) in order to obtain underneath the membrane a cavity, with quasi-constant pressure, that offers the possibility of deflection of the active area (with IDTs) on the membrane when an external pressure is applied. Initial, the reflection coefficient (S_{11}) was measured at room temperature and ambient pressure with a vector network analyzer (VNA) type 37397D from Anritsu, with a PM5 on wafer set-up from Suss Microtec. Two resonance frequencies have been observed (f_1 and f_2 in Fig. 5b). **The SAW devices have the resonance frequency > 10 GHz.** The variation of the resonance frequency versus the applied pressure was measured in a pressure controlled chamber. The simulations have been validated by the pressure coefficient of frequency (PCF) obtained from measurements. The value of the PCF of 216 ppm/Bar, at room temperature, for Rayleigh mode is very close to the value of the PCF of 300 ppm/Bar obtained from simulations.



(a) (b) (c)

Fig.5 SAW structures (w_{IDT} = 100 nm) supported on 1.3 μm GaN membrane soldered on a metallic carrier (a); Reflection parameter S_{11} (b); Resonance frequency f_1 vs. pressure (c)

Dissemination

A paper is in evaluation process at IEEE Access journal:

George Boldeiu, George E. Ponchak, Alexandra Nicoloiu, Claudia Nastase, Ioana Zdru, Adrian Dinescu, Alexandru Müller, *Investigation of Temperature Sensing Capabilities of GaN/SiC and GaN/Sapphire Surface Acoustic Wave Devices*, in review la IEEE Access.