AlN/Cu(IDTs)/LNY128 bilayer structure for SAW packageless devices

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Background, Motivation and Objective

Thanks to their sensitivity to external parameters Surface Acoustic Waves (SAW) devices are very promising sensing tools. More than batteryless and wireless, they can also be packageless. Indeed, the use of a protective multilayer stack where the wave is confined in a low-velocity layer, itself sandwiched into two high-velocity layers, authorize the extreme miniaturization of the SAW [1]. Recently, an alternative with only two layers, one of which is $LiNbO_3$ Y+128° cut (LNY128), has been suggested [2]. In addition to simplifying the manufacturing process, this bilayer structure can reach a relatively high coupling coefficient K^2. The specific cut of Y+128° is essential for the uncoupling between the Rayleigh and the Shear Horizontal (SH) modes. Here the purpose is to study the AlN/Cu(IDTs)/LNY128 structure. It is particularly interesting for sensing applications in harsh environments such as high temperature environments.

Statement of Contribution/Methods

Using a SDA/FEM/SDA software, the minimum Cu electrode thickness to obtain a guided Rayleigh type wave was estimated. The experimental devices were realized with a Cu deposition by RF sputtering on a LNY128 substrate, a lithography step (optical or electronic) with a positive resist and an ion beam etching step, respectively. The electrical characterizations were done by a network analyzer and compared to the simulations.

Results/Discussion

The Cu thickness must be at least $h_{Cu}=0.2\lambda$ (see Fig.1). For thinner Cu electrodes, the Rayleigh wave degenerates into a bulk wave and does not exist as guided mode. For thicker Cu electrodes, the experimental realization becomes difficult, especially at high frequency where the fingers' wide is small. In terms of velocity and K^2 values, experimental measurements are in good agreement with numerical simulations. This numerical model can further be used to predict the wave behavior in the final AlN/Cu(IDTs)/LNY128 structure. Experimental measurements with fixed AlN and Cu thicknesses but different electrode periods are in progress. This will help to extract experimental AlN constants and then to optimized the AlN/Cu(IDTs)/LNY128 structure to obtain the high velocity Rayleigh wave mode.

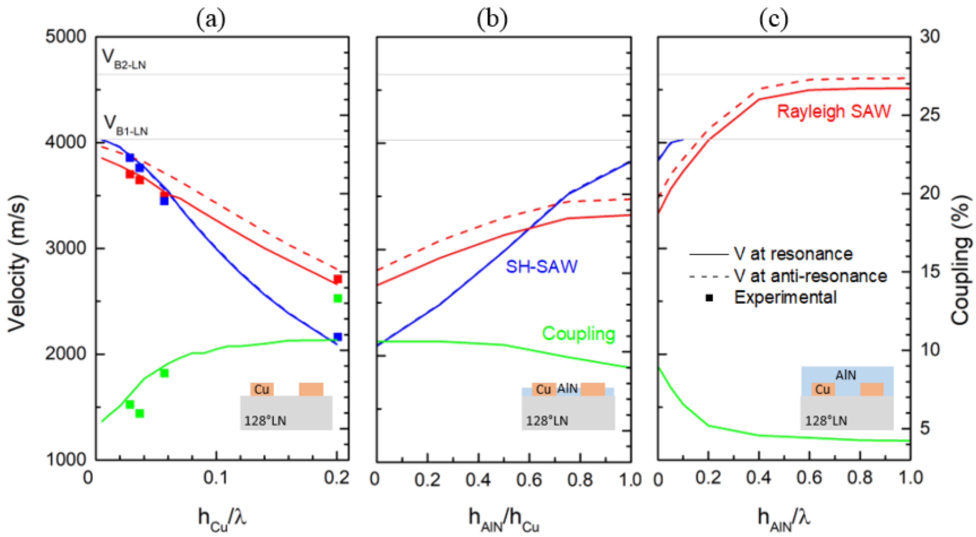

Figure 1: Velocities and coupling of the two propagating modes on LNY128 (a) as function of h_{Cu}/λ; (b) with $h_{Cu}/\lambda=0.2$ as function of the AlN thickness between the Cu electrodes; (c) with $h_{Cu}/\lambda=0.2$ as function of the AlN thickness above the electrodes

[1] K. Bhattacharjee *et al.*, *2007 IEEE International Frequency Control Symposium Joint with the 21st European Frequency and Time Forum*, 2007.
[2] N. Naumenko *et al.*, *Appl. Phys. Lett. 111*, 2017.