SAW Sensors for Surgical Arm Using Piezoelectric Devices

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Abstract

Introduction: Despite of the existing successful clinical applications, artificial sensing, between the robot and the patient is still very limited. With the help of various cameras, vision is almost the only feeling that a robot can have. Although the vision feedback can do some help in complex tasks, lacking of other feedbacks prevents the emergence of autonomous robots evolved from passive robots. For instance, tactile and tensile feedbacks are desired by surgeons in a gastrointestinal surgery. Nevertheless by now surgeons can only rely on the video feedback from robots to estimate the tension exerted on the tissue. In order to imitate the human skin, various signals e.g. the strength of pressure, change of strength, speed and acceleration should be measured. All these signals are then processed with the help of artificial intelligent approaches to restore the tissues texture. Here we explore some design and fabrication techniques on an effective sensor which will be installed on our surgical robotic arm in the future. SAW sensors have unique superiority which include but not limited to competitively low cost, high sensitivity, intrinsically reliability, compact size and fast response in high dynamical environment. The surgical robotic arm may bring the sensor into the human body where the sensor has to have the capability to operate in the liquid environment. This intrinsic drawback can be overcome by using SH-SAW dual mode sensor. In the dual mode sensor, a strong shear-horizontal mode is found to coexist with the SAW mode which has the displacement parallel to the sensor surface so that the most energy is reserved even in the liquid environment. This property makes the dual mode device work in an aqueous environment without losing the high sensitivity as the SAW mode device.

SAW devices are some tools that utilize surface acoustic wave to generate electrical signal in response to some input quantities e.g. chemical concentrations, mass, relative humidity, pressure, temperature etc. For SAW devices SAW plays an important role that can couple with any media in contact with the surface of the device.

Use of COMSOL: By using COMSOL Multiphysics® we have designed structural model of AIN Based pressure sensor . We have studied the structure for different materials, for eigenfrequencies, and carried out time domain analysis too. Structural design is shown in Figure 1 and 2.

Results: Wave transportation when the pressure was applied to the structure is shown in Figure 1

and 4. From the wave analysis we can study the amplitude, wavelength and displacement of the signal.

Conclusion: SAW sensors in surgical robotic arm provide fast response even in aqueous environment. SAW can be excited and detected efficiently by using comb-like electrodes named IDT placed on the surface of a piezoelectric substrate.

Reference

1)R.Weigel,et al.,"microwave acoustic materials,devices and applications",IEEE transactions on microwave theory and techniques,vol-50,pp 738-749,2002
2)7.K. Cleary and C. Nguyen, "State of the art in surgical robotics: Clinical applications and technology challenges", Comput. Aided Surgery, vol. 6, pp.312 -328 2001
3)11.R. H. Taylor, S. Y. Nof, "Medical robotics", Handbook of Industrial Robotics, pp.1213 - 1230 1999 :Wiley

Figures used in the abstract

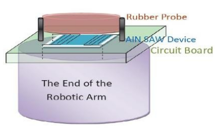

Figure 1: Schematics of a prototype AlN-based SAW sensor

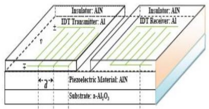

Figure 2: Structure of a SAW Device

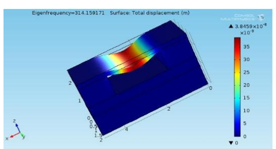

Figure 3: Eigen Freq. Vs Surface total displacement

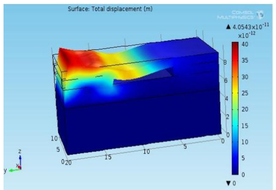

Figure 4: Total Displacement in Time domain