2022 IEEE IUS

International Ultrasonics Symposium

Venice, Italy || October 10-13, 2022

SPONSORS AND ORGANIZERS

UFFC

IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society

IEEE

(https://2022.ieee-ius.org/wp-content/uploads/sites/64/2022/10/IUS-2022-Final-Program-Updated.pdf)

Active and Reactive Power Flow in Ultrasonic Love Wave Waveguides

Piotr Kiełczyński
Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland

Background, Motivation and Objective

Your text explaining what has been done previously and why this work is of importance.

In this presentation, we analyze theoretically the flow of active and reactive power in Love wave waveguides loaded with an infinitesimal layer of mass. Power flow in Love wave waveguides is determined by the distribution of the acoustic Poynting vector in the waveguide structure.
The simplest Love wave waveguide is composed of an elastic surface layer deposited on an elastic substrate. If loaded with an infinitesimal layer of mass the phase velocity v of the Love wave changes accordingly. The sensitivity of the Love wave to mass loading is quantified by the following coefficient of sensitivity $S_\sigma^v = (1/v) \cdot (dv/d\sigma)$, where $dv/d\sigma$ is the derivate of the phase velocity with respect to the loading surface mass density σ.
Unexpectedly, we found a correlation between the mass sensitivity S_σ^v of the Love wave sensor and the flow of active and reactive power in Love wave waveguide structures.

Statement of Contribution/Methods

Description of equipment, methods used.

Using the equations of motion, constitutive equations and the appropriate boundary conditions we developed analytical formulas for the longitudinal and vertical components of Poynting vectors (active and reactive power).

Results/Discussion

Presentation of the results obtained and discussion of the results.

The flow of the active and reactive power (Poynting vector) as well as the coefficient of mass sensitivity S_σ^v were evaluated numerically for Love waves propagating in waveguides composed of a PMMA surface layer deposited on ST-Quartz substrate in the frequency range 0-1000 MHz (see Figs. 1 and 2). The thickness of the PMMA surface layer was 0.5 1.0 and 2.0 micrometers.
We discovered, that maxima of the mass sensitivity and maxima of the active and reactive Poynting vectors along the direction of propagation and in the direction perpendicular to the surface occur at virtually the same values of frequency and surface layer thickness, see Figs.1 and 2.
This fact sheds new light on the physical background of the dependency between the complex power flow and the coefficient of mass sensitivity in Love wave waveguides. Consequently, this result can be employed in design and optimization of Love wave biosensors, chemosensors and sensors of physical quantities, such as density and viscosity.

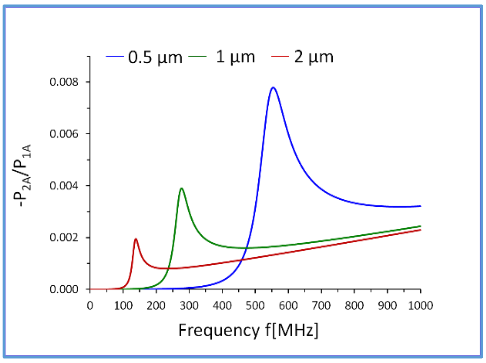

Fig.1 Normalized active power flow P_{2A}/P_{1A} in the transverse direction $-x_2$, towards the surface loaded with a Newtonian liquid in the PMMA-ST-Quartz waveguide.

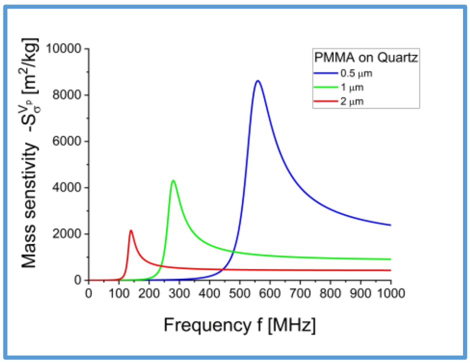

Fig.2 Coefficient of mass sensitivity $-S_\sigma^v$ for Love surface waves propagating in the PMMA-ST- Quartz waveguide.