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2016 IUS

IEEE INTERNATIONAL ULTRASONICS SYMPOSIUM

september 18-21, Tours, France

ABSTRACT BOOK

September 18-21, 2016, **TOURS, FRANCE**

IEEE INTERNATIONAL ULTRASONICS SYMPOSIUM

VINCI CONVENTION CENTER

P3-B1-3

Piezoelectric resonance laser calorimetry of glass and crystalline optical materials

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Background, Motivation and Objective

Development of high power laser systems is limited by the problem of optical materials overheating by laser radiation. For optical absorptance testing laser calorimetry [1] is widely used. Its main part is temperature kinetics measurement of the sample exposed to laser radiation. Temperature is measured mostly by indirect methods with sensors adjusted to sample surface. However, absorption of scattered radiation can induce additional heating of the sensor. It was shown that piezoelectric resonance impedance spectroscopy (PRIS) helps to overcome this drawback and it can be applied for precise noncontact temperature measurement of piezoelectric crystals [2]. However this method is inappropriate for examination of nonpiezoelectric materials.

Statement of Contribution/Methods

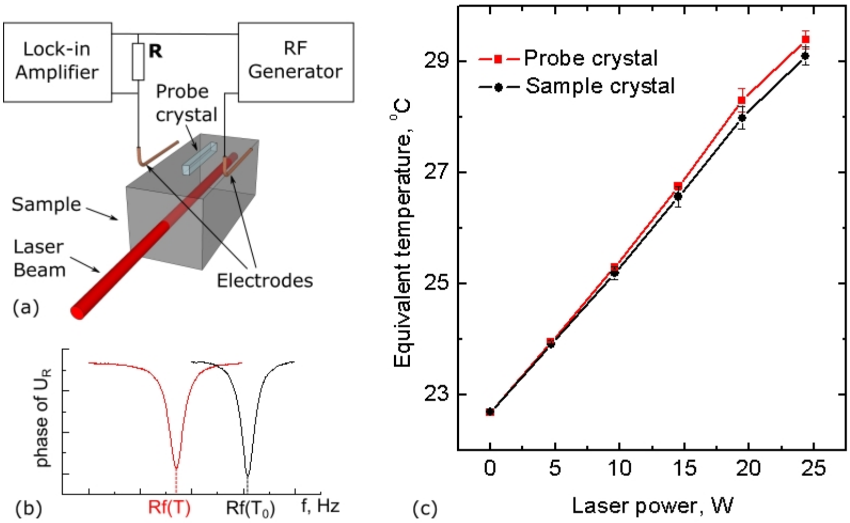
For precise temperature measurement of any sample interacting with laser radiation we propose to use tiny probe piezoelectric crystals placed at certain points in thermal contact with the sample. Probe crystals temperature is determined noncontactly by measuring its piezoelectric resonance (PR) frequency shift induced by heating. To prove this concept we used piezoelectric quartz crystal as a sample to be able to measure its own temperature via PRIS. Block scheme of experimental setup is shown in figure (a). AC voltage is applied to capacitor electrodes with probe crystal in between. Resonance frequency Rf of certain PR depends on crystal temperature T. Figure (b) shows R voltage drop phase response near PR. Calibration at uniform heating reveals linear relation $Rf(T)\text{-}Rf(T_0)=K^{prt}\,(T\text{-}T_0)$. When sample crystal is heated by laser radiation of power P, its nonuniform temperature distribution can be replaced by equivalent temperature derived from Rf value of PR: $\Theta_{eq}\,(P)=T_0+[Rf(P)–Rf(0)]/K^{prt}$ [2].

Results/Discussion

Dependences of equivalent temperature of the probe crystal (lithium niobate) and sample crystal on laser power transmitted through the sample are shown in figure (c). Discrepancy beetween its Θ_{eq} values is below measurement error. Thus temperature of any dielectric sample can be determined via noncontact PRIS of allocated piezoelectric probe crystals. Main advantage of present approach is that crystal sensors are transparent and its heating by scattered radiation is eliminated.

[1] ISO 11551:2003.

[2] O.A. Ryabushkin et. al, J. Eur. Opt. Soc., Rapid Publ. 6, 11032 (2011).



P3-B1-4

Leaky backward Lamb waves in various isotropic and anisotropic plate/liquid systems

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Background, Motivation and Objective

In spite of a great deal of attention paid to studies of backward waves (i.e. modes with opposite directions of the phase and energy velocities) in various areas of wave physics, little is known about the effect of leakage on this type of waves. In particular, the energy fluxes for these waves are not calculated in the literature till now, although the energy flux is the single reliable characteristic to identify correctly the backward waves. The aim of the present study is to investigate theoretically and numerically the general and particular features of the basic characteristics of leaky backward Lamb waves in isotropic plates (aluminum, steel) and anisotropic ones (LiNbO3 and NBBT95/5 single crystals) placed in various liquids (water, petrol, liquid helium). The phase velocity and attenuation, the group and energy flux velocities, the local and integrated energies and energy fluxes are among the studied characteristics.

Statement of Contribution/Methods

The symmetry case is considered when the same liquid is above and below the plate. The perturbation theory and the energy conservation law are applied to calculate the decay constant of leaky waves along the plate. Besides, the conservation laws for the real and imaginary parts of the complex energy fluxes are used to analyze the properties of the waves. To study the relationship between the energy flux velocity and the group velocity, the procedure described by Auld (1973) is utilized. The properties of specific solid/liquid systems are calculated numerically and presented in graphical form.

Results/Discussion

The total (integrated over the depth of the plate and in the liquid) time-averaged energy flux for the leaky backward Lamb waves is proved analytically to be always zero. This is explained by controversial energy fluxes in the plate and in the liquid for these waves. Besides, the common equality of integrated kinetic and potential energies is violated as a result of the leakage. Thus, the traditional definition of the energy flux velocity in terms of integrated quantities over the whole region occupied by the wave fields is not appropriate to the present unconventional case. The integration over the plate thickness only is used by us to calculate the energy flux velocity. It is found that this velocity and the group velocity obtained via the derivatives of the dispersive curves do not coincide with each other. The analysis shows that the attenuation of backward leaky waves cannot be small in the locality of their onset points if the plate is isotropic. Nevertheless, the anisotropy provides such an opportunity. It is demonstrated numerically that the attenuation of backward leaky Lamb waves is significantly (one order or even more) greater then for forward ones in aluminum/water system. But it is possible to avoid such high attenuation by choosing media with higher contrast of acoustic impedances. This study is supported in part by the Russian Foundation for Basic Research (grant # 16-07-00629 A).