A highly sensitive and compact liquid sensor based on annular slotted cylinders

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Background, Motivation and Objective

Acoustic wave can be used for sensing purposes. The basic principle of operation is that acoustic wave travel through the medium of interest thereby probing its properties. It is worth noting that the localized and concentrated acoustic energy can not only improve the sensing sensitivity but also reduce the amount of the liquid sample to be measured. In this study, we report a novel compact liquid sensor based on annular slotted cylinders (ASC).

Statement of Contribution/Methods

Fig. 1(a) schematically shows the system consisting of a glass cylindrical shell (white) with inner radius b=120 μm, outer radius a=150 μm and 10mm in length. The annular slot filled with the liquid to be sensed (grey) is formed by a gap between the central-position steel cylinder (orange) of radius c=115μm and the cylindrical shell. The ambient liquid surrounds the ASC is water (blue).The normal transmission spectrum and field distribution of this system are calculated by using the COMSOL Multiphysics software with Gaussian beam along the bottom boundary, expressed as $p(x) = p_0 \exp\left(-(x - x_c)^2 / w_0^2\right)$, where p_0 = 1[Pa]. As shown in Fig. 1(b), there is a transmission dip at frequency of 1.3127MHz. The pressure field of ASC at the resonance frequency is illustrated in Fig. 1(c). It is clearly illustrated that the acoustic energy is mostly confined inside the annular slot of ASC system, which can enhance the interaction between the acoustic wave and liquid in the slot.

Results/Discussion

To show the sensing capabilities of the ASC system, the resonance frequencies versus different concentration of NaI-water mixtures filled in the annular slot of ASC are shown in Fig. 1(d). More interestingly, the relative resonance frequency shift increases with decreasing slot size, as shown in Fig.1 (e). Thus the ASC sensor can be served as a highly compact and sensitive liquid sensor.

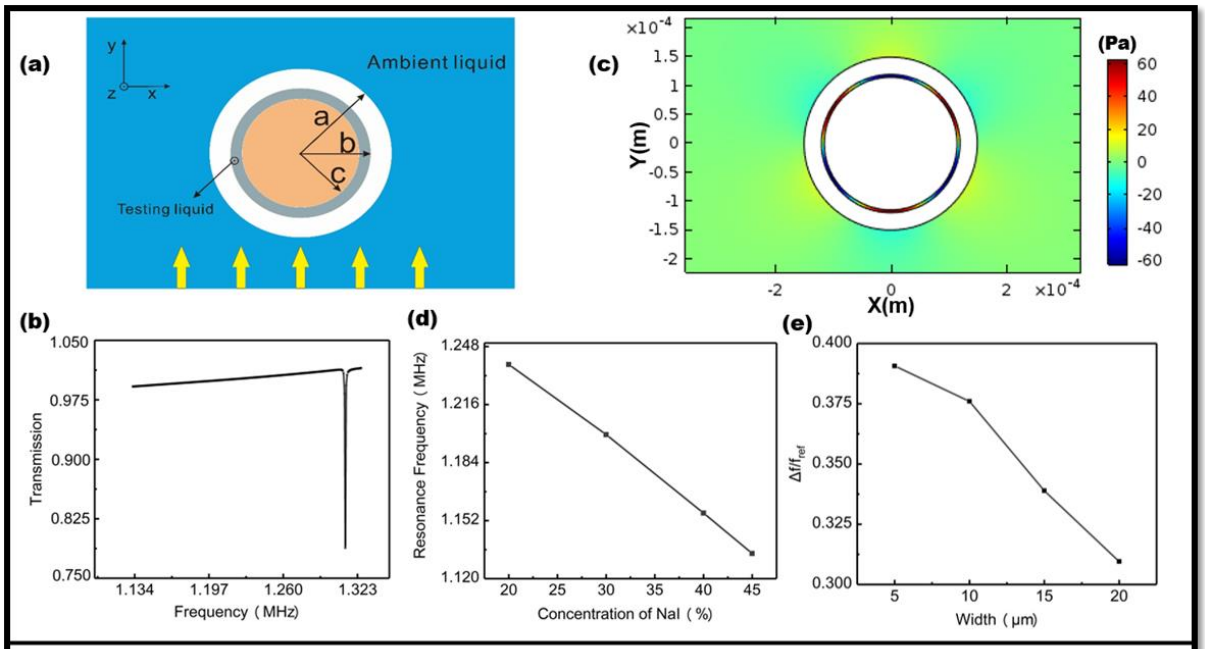

Figure 1 (a) Schematic diagrams of ASC system. The transmission spectrum (b). The pressure field distribution (c) at resonance frequency. (d) The resonance frequencies versus different concentrations of NaI-water mixtures. (e) Relative resonance frequency shifts versus different slot widths, where $\Delta f/f = |f - f_{ref}|/f_{ref}$, f is the resonance frequency when the slot is filled with 45% NaI-water mixture and f_{ref} is the resonance frequency when the slot is filled with water.