Computer Programs for Calculating Effective Permittivity

EPS Version 2.0

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1 "EPS"

1.1 Outline

The computer program calculates complex effective permittivity $\epsilon(S)$ as a function of velocity $V = S^{-1}$, which can effectively be used to characterise piezoelectric radiation of acoustic waves by the surface charge. Effects of film with finite thickness can be taken into account. Supported substrate materials are $LiNbO_3$, $LiTaO_3$, $Li_2B_4O_7$, GaAs, quartz, $La_3Ga_5SiO_{14}$ and $KNbO_3$ with Al, Au or SiO_2 as the film. Other substrates and/or films can be analysed by slightly modifying the source code. The program also enables us to evaluate approximate values of (leaky-)SAW velocities, attenuation, and electromechanical coupling factor. In addition, location of SSBW branch cuts is given.

1.2 Usage

Type "EPS" for execution.

1. "Enter File Name" where the output data will be stored. Note that, if the file has already existed, the output will be overwritten and the former data will be erased.

2. "Enter 1-11 for LNOW(arner), LNON(akagawa), LNOK(ovacs), LTOW(arner), LTOS(mith), LTOK(ovacs), LBO, GAAS, quartz, LGS and KNO" for specifying the substrate materials. If you enter other value, the program will be terminated.

3. "Enter Axis & Angle" for specifying the rotation of the substrate and "To proceed next step, enter 0 for axis". For example, if desired substrate cut and SAW propagation direction is specified by the Euler angles $(45, 30, -20)$ in degree, type

   3,45 <CR>
   1,30 <CR>
   3,-20 <CR>
   0,0 <CR>

   Then the program prints the bulk wave velocities whose wavenumbers are parallel to the surface. If the piezoelectricity is decoupled with some displacement components u_i, the program displays its situation and does not display corresponding bulk wave velocities.

4. "Enter 1 for Al, 2 for Au or 3 for SiO_2" to specify the film material, and "h/lambda" where h and λ are the film thickness and SAW wavelength, respectively. Then the program prints the effective permittivity $\epsilon(\infty)/\epsilon_0$ and $\epsilon(0)/\epsilon_0$, and the longitudinal and shear bulk wave velocities in the film.

5. "Enter VS and VE" where V_s and V_e are the start and end velocities, respectively, for the tabulation. Then the program starts to calculate $\epsilon(S)/\epsilon(\infty)$ and $\epsilon(\infty)/\epsilon(S)$ for 501 velocity points from V_s to V_e, and the results will be stored into the specified file.

6. After tabulating, the program displays and stores location of (leaky-)SAW poles if they exist within the specified velocity range. In addition, estimated attenuation due to leakage and the electromechanical coupling factors will be shown. Furthermore, the program also displays and stores location of the branch cuts corresponding to the SSBW velocities, if they exists within the specified velocity range. The program will be terminated automatically when all of the iteration finishes.

1.3 Note

1. In the case of metal films, the free surface boundary condition is corresponds to set (1) the film conductivity as zero and (2) the film permittivity as ϵ_0.

2. How to use the effective permittivity function for the SAW identification is given in the appendix 2 of

   K.Hashimoto and M.Yamaguchi:"Non-leaky, piezoelectric,
   quasi-shear-horizontal type SAW on X-cut $LiTaO_3$", in Proc. IEEE Ultrason. Symp. (1988) pp.97-101.

   And how to estimate BAW characteristics is fully given in

K.Hashimoto and M.Yamaguchi:"Analysis of acoustic waves launched from an interdigital transducer by means of effective permittivity", in Journal of Fac. Engrg., Chiba Univ., Vol.41, No. 2 (1990) pp.9-17,

whose summarised version is

K.Hashimoto and M.Yamaguchi:"Effects of Surface Electrical Boundary Condition on Excitation and Propagation of Highly Piezoelectric Leaky Surface Acoustic Waves", in Proc. 7th European Frequency and Time Forum (1993) pp.517-522.

3. In the software, the temperature is assumed to be 25°C. It can be adjusted by specifying the parameter "temp" in the main routines in "eps.f".