THICKNESS DEPENDENCE OF SOUND VELOCITY IN ULTRATHIN METALLIC FILMS

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Recently an unusual behaviour of sound velocity in ultrathin metallic films has been observed [1]. Namely, it was found out, that sound velocity decreases with decreasing of film thickness. For ultrathin nickel film containing four monolayers, in the direction perpendicular to the film plane, the sound velocity is approximately three times less than in bulk.

In order to explain this phenomenon, we have developed a theory of acoustic wave`s propagation in ultrathin metallic films under the condition of phonon confinement. Calculations show, that acoustic phonon group velocity in the confinement direction decreases as the film thickness decreases. The physical explanation of this dependence is related to the existence of non zero minimal frequency of acoustic phonons in the confinement direction. The experimental data for four monolayer nickel film were fitted to our calculated values, and the best fit was achieved under assumption, that the fourth vibrational mode is exited. Besides, within the frame of our model we have obtained the value of the lowest vibrational frequency of 1.4 THz, without any fitting, which has been observed in the exoeriment.

[1] 14 J.Hohlfeld, S.-S.Wellershof, J.Guedde, U.Conrad, V.Jaehnke, E.Matthias. Chemical Physics, 251(1-3)(2000) pp.237-258.