Relationship between temperature coefficient of sound velocity and bond angle in vitreous SiO_2-type films

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Background, Motivation and Objective

Vitreous silica (v-SiO_2) shows positive temperature coefficient of velocity (TCV), which is very important for wireless communication because v-SiO_2 can compensate the sound velocity variation due to temperature change. However, the origin of positive TCV is still unknown. In this study, we dope nitrogen into v-SiO_2 and control TCV of v-SiO_xN_y from positive to negative. We discuss relationship between acoustic properties and Si-O-Si bond angle.

Statement of Contribution/Methods

We synthesized v-SiO_xN_y films by a reactive sputtering method and measured sound velocity of them by picosecond ultrasonics between 10 and 300 K. We also evaluated the bond angle change by Raman spectroscopy and Fourier-transform infrared (FT-IR) spectroscopy.

Results/Discussion

Mass density, sound velocity and stiffness increase with increase in nitrogen in spite of the smallest mass of nitrogen among N, O, Si, which insist that the bond angle becomes smaller and we evaluate the bond angle change from the FT-IR spectra. As the nitrogen ratio increases, TCV decreases especially in a low-nitrogen-ratio region and we succeeded in synthesizing zero-TCV v-SiO_xN_y film. We further derive the relationship between temperature coefficient of the bond angle and phonon frequency. Temperature coefficient of velocity and bond angle show similar dependence on nitrogen.