Investigation of GeO_2 Thin Film Properties for Improvement of Temperature Coefficient of Frequency of SAW Devices

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The improvement of filter performance in recent years has led to a rapid development and integration of functional layers in surface acoustic wave (SAW) filters. Temperature compensation is required for excellent frequency stability in combination with large filter bandwidths. The temperature coefficient of frequency (TCF) of the device can be improved by combining two materials with opposite temperature dependence of its acoustic velocity. A SiO_2 layer is widely used for this purpose, because its temperature coefficient of velocity (TCV) is positive and can compensate the negative TCF of e.g. $LiNbO_3$ based SAW filters, as it is well known. The positive TCV of SiO_2 is a result of its elastic anomaly.[1] It is reported that this abnormal behavior can also be observed in Germanium dioxide (GeO_2).[2] In our work, we determined the elastic constants of GeO_2 thin film at different temperatures, investigating a $GeO_2/LiNbO_3$ system. Therefore, we experimentally investigated if GeO_2 can be used to reduce the TCF of surface acoustic wave filters.

The GeO_2 thin film was produced in a physical vapour deposition (PVD) sputtering process on $LiNbO_3$ 128° rot.YX and $LiNbO_3$ 0° rot.YX substrates. Layer thickness and refractive index of the films were measured with spectral ellipsometry. We used differential delay lines to accurately determine the group and phase velocity of the GeO_2 thin film on $LiNbO_3$. From these data we extracted the temperature dependent elastic constants of GeO2 by fitting the phase velocity dispersion from finite element based simulations to the experimental data. The material constants stiffness, density and temperature coefficient of stiffness of the film were extracted. The method is explained in more detail in literature.[3] The extracted material constants will be shown in the publication.

The elastic constants of GeO_2 thin film have demonstrated that a GeO_2 layer has a positive temperature coefficient of velocity. It can therefore be used to improve the TCF of surface acoustic wave devices. The determined phase velocity of the GeO2 layer was compared to the phase velocity of a SiO2 layer. The GeO2 layer shows a significant reduction of the phase velocity which yields to an improved energy trapping of the surface acoustic wave in the overlay.

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[1] T. E. Parker and M. B. Schulz, "Temperature stable surface acoustic wave delay lines with SiO_2 film overlays", IEEE International Ultrasonics Symposium, p. 295-298, 1974.

[2] J. T. Krause and C. R. Kurkjian, "Vibrational Anomalies in Inorganic Glass Formers", Journal of American Ceramic Society, vol. 51, p. 226-227, 1968.

[3] M. Knapp et al., "Accurate determination of thin film properties using SAW differential delay lines", IEEE International Ultrasonics Symposium, p. 1704-1707, 2013.