2pm/V in Poled Bismuth-Zinc-Borate High Index Glass

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Thermal poling freezes an intense static electric field (E_{dc}) in glass resulting in a permanent second-order nonlinearity via a rectification process: $\chi^{(2)}=3\chi^{(3)}E_{dc}$. The low third-order nonlinearity limits the $\chi^{(2)}$ of silica glass to 0.7 pm/V. Hence, poling of high $\chi^{(3)}$ glasses offers an attractive route towards glass based integrated electro-optical modulators and frequency converters for which $\chi^{(2)}$ of the order of 5 pm/V or higher would be desirable. In the present work 2 pm/V have been demonstrated in poled bismuth-zinc-borate glass planar waveguides with opportunely chosen substrates having lower electrical resistance than the guiding region. The innovative sample configuration, which provided a 4-fold improvement in the induced $\chi^{(2)}$ compared to bulk glasses [1], was suggested by a poling model that takes into account both ionic and electronic conduction. The $\chi^{(2)}$ is found to be limited by the onset of nonlinear conductivity. This work opens the way to a further enhancement of $\chi^{(2)}$ through tailoring the nonlinear conductivity via the glass composition and preparation.

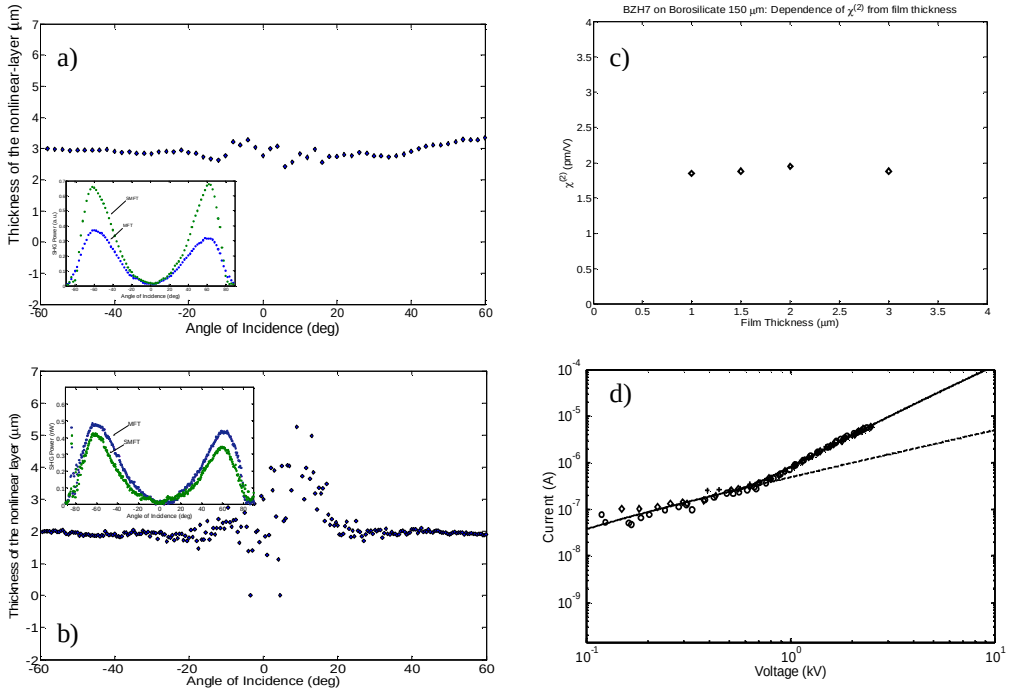

Fig. 1 Measurements of the nonlinearity and of its thickness taken by the stack Maker's fringe technique (SMFT)[2] in a) 3µm and b) 2µm BZH7-film ($12.5Bi_2O_3$-$43.75ZnO$-$43.75B_2O_3$) sputtered on 150µm borosilicate substrate. The $\chi^{(2)}$ is found to extend across the whole film thickness and c) constant in value suggesting that the glass sustains a maximum electric field ($E_{dc}=\chi^{(2)}/3\chi^{(3)}$). Current measurements during poling d) show a strong correlation between E_{dc} and the field at which nonlinearity conductivity occurs.

A range of films of bismuth-zinc-borate glasses (supplied by NSG Ltd.) with various thickness of 1, 1.5, 2 and 3µm were grown by RF-sputtering on 150µm borosilicate substrates and poled (150 ^{o}C, 2.5 kV, 60 sec). The lower electrical resistance of the substrate compared to the film provided a 4-fold enhancement of $\chi^{(2)}$ compared to bulk glass. Moreover, the induced nonlinearity extended across the whole thickness of the film without penetrating the substrate thus ensuring an optimum overlap with the guided modes of the planar waveguide (Fig. 1a, 1b). The correlation between optical and current measurements revealed that the $\chi^{(2)}$ is limited by the onset of nonlinear conductivity (Fig. 1d). Therefore tailoring of the nonlinear conductivity by optimizing glass composition and preparation can provide that further factor of 2.5 enhancements in the second-order nonlinearity that would make glass-based integrated electro-optic modulators viable.

References

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