Introduction

Thermal poling of glasses is in use to induce Pockels electrooptical sensitivity and quadratic optical nonlinearity of the poled glass region [1]. Structural and compositional modifications of this region also result in a change of chemical durability of poled glasses. Poling of glasses with periodically profiled anodic electrode followed by acidic [2] or alkaline [3] etching has recently been applied for the formation of relief diffraction gratings on the glass surface. However structured anodes usually have sharp edges of the conducting electrodes, which should result in arising regions of high electric field in the vicinity of the edges in the course of glass poling. Also an inflow of ionic species resulting from the decomposition of nitrogen molecules and atmospheric water vapor near the electrode edges and glass stresses arising because of the modifications of poled (subanodic) region of the glass influence results of poling with profiled electrodes. Here we present our studies of the peculiarities of 2D structuring of glass surface with thermal poling and subsequent chemical etching.

Surface relief formation in glass poling: influence of periodicity

Grooves formed on the surface of poled glass after poling

Poling of the glass slides using pressed profiled electrode resulted in the formation of a periodic relief on the surface of the poled glasses. One can see that bigger period provides deeper (24 nm) relief compared to shorter period which provide 16 nm relief depth in poling. This is because of partial poling of the glass under the electrode grooves because of the lateral components of electric field generated by the electrode under the grooves and local electric discharge arising under the electrode.

Atmospheric electric discharge: influence on the surface relief

Higher poling voltage results in stronger volume relaxation under the anodic electrode and in local surface uniformity of the electrode region. This should be related to the poling under atmospheric electric discharge near the electrode edge which behaves as a “broadened” anodic electrode.

Etching peculiarities near anodic electrode edges

“Whiskers” near both edges of the strips are developing in the course of the chemical etching. Their formation is just because of stronger poling and corresponding change of the glass composition and chemical durability near the strips edges. Similar behaviour takes place at higher poling voltages but it is essential that increase in poling voltage does not improve quality of relief of the etched structures.

The absence of the edge defect in titania-covered structure allows supposing that it is mainly related with in-flow and following deep penetration of atmospheric species into the glass.

Conclusion

Performed studies have shown that the difference in chemical etching rate of poled and unpoled glass region allows formation of relief structures with the height exceeding one micron. The increase in poling voltage above 300 V results in smearing the structure and decreasing its relief contrast (both for only poled and for poled and etched structures) because of electric discharge arising near the anodic electrode edge and in the gap between the electrode and glass subjected to poling. Poling non-uniformities near the electrode edge corresponding to closed-open anode interface result in deeper poling regions near the edges. In chemical etching these features result in arising the additional relief. These also lead to defects in the cleaved edge of samples poled with structured electrodes. Deposition of titania cover onto the glass with chromium electrodes provides the glass poling in closed anode mode near the electrodes edges. The absence of defects near these edges in cleaved glass samples indicates that the in-flow of atmospheric species rather than electric field non-uniformities is responsible for peculiarities of glass poling near electrode edges. Poling with structured electrodes results in stresses generated in glass by the poled region, and the depth of the stressed region essentially exceeds the thickness of the poled glass layer. These stresses can be visualized via chemical etching.

References


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