Femtosecond laser-written nanogratings in alkali silicate glasses

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Abstract

Birefringent periodical nanostructures induced by a series of femtosecond laser pulses in the bulk of glass which are known as nanogratings have drawn a lot of attention due to possibility to control their orientation and optical retardance by the parameters of laser treatment and have already been used in applications such as polatization converters and ultrastable data storage. Most of the studies of this phenomenon were performed in fused silica. Recently, inscription of nanogratings was also demonstrated in several multicomponent glasses though studies of possibility, conditions and mechanism of their inscription depending on glass composition are still scarce.
Here, we have demonstrated possibility of nanograting formation in binary R2O-SiO2 glasses (R = Li, Na, K) and investigated their inscription conditions and properties depending on the alkaline cation type and, in the case of Na, on its content. By example of sodium silicate glasses, the number of laser pulses required to induce nanogratings is shown to depend exponentially on the contents of Na2O changing from ˜102 for pure SiO2 to 106-107 for 23Na2O77SiO2 glass at a certain pulse energy.

Conditions of nanograting formation have been found to strongly depend on the alkali cation type. As it has been demonstrated in 15Na2O85SiO2 glass, most of sodium ions migrate from the laser-irradiated area along with formation of a SiO2-like nanograting. Na+ cations remaining within the nanograting are accumulated near or inside the 20-30 nm thick nanoplanes whereas composition of regions between the nanoplanes approaches to pure SiO2 making drastic nanoscale chemical differentiation. However, formation of nanogratings in 23K2O77SiO2 glass at similar laser exposure conditions isn't accompanied by noticeable migration K+ cations out of the nanograting. Thus, depletion of alkaline cations within the laser-exposed area is shown to be unnecessary for nanograting appearance in glasses.
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