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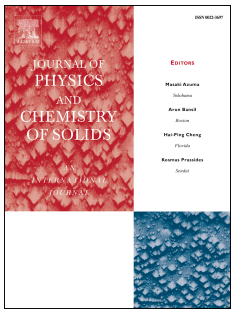

Relationships between lithium and sodium nanoparticles and color centers formation in LiF and NaF crystals with hydroxide and magnesium ions impurities

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Relationships between lithium and sodium nanoparticles and color centers formation in LiF and NaF crystals with hydroxide and magnesium ions impurities

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Abstract

In this study, we investigated the mutual influence of metal nanoparticles and the color centers in lithium and sodium fluorides based on absorption spectroscopy, infrared spectroscopy, atomic force microscopy, and photoluminescence method. Atomic force images of the fresh cleavage of the γ-irradiated and photo-bleached single crystal of sodium fluoride indicated the photo-induced aggregation of F color centers followed by the formation and integration of sodium nanoparticles. The thermo-induced changes in the photo-bleached samples exhibited the inverse trend, i.e., disintegration of the nanoparticles and restoration of a crystal lattice. In the photo-bleached γ-irradiated lithium fluoride crystals, we detected the luminescence of F_3 centers and confirmed that the mechanism of nanoparticle formation was due to aggregation of the color centers.

Keywords: color center, OH^- radiolysis, irradiated LiF and NaF crystals, metal nanoparticle.

1. Introduction

Irradiated lithium and sodium fluorides are employed widely in dosimetry and laser physics, as well as in the manufacture of micro- and nanodevices from micro-structures inside photo-sensitive crystals using high-intensity femtosecond laser pulses, and as models for investigating the fundamental processes that occur at the level of point defects [1-7]. Their application is attributable to the formation of luminescent color centers under the action of radiation. In addition to the color centers, alkaline metal nanoparticles (MNs) can be generated under certain conditions and exposure doses, but also after the subsequent thermal and optical treatment of crystals. MNs modify a crystalline lattice to change the structure of the color centers nearest the surroundings and their optical properties. The sizes of nanoparticles depend on the radiation type (e.g., X-, γ-, β-, and neutron rays) and dose. Opinions differ regarding the mechanisms related to the formation of lithium and sodium nanoparticles [8-10]. However, in most cases, conclusions are based on indirect evidence and there is a lack of direct observations, such as those obtained using atomic force microscopy (AFM). In this study, we aimed to understand the regularity of MN formation in irradiated LiF and NaF crystals under photo and thermal affects. We also studied the effects of MNs