Nanocomposites and nanomaterials

In situ Raman study of $TlInSe_2$ nanocrystallites formed in Tl–In–As–Se glass under laser beam annealing

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Composite amorphous materials formed from arsenic chalcogenides and ferroelectrics seem interesting in view of possible targeted formation of ferroelectric crystallites in amorphous matrices. Such materials can find application for memory elements and temperature sensors.

Here we present micro-Raman measurements (Dilor XY 800) directly confirming the formation of $TlInSe_2$ crystallites under laser beam (λ_{exc} =647.1 nm) irradiation of Tl–In–As–Se glass at room temperature.

At laser power densities P_{exc} below 1 MW/cm^2 the features in the Raman spectra of $(As_2Se_3)_{1-x}(TlInSe_2)_x$ are rather broad, confirming the amorphous structure of the material. At increasing P_{exc}, $TlInSe_2$-related phonon bands near 56 and 180 cm^{-1} appear, increase, and finally dominate the Raman spectrum. One may conclude that under laser beam illumination during the micro-Raman measurement, $TlInSe_2$ crystallites are formed in the glass structure. The laser-induced crystallization depends on P_{exc}. In particular, at medium P_{exc} (1.3 MW/cm^2) crystallization of $TlInSe_2$ is accompanied by appearance of another crystalline species in the material, their nature being discussed. The observed crystallization is caused by local heating of the sample under the laser beam.

A photoplastic effect (radial mass transfer from the laser spot) is observed in the Tl–In–As–Se glasses, depending on the beam power density and the duration of the laser irradiation. The photoplastic effect is manifested at lower power densities than the crystallization of $TlInSe_2$. The laser-induced structural changes in the material are irreversible.