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Micro-Raman mapping of surface changes induced by XUV laser radiation in cadmium telluride

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Abstract

A bulk sample of semi-insulating CdTe:In was exposed to single pulses of 21.2-nm radiation of Ne-like zinc plasma-based laser and 46.9-nm radiation of Ne-like argon capillary discharge laser. Irreversible changes induced by pure XUV laser radiation are studied and compared with action of continuous 532-nm high-power laser and IR pulses at 1320 nm. Modified surface is analyzed by optical and atomic force microscopy, micro-Raman imaging and low temperature photoluminescence. Noticeable amount of absorbed energy from the laser radiation is transferred into Te inclusions which are thermo-diffused and potentially evaporated from the surface layer surrounding the ablation imprint. Annealed CdTe lattice in these areas is detected via strong increase of Raman signal from longitudinal vibrations of the CdTe at 166 cm^{-1}, which are otherwise suppressed in pristine sample. Furthermore, detailed analysis of measured micro-Raman maps showed that peak at 121 cm^{-1} of elemental Te is blueshifted to 127 cm^{-1} due to compressive stress around Te inclusions in the CdTe matrix and is shifted back towards its unstressed position after application of the laser radiation. Low temperature photoluminescence measurements have shown that dislocations are generated in samples due to heating effects with IR radiation.

Keywords: Semiconductors, laser processing, crystal structure, impurities in semiconductors, atomic force microscopy, AFM, luminescence

1. Introduction

CdTe and related compound materials Cd$_{1-x}$Zn$_x$Te (x=0.1–0.2) are important II–VI semiconductors with extensive applications in solar cells [1], room temperature x-ray and gamma-ray detectors [2], substrates for narrow gap (HgCd)Te epitaxy [3], electro-optical modulators and multiple optical applications [4]. The crystals are grown with large concentrations of point defects as well as dislocations and volume defects (Te inclusions and precipitates) critically influencing the device performance in many aspects. Furthermore, additional defects can be generated during technological operations when fabricating the devices. The reliable device manufacture requests the mastering of technological operations like cutting, grinding, polishing, etching, sputtering, etc. Forasmuch as CdTe is known as the material with very low hardness, Vickers hardness results 50–60 kg/mm^2 [5, 6], the mechanical treatment and manipulation with CdTe is complicated by the risk of damage to the sample. As-grown crystals are often decorated by twins or reveal cracks [2] induced by mechanical stress forced by unlike thermal expansion coefficients of CdTe and the wall