Defect tailoring in CuI film produced by pulsed laser deposition based on plasma diagnostic techniques

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The development of novel field-effect transistors utilizing doped transition metal halides as channels represents a cutting-edge pursuit in contemporary electronics, poised to make an immediate impact in the semiconductor industry. Among these materials, copper halide semiconductors (CuI, CuBr, and CuCl) have demonstrated significant promise, with direct wide bandgaps, substantial exciton binding energies, high mobility, and exceptional transparency within the visible spectrum. CuI, in particular, stands out for its superior stability and higher resistance to oxidation when compared to similar copper halides. The superior optical and electrical properties of the CuI films are induced by Cu vacancies in the CuI structure. Our research is focused on exercising control over defects and fine-tuning the physical properties through kinetic regulation during the deposition process. We focus the defect characteristics within CuI, examining their dependence on growth temperature, substrate composition, and ambient gas conditions. Additionally, we explore the role of kinetics in plasma generation during deposition as a primary mechanism for defect formation.

To discern and elucidate these relationships, we deposited of a range of films under diverse experimental conditions encompassing substrate temperature variations (up to 375°C), pressure fluctuations (Ar or N atmospheres up to 20 Pa), and differing laser fluences (2-10 J/cm^2). The depositions were performed using a Nd:YAG laser operated at 266 nm on FuSi substrates. Employing in situ and real-time plasma diagnostics, including optical emission spectroscopy and a dual Langmuir probe system, we quantify parameters such as plasma energy and Cu/I densities. Simultaneously, we employ a comprehensive array of surface analysis techniques (e.g., photoluminescence, atomic force microscopy, X-ray diffraction, X-ray photoelectron spectroscopy) to assess the proprieties of the highly oriented (111) films. Our investigations reveal correlations between plasma temperature, ion kinetic energy during deposition, and the nature and density of defects within CuI films. These findings provide valuable insights into the intricate interplay between deposition conditions and film characteristics, paving the way for enhanced control and optimization of semiconductor device performance.

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