ISOTROPIC MICROCRYSTALLINE CDS THIN FILMS OBTAINED BY DC MAGNETRON SPUTTERING

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The study of cadmium sulfide (CdS) thin films is crucial for advancing solar energy and optoelectronic technologies, where controlled microcrystalline properties directly influence device efficiency. Magnetron sputtering, particularly direct current (DC) methods, offers an economically viable approach for scalable industrial production, yet optimizing structural parameters like crystallite size and microstrain remains essential for enhancing performance.

This study establishes direct current (DC) magnetron sputtering as a scalable method to synthesize hexagonal CdS films with intrinsic isotropy in structural and mechanical behavior, a critical feature for minimizing performance variability in industrial applications. By systematically varying deposition times (5–15 min), crystallite sizes (55–88 nm) and microstrain levels ($1.4–1.8\times10^{-3}$ a.u.) were rigorously quantified using X-ray diffraction (XRD) and advanced analytical models (UDM, USDM, UDEDM, SSP). The hexagonal lattice symmetry of CdS underpins its isotropic elastic response, as evidenced by uniform stress distributions (0.14 GPa via USDM, 0.08 GPa via UDEDM), which suppress anisotropic defects and enhance structural homogeneity.

Extended deposition durations (15 min) yielded films with heightened crystallinity, marked by pronounced (101), (102), and (105) plane reflections, while maintaining microstrain below 2.0×10^{-3} a.u. These findings align with theoretical frameworks for hexagonal systems, where isotropic mechanical properties ensure predictable performance in solar cells and photodetectors. Notably, the absence of anisotropy reduces localized stress concentrations, mitigating crack propagation and interfacial failures in multilayer architectures. The correlation between deposition parameters and isotropic microstructural properties was further validated through statistical consistency across multiple models, underscoring the reliability of DC magnetron sputtering for industrial-scale reproducibility.

By linking deposition time to crystallite size and strain dynamics, this work provides a roadmap for tailoring CdS films to specific optoelectronic requirements, such as minimizing photon absorption in thin-film solar cells or enhancing carrier mobility in transparent electrodes. The demonstrated isotropy simplifies manufacturing protocols and enhances device longevity under operational stresses, addressing a key challenge in sustainable energy technologies. Future applications could leverage these insights to design hybrid CdS-based composites or integrate dopants for targeted property modulation. Ultimately, this study bridges fundamental crystallographic analysis with practical engineering, positioning DC magnetron sputtering as a cornerstone technique for next-generation optoelectronic material design.