INFLUENCE OF Al DOPING ON THE MICROSTRUCTURAL AND OPTICAL PROPERTIES OF CdSe THIN FILMS

Aye Aye Thandar Naing[1], Mar Mar Swe[2], and Moht Moht Than[3]

Abstract

Al doped CdSe films were deposited on glass substrate using rolling method. Difference concentrations of Al (10 mol%, 20 mol% & 30 mol%) were introduced into the CdSe matrix. The deposited thin films were annealed at 300˚C for 1 hour. The microstructural properties such as lattice parameters, microstrain and dislocation density of the thin films were characterized by X-ray diffraction. Grain size and crystallite variation were studied for Al doping effect. The UV-Vis spectrometer used to determine optical band gap of thin films.

Keywords : Al doped CdSe, optical band gap E_g, Grain size

Introduction

CdSe is II-IV n-type semiconductor and is taken into consideration as an essential material for the advance of different optoelectronic devices. It has inherent band energy of 1.74 eV that makes it an attractive materials for different applications consists of light emitting diodes, solar devices, photodectors and other optoelectronic gadgets.

A proficient manner to decrease the resistivity and to get better properties of semiconducting substance is to dope with an appropriate impurity such as copper, silver, aluminium and indium. The dopant has revealed to improve properties in number of host crystal lattices. The electronic and optical properties of semiconductors are strongly influence via the doping technique that provides the origin for tailoring the preferred carrier density and, therefore, the absorption, emission and transport characteristic as well.

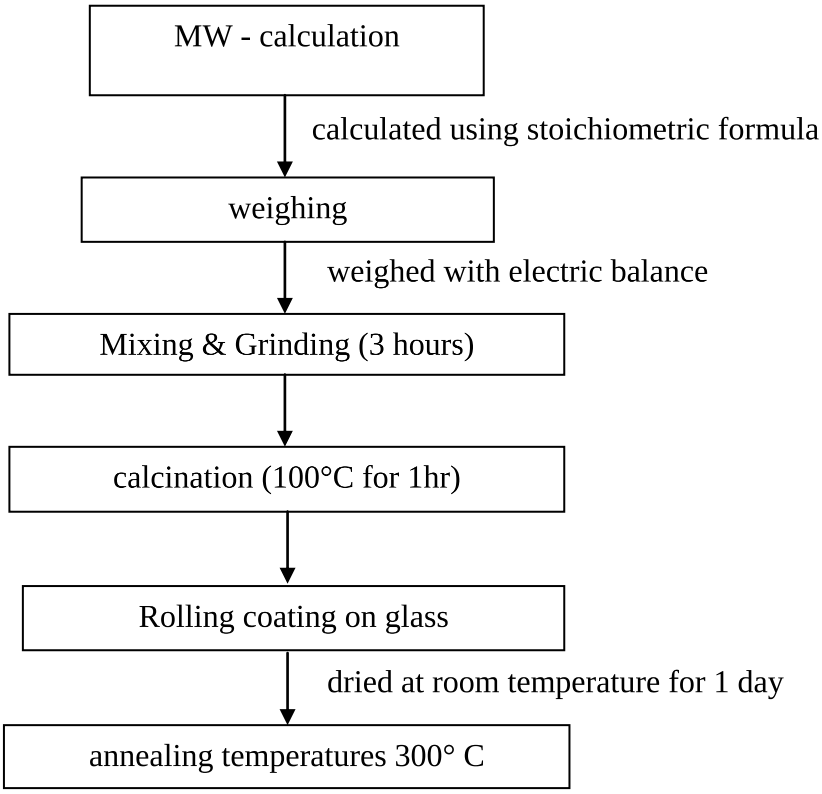
Optical and electrical characteristic of semiconducting films are necessary obligation for proper application in a variety of optoelectronic tools. These characteristic of such films are adequately structure responsive. Consequently, proper structural description of the films is essential. It can be well-known that the structural parameters which include crystal phase, crystallinity, grain size, lattice constant are strongly depending on the deposition situation. The structure of the films is possibly relies upon at the preparative parameters.[Chate P A,2016]

Experimental Details

Aluminum(10 mol%, 20 mol% & 30 mol %)doped CdSe were prepared by using rolling method. The row materials of CdSe and Aluminum were weighted by digital balance to get desire composition. The two powder were mixed with appropriate ratio. Appropriate proportions of highly pure (99.99%) CdSe and Al powders were ground separately by mean of an agate mortar and pestle. The specific weight from CdSe powder and 10%,20% and 30%from this weight of aluminum powder must be taken and put it into starting materials. To increase complete mixing, the mixtures were ground for at least three hours. The stirring speed was 500 rpm. After stirring, the mixing powder were heated at 100℃ for 1h for doping. After that,

[1] Dr, Lecturer, Department of Physics, University of Yangon
[2] Lecturer, Department of Physics, University of Yangon
[3] Associate Professor, Department of Physics, Mohnyin Degree College

2 methoxy ethanol ($CH_3OCH_2CH_2OH$) is added to the mixture and rolling on glass substrates. For deposition of the films, the glass substrate choosing is very important. Indium Tin Oxide glass (ITO) slides of dimension 1.5 cm x 1.5 cm with a sheet resistance of 18W are used. After the coating all the films were dried at room temperature for 1 day in order to diffuse the solvent. After that, the glass substrates were heated with the temperature 300°C for 1 h. Figure 1 shows that flow chart for sample preparation of Al doped CdSe thin films.



Results and Discussions

XRD Analysis of Al Doped CdSe Thin Films

Al doped CdSe thin films were characterized by using monochromatic Cu-$K_\alpha$radiation (λ= 1.54056Å) operated at 40 kV (tube voltage) and 30 mA (tube current). Specimen was scanned from 10º to 70º in diffraction angle, 2 θ with step-size of 0.02. The upper site of XRD spectrum was represented the observed profile while the lower site indicated the standard CdSe library file. The X-ray diffraction (XRD) spectra of pure CdSe as shown in figure 2.They can be form hexagonal structure. The upper site of XRD spectrum was represented the observed profile while the lower site indicated the standard CdSe of JCPDS library file. From figure 2, three peaks such as (100),(002)and (110) were performed on XRD profile of CdSe. All peaks were well matched with standard profile of JCPDS library file. The structure for pure CdSe were used for identification purpose.

The XRD pattern shows a large number of peaks indicating the polycrystalling character of the films. The examination of spectrum indicated that all the films have hexagonal structure in the whole range of composition studied. The cubic phase of CdSe has not been observed. Figrue 3 shows that the comparison between three XRD results for three different ratios of Al doped CdSe thin films.

The crystallite size of the particle can be calculated from the XRD peak broadening of the peaks using the Scherrer's formula.

$$g_{crystallite} = \frac{0.9\lambda}{D \cos \theta} \qquad \ldots\ldots\ldots(1)$$

where, ' s the size of the crystallites, 'λ' is the wavelength of the x-ray used, '*D*' is the full width at half maximum height and '*θ*'is the angle of diffraction. In this research, we used Cu K_{α} radiation in which λ = 1.54056 Å.The analysis of XRD patterns in terms the values of hkl ,lattice parameter, crystallite size, Dislocation Density, Microstrain of the Al (10%, 20%,30%) doped CdSe thin films have been done by considering hexagonal structure and is displayed in table 1. Figure 4 shows Crystallite size vs dislocation density plot for CdSe:Al(10%) thin film. Figure 5 shows Crystallite size vs dislocation density plot for CdSe:Al(20%) thin film at 300°C. Figure 6 shows Crystallite size vs dislocation density plot for CdSe:Al(30%) thin film at 300°C.

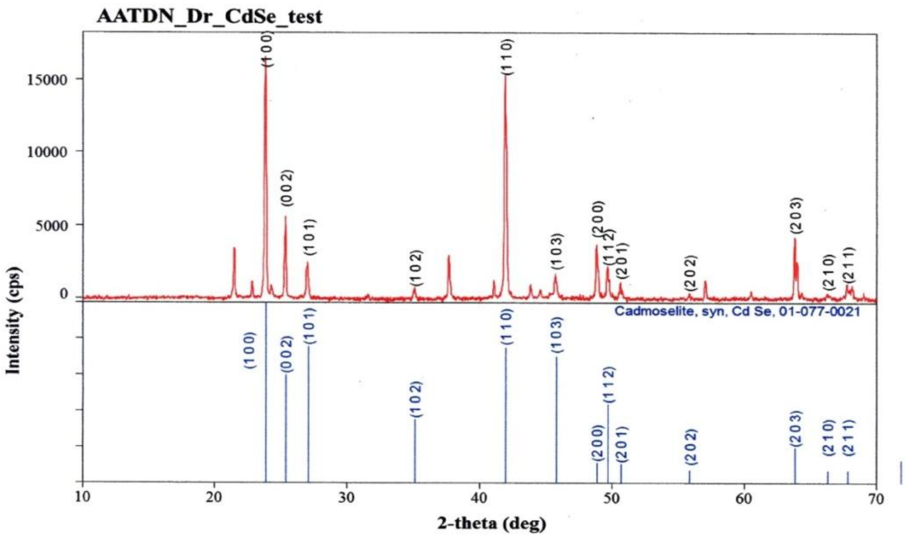


Figure 2 XRD spectrum of pure CdSe powder

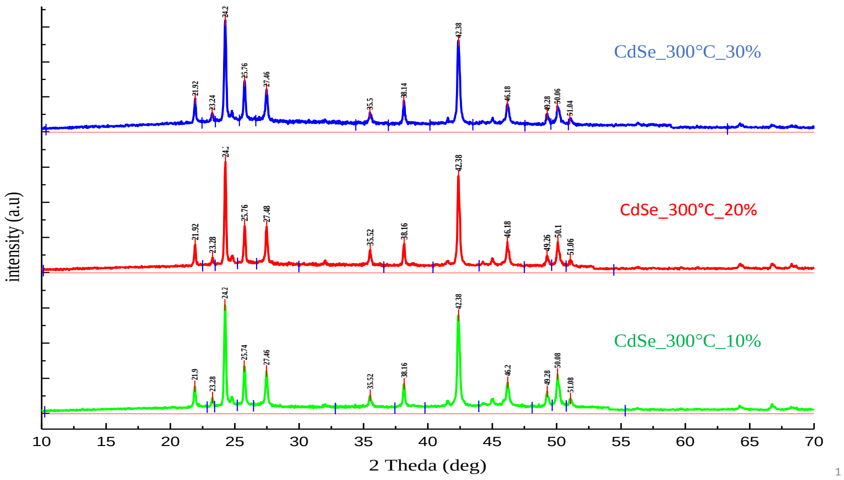


Figure 3 X-ray diffraction pattern of CdSe: Al(10%,20%,30%) thin film

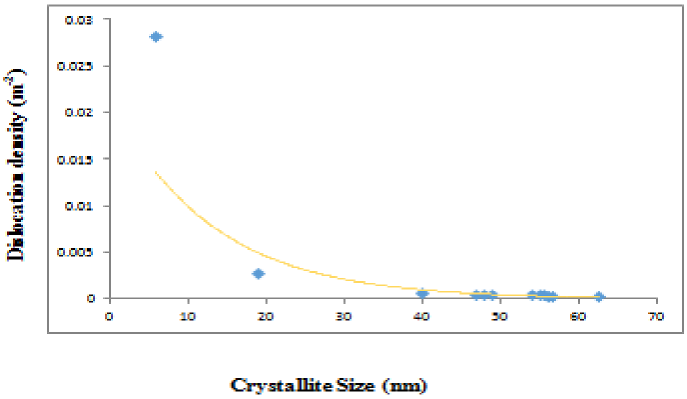


Figure 4 Crystallite size vs dislocation density plot for CdSe: Al(10%) thin film at 300°C

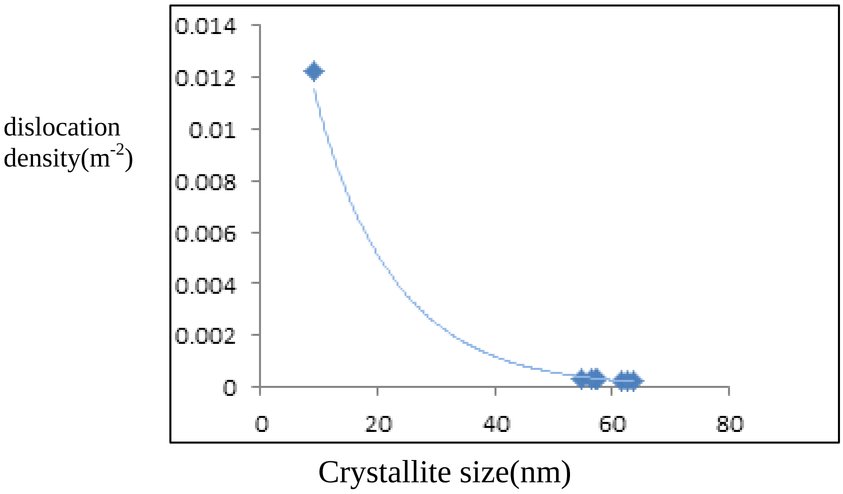


Figure 5 Crystallite size Vs dislocation density plot for CdSe:Al(20%) thin film at 300°C

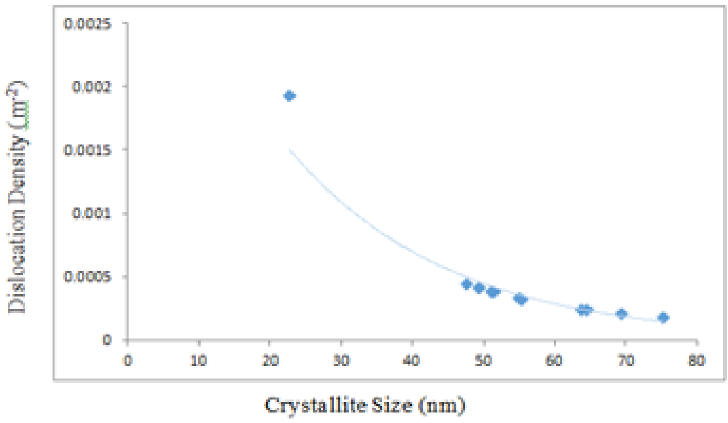


Figure 6 Crystallite Size Vs dislocation density plot for CdSe:Al(30%) thin film at 300°C

Table 1 The value of hkl, lattice parameter, crystallite size, disolcation density and microstrains of the Al doped CdSe thin films

Ddoping Conc (mol)	Plane (hkl)	lattice paremeter(A)	2-theta (deg)	FWHM (deg)	Crystallite size(nm)	Dislocation Density (m^{-2})x10^{14}	Microstrain (10^{-4})
10%	(100)	a = 4.2600	24.241	0.146	55.652	3.228	6.228
	(002)	c = 6.9402	25.74	0.13	62.683	2.545	5.529
	(110)		42.346	0.154	55.319	3.268	6.265
20%	(100)	a = 4.2590	24.259	0.136	57.108	3.066	5.79
	(002)	c = 6.9409	25.772	0.132	61.737	2.623	5.614
	(110)		42.367	0.136	62.645	2.548	5.533
30%	(100)	a = 4.2624	24.252	0.159	51.102	3.829	6.78
	(002)	c = 6.9398	25.739	0.126	64.672	2.39	5.359
	(110)		42.347	0.154	55.319	3.267	6.265

SEM Analysis of Al Doped CdSe Thin Films

The study of scanning electron micrographs, this can be shown that the presence of non homogeneous grains and having different sizes. Figure 7 (a),(b) and (c) shows that SEM image of Al (10%,20%,30%)doped CdSe with thin films at 300°C. The grain sizes are expressed with table 2.

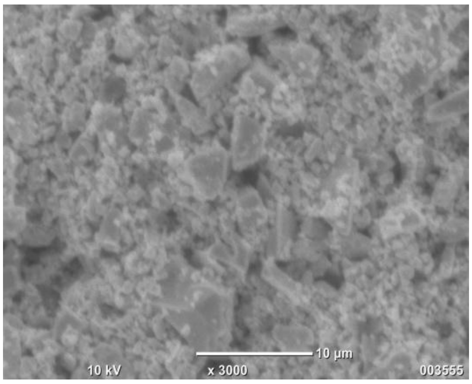


Figure7 (a) The SEM image of CdSe:Al(10%) thin film at 300°C

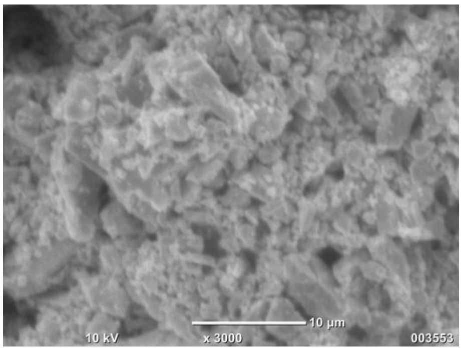


Figure7 (b) The SEM image of CdSe:Al(20%) thin film at 300°C

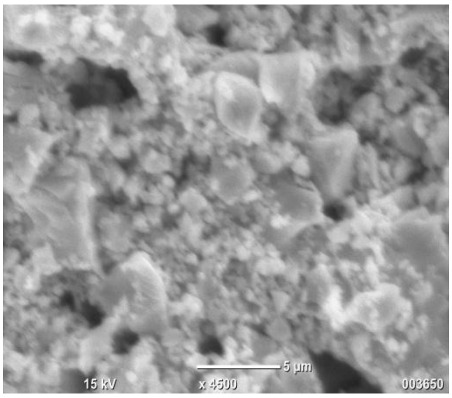


Figure7(c) The SEM image of CdSe:Al (30%) thin film at 300°C

Table 2 The value of grain size for Al doped CdSe thin films

Doping Conc (mol)	Grain Size (µm)
10%	3.2806
20%	3.0026
30%	1.8632

UV-Vis Analysis of Al Doped CdSe Thin Films

The optical absorption spectrum are measure by UV-Vis spectrometer as shown in figure 8(a),9(a) and 10(a). The plot of $(\alpha h\upsilon)^2$vshυ is shown in figure 8 (b),9(b),10(b). The value of band gap for three ratios of Al(10%,20% and 30%) doped CdSe thin film at 300°C are 1.0938 eV, 2.2062eV and 2.87 eV.

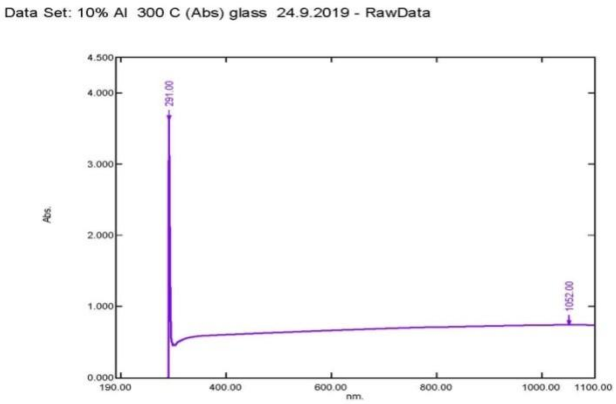


Figure 8(a) Optical absorption spectrum of Al(10%) doped CdSe thin film at 300°

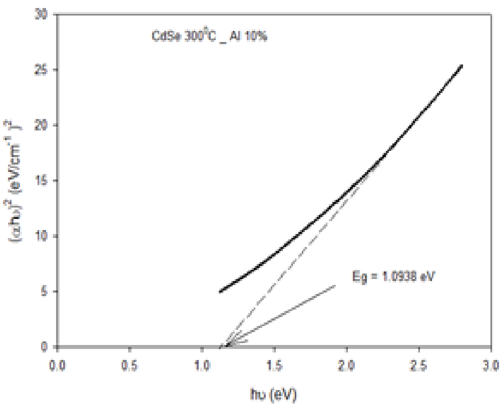


Figure 8 (b) Plot of α^2vshυ in curve of Al 10% doped CdSe thin film at 300°C

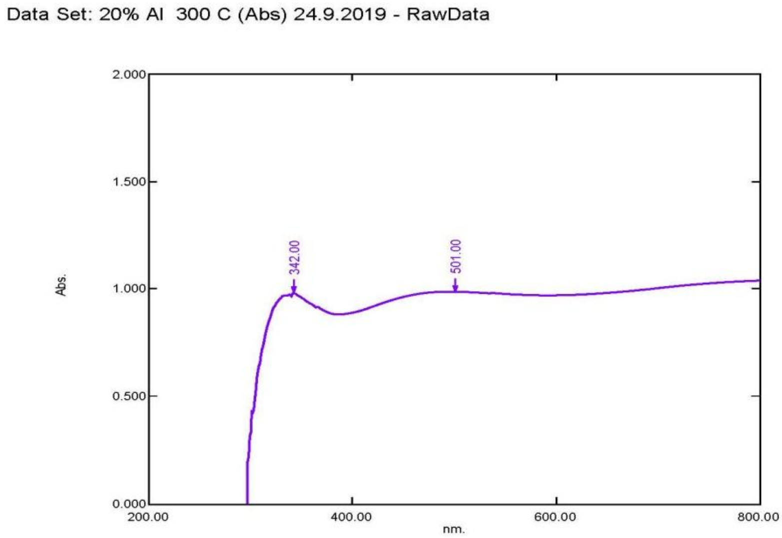


Figure 9(a) Optical absorption spectrum of Al(20%) doped CdSe thin film at 300°C

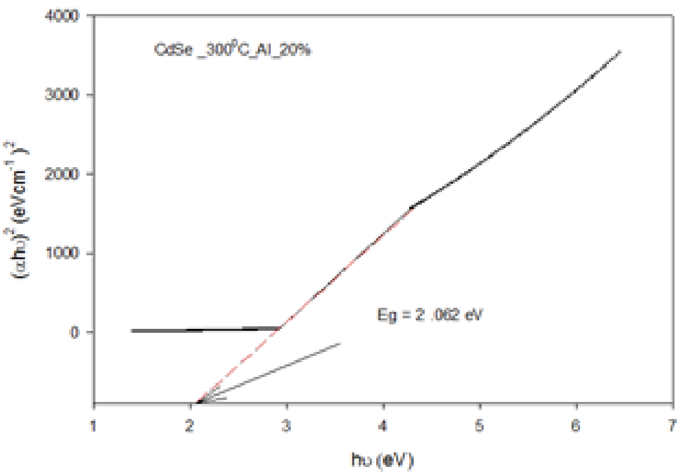


Figure 9 (b) Plot of α^2vshυ in curve of Al 20% doped CdSe thin film at 300°C

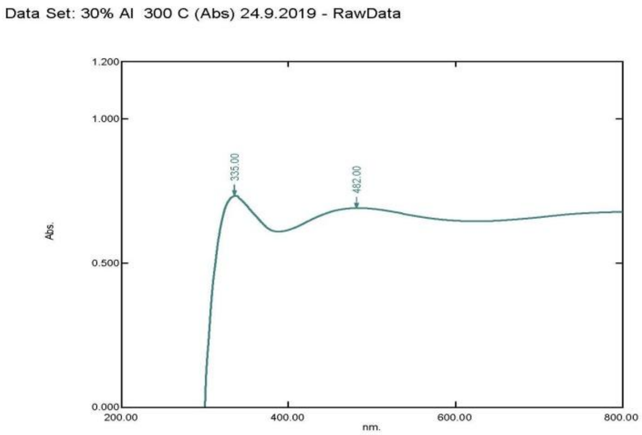


Figure 10(a) Optical absorption spectrum of Al(30%) doped CdSe thin film at 300°C

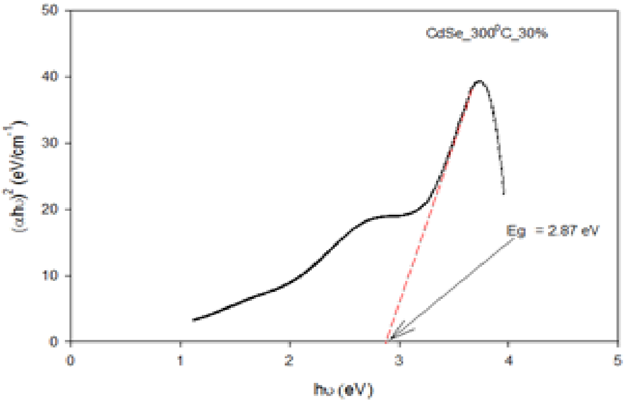


Figure 10 (b) Plot of α^2vshυ in curve of Al 30% doped CdSe thin film at 300°C

Conclusion

Aluminium doped CdSe thin films have been synthesized by using rolling method. The varying concentration of aluminium (10 %, 20 % & 30 %) was used. The structural studies was done using X-ray diffraction pattern. Polycrystalline character as well as a hexagonal structure having (100) plane as the preferred orientation was observed. The average grain size of three sample is found 2.715µm. The direct optical band gap of three samples are 1.903eV, 2.062 eV and 2.87eV. The study of these results shows that the Al doped CdSe thin films can be suitable for optoelectronic application.

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