AN 454

Element Determinations in Photovoltaic (PV) Grade CdTe/CdS Powders

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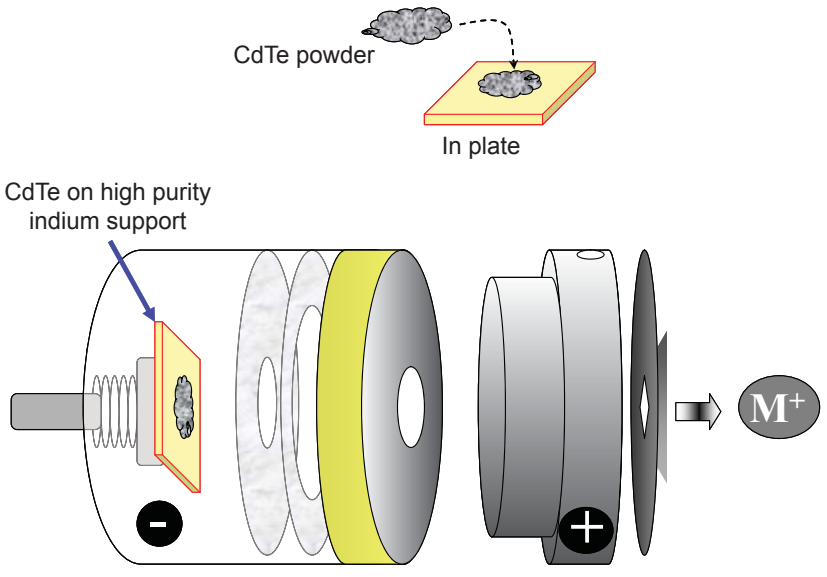
Introduction

Cadmium telluride (CdTe) has been shown to be one of the most promising polycrystalline materials for producing thin film PV solar cells (CdTe/CdS) because of its high absorption coefficient ($\alpha > 10^4$ cm^{-1}) and a band-gap of 1.5 eV, which is well matched to the solar spectrum. In addition, of the various commercial or near commercial thin film technologies, PV grade CdTe has a very favorable combination of performance, manufacturability, cost, and upside performance potential. Several elements, even in trace levels, are shown to have a major impact on the performance of the final devices. Historically, it has been seen that raw material batches from the same purity grade show differences in impurity level of critical elements. It is believed that these fluctuations in purity level are linked to observed differences in final device efficiencies and long-term performance.

Discussion

A number of analytical techniques can be used for trace element monitoring of PV grade CdTe/CdS materials. These include both wet chemical and direct solid sample introduction methods. However, accurate wet chemical analyses tend to require complex dissolution procedures that normally involve the use of combinations of concentrated acids prior to analysis, for instance by Inductively Coupled Plasma Optical Emission or Mass Spectrometry techniques (ICP-OES/MS). Wet chemical methods can be complicated, they also dilute the sample by several fold, and may result in the loss of some of the volatile analytes during the dissolution process.

High Resolution Glow-Discharge Mass Spectrometry (GDMS) based on reduced pressure GD ion source operating with flat-cell geometry is an ideally suited analytical technique for complete, precise and accurate element characterizations of powdered/particulate materials (Figure 1). The growing attention to GDMS for trace element characterizations of PV grade CdTe/CdS powders is mainly due to its ability to quantify almost all elements in solid samples with sensitivity down to the ultra-trace range (Table 1). Due to the technique's excellent reproducibility the quality of the raw materials can be easily monitored. Besides bulk element analyses, glow discharge is also an excellent method for depth profile measurements on the final deposited films.



VG9000 – Mega Flat Cell Assembly for
CdTe Powder Analysis

Figure 1. Glow-Discharge Cell Configuration for Analysis of CdTe/CdS Powders

	PV Grade CdTe (powder)		PV Grade CdS (powder)	
Element	Limits of Detection	Typical result	Limits of Detection	Typical result
	ppba	ppba	ppba	ppba
B	10	100	30	250
Na	5	850	15	500
Mg	5	200	3	180
Al	4	150	15	740
Si	20	3500	15	15000
S	20	1800	Major	Major
Ti	3	20	10	40
Fe	10	1200	5	1100
Ni	2	120	1	110
Cu	2	75	1	70
Zn	10	60	550	< 550
Se	150	1200	10	25
Pb	3	12	1	60

Table 1. Typical Mass Fractions of Selected Elements in CdTe/CdS PV Grade Raw Materials