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# The effect of etchants on surface of CdTe single crystal

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## Abstract

Cadmium telluride crystals (CdTe) have been grown by the sublimation method. The crystal polarity of the CdTe with the zincblend structure has been studied. Two different crystallographic defect and etch pits are revealed on the (111) Cd and $(\bar{1}\bar{1}\bar{1})$ Te surfaces by different etchant.

## Indexing terms/Keywords

Cadmium telluride, Polarity, etch pits, single crystal

## Introduction

Among the II-VI compounds, cadmium telluride found to be of considerable interest because of its potential applications in a large variety of devices. Cadmium telluride is a promising semiconductor material for nuclear radiation detectors, electrooptic modulators, for use a substrate to HgCdTe photodiodes [1-2]. CdTe is highly photosensitive to infrared, visible and X-ray radiations, it may be used as photosensitive devices such as infrared telescope image intensifiers, camera tubes, photoelectric cells, X-ray dosimeters and like. Pure homogeneous crystals with carefully controlled composition are needed to meet the requirements of these devices. Cadmium telluride has a large band gap, relatively high mobilities, a large transmission range (1-30 µm), a very low optical absorption coefficient and large photoelectric coefficient [3-6]. CdTe has a zincblend structure, which belongs to the cubic noncentro-symmetric space group $(F\bar{4}3m)$. This structure is the alternation of the same as that of diamond except for the alternation of the two different elements (Cadmium and tellurium) on successive lattice sites. Generally, CdTe crystals have been grown by the melt, solution, and vapor growth techniques [7,8]. The CdTe crystal with the zincblend structure exhibits a polarity along the (111) directions. The (111) surfaces terminating with Cd atoms (A surfaces) and the opposite$(\bar{1}\bar{1}\bar{1})$ surfaces terminating with Te atoms (B surfaces) show marked differences in their response to chemical etching. In this paper, CdTe single crystals were grown and the optical measurements were carried out to characterize the material.

## Experimental procedure

The growth of cadmium telluride single crystal from the vapor phase, by sublimation of a polycrystalline charge in open tubes and subsequent recrystallization in a zone of lower temperature have been done. The experimental equipment used to grow CdTe crystals is shown in Fig. 1 which consists of a tube of transparent guartz, 2.5 Cm in inner diameter and 1 m in length is placed in a kanthal furnace whose temperature can be kept constant by a proportional controller.

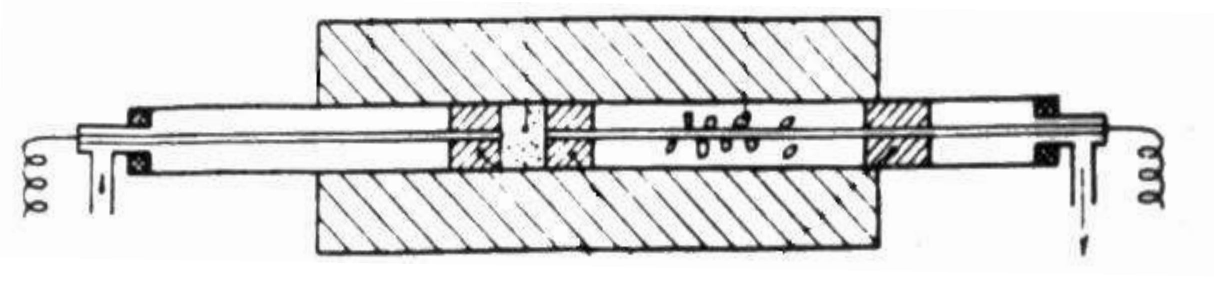

**Fig. 1 The experimental equipment used to grow CdTe crystals**

By a thermocouple the temperature of the furnace has been controlled. A crystallization chamber is formed in the reaction tube and the polycrystalline charge is packed between two plugs of quartz wool.

Argon or helium is passed through the reaction tube and the crystals grow the inner wall of the tube. The growth time for CdTe crystals are in the range of 16-20 h. The flow rate of the gas is in the range 90-150 $^{ml}/_{min}$ .

## Results and Discussion

CdTe crystals were grown in a closed quartz tube by the sublimation method at 900 $^{o}$C. The CdTe crystal exhibits crystal Polarity along the (111) directions. Fig. 2 is a schematic drawing of an atomic configuration in the (111) plane.

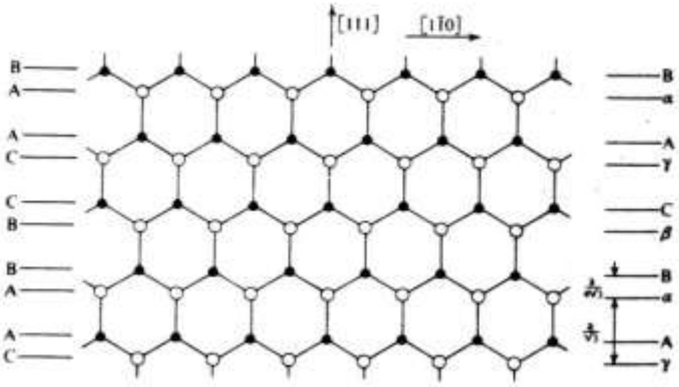


**Fig. 2 A schematic drawing of an atomic configuration in the (111) plane**

The (111) surfaces terminating with Cd atoms (A surfaces) and the opposite $(\bar{1}\bar{1}\bar{1})$ surfaces terminating with Te atoms (B surfaces) show marked differences in their response to chemical etching. It has been observed that the surface morphology of the epitaxial layers depends upon whether the (111) Cd or $(\bar{1}\bar{1}\bar{1})$ Te surface has been used. Thus it is essential to identify the (111) Cd and $(\bar{1}\bar{1}\bar{1})$ Te surfaces and also find out the polarity of each surfaces. Among the large variety of techniques known for characterizing the crystal quality, preferential chemical etching is the simplest and most versatile.

The specimens were chemically polished for about 2 min in the E [H2O (10 cm3) : HNO3 (5cm3) : K2Cr2O7 (2 g)] reagent to remove lapping damage. A variety of etchants have been used to etching but the four most commonly known etchants are EAg1, EAg2, E and B. Table 1 shows the effect of etchants on Te and Cd surface.

**Table 1. the effect of etchants on Te and Cd surface**

| Etchant | Composition | Effect on Te surface | Effect on Te surface |
|---|---|---|---|
| E | $H_2O, HNO_3 K_2Cr_2O_7$ | Polish the surface | Polish the surface |
| B | $HF, H_2O_2, H_2O$ | Two kind of etch pits | Polish the surface |
| EAg1 | $E, AgNO_3$ | Flat-bottomed triangular etch pits | Deep triangular etch pits |
| EAg2 | $E, AgNO_3$ | Flat-bottomed triangular etch pits | Deep triangular etch pits |

For observation of A and B surfaces of CdTe single crystal a X-ray beam was incident normally on the CdTe surface. Fig. 3 shows the optical micrograph of etch pits which were developed on the $(111)_A$ surface.

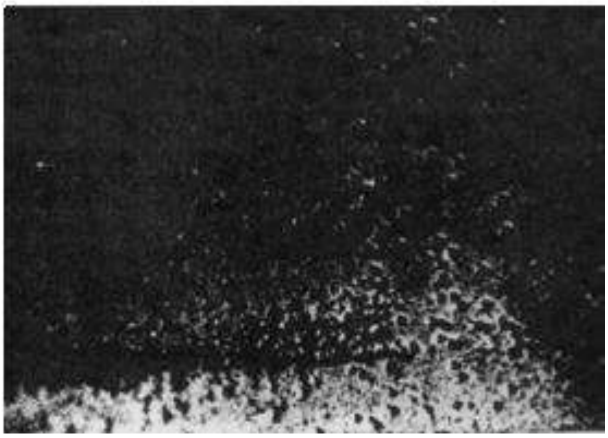

**Fig. 3 The optical micrograph of etch pits on the (111)A surface**

An optical micrograph of etch pits on the opposite surface that is $(\bar{1}\bar{1}\bar{1})_B$ surface is shown in Fig. 4.

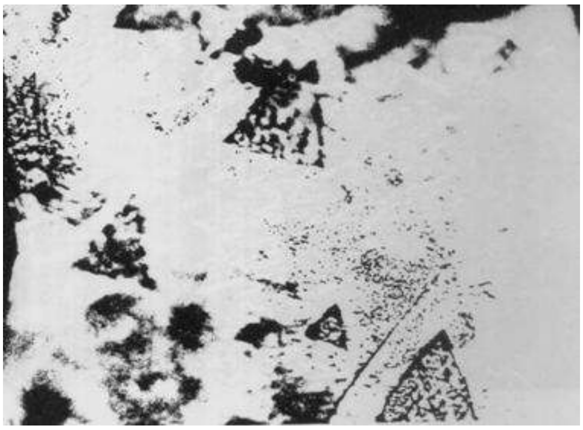

**Fig. 4 The optical micrograph of etch pits on the (111)B surface**

Flat-bottomed triangular etch pits were observed on the $(\bar{1}\bar{1}\bar{1})$ surface and the etch pits on the A surface are deeper than those on the B surface. That is Cd surface is easily etched compared with the Te surface.

## Conclusion

Two different kinds of dislocations are present in the CdTe structure, One terminating in Cd atoms and the other terminating in Te atoms. Thus two types etch pits are revealed on the (111) Cd and $(\bar{1}\bar{1}\bar{1})$ Te surfaces by different etchant. Flat-bottomed triangular etch pits were observed on the $(\bar{1}\bar{1}\bar{1})$ surface and the etch pits on the A surface are deeper than those on the B surface.

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