# Cd 溶媒を用いた THM 法による V 族元素ドープ CdTe 単結晶成長と評価

## Growth and characterization of group-V doped CdTe single crystals by Cd-solvent THM

ユタ大材料工 [1]，宮崎大工 [2]，京大院工 [3]，学振海外特別研究員 [4]

○永岡　章 [1,4]，Kyu-Bun Han[1], Sudhajit Misra[1], Thomas Wilenski[1]，吉野 賢二 [2]，

野瀬　嘉太郎 [3], Michael Scarpulla[1]

Univ. of Utah [1], Miyazaki Univ. [2], Kyoto Univ. [3], JSPS Postdoctoral Fellow for Research Abroad[4]

°A. Nagaoka[1,4], K. B. Han[1], S. Misra[1], T. Wilenski[1], K. Yoshino[2], Y. Nose[3], M. Scarpulla[1]

E-mail: nagaoka@eng.utah.edu

**Introduction**

Cadmium telluride (CdTe) has been well demonstrated as one of the promising photovoltaic material for solar cells because of its near-optimum bandgap of 1.5 eV and its high absorption coefficient, and is the only II-VI group semiconductor that can be relatively easily doped both p and n type conductivity. Recently, power conversion efficiency >22 % was reported for polycrystalline CdTe cells, but further improvements rely on increasing p-type doping while maintaining long minority carrier lifetime[1)]. CdTe solar cells using P-doped bulk crystals as the absorber layer and exhibiting open-circuit voltage ($V_{OC}$) >1 V has been reported [3)]. Combined experimental and theoretical studies indicate that Cd-rich conditions are needed to achieve long carrier lifetime >10 ns by suppressing Te on Cd antisites[2)], but typical bulk crystal growth is carried out either stoichiometriclaly or in Te solvent.　For these reasons, it is important to fundamentally understand bulk group-V doping in CdTe under Cd-rich conditions.

**Experimental procedure**

Group-V doped CdTe single crystals were grown by traveling heater method (THM) using Cd solvent and dopants such as $Cd_3As_2$.The structural, compositional and electrical properties were determined by powder X-ray diffraction (XRD), Energy Dispersive X-ray spectroscopy (EDX), Hall effect and capacitance-voltage (CV) measurements.

**Results and Discussion**

One of our goals in THM growth of CdTe using Cd solvent is to obtain Cd-rich composition single crystal and decrease growth temperature. Because of the high Cd vapor pressure, the ampoule loaded CdTe feed polycrystalline and Cd solvent was kept at 650℃ for 24 hours to be stable as (Liquid + CdTe) phase and prevent explosion before heating up to growth temperature. Cd-rich CdTe single crystals can be obtained at growth temperature of 950 ˚C and a growth speed of 4-5 mm/day. Figure 1 shows a CdTe ingot which was stopped in the middle of growth and exhibits a well-defined Cd solvent zone.

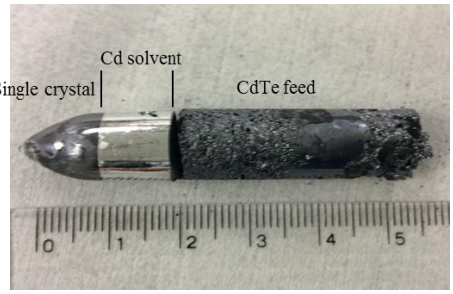


Fig. 1 CdTe ingot by using Cd solvent

1) M. A. Green *et al.*, Prog. Photovoltaics **24**, 3 (2016). 2) J. Ma *et al.*, Phys. Rev. Lett. **111**, 067402 (2013).
3) J. M. Burst *et al.*, Nature Energy doi:10.1038/nenergy.2016.15 (2016).