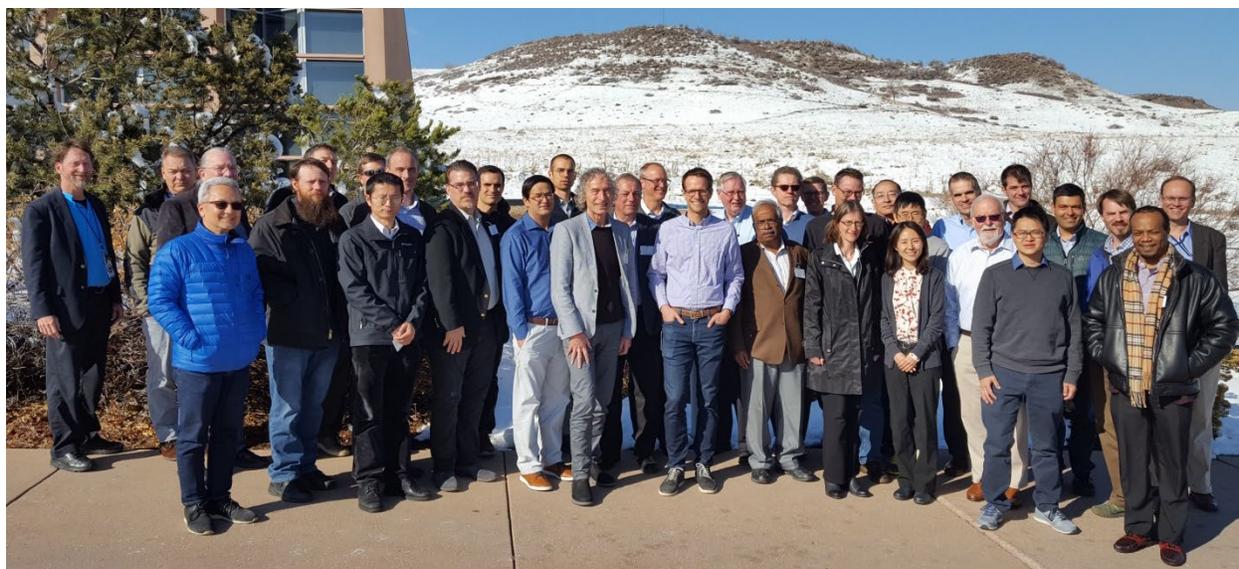


2019 CdTe Device Workshop NREL Education Center, October 24/25, 2019

The third annual two-day CdTe Device Workshop was hosted this year by NREL with organizational support from First Solar and Colorado State University. Its primary focus was to foster collaboration within the CdTe community to achieve 25% efficiency with polycrystalline cells. The first day had 24 presentations on CdTe cell results from the past year. The second morning included four breakout sessions designed to critically evaluate research priorities, community effectiveness, and future vision. It was followed by a session to organize the Workshop participants and others into five working groups to focus on different aspects of CdTe research throughout the year.

This year's Workshop was again by invitation following a request for suggested participants. As in past years, there were slightly over 30 attendees, which has seemed an appropriate size for productive interactions. Besides the organizing institutions, there were participants from the University of Toledo, Reel Solar, the University of Utah, Arizona State University, Colorado School of Mines, the University of Illinois at Chicago, Washington State University, Texas State University, Swansea University, Loughborough University, and the U.S. Department of Energy.



Day 1: Presentations

The presenters, one to three from each organization, were asked to focus on recent CdTe device results that most would not have heard before. The presentations were grouped into sessions on absorbers, interfaces, advanced characterization, and the overall challenge to achieve 25% efficiency. Each presenter had twelve minutes with three for discussion. There was no confidentiality requirement, and there was a clear flavor of openness among the participants. Slides from the presentations were not distributed by the Workshop, but have generally been available through individual requests.

Day 2: Breakout Brainstorming

The second day began with polls using clickers to assess the views of the participants on several questions related to the health of the CdTe research community, which in some cases led to lively

discussion. For much of the day, however, the Workshop divided into four smaller groups to brainstorm the following topics and report later in the day when the larger group reconvened.

- **Efficiency Limitations.** There was a clear consensus that the 25% efficiency goal is both appropriate and achievable in the relatively near term. Several recent developments including higher carrier concentrations with group-V doping and verification of high absorber lifetimes have been very promising, but have not yet translated into higher cell voltages. Two challenges are integrating the successes to date into complete high-efficiency cells and the long-term issue of contacting p-type CdTe. There is also work to be done to make more effective use of materials characterization and fundamental theory, which have been increasingly sophisticated, but are a challenge to relate directly to cell performance.

- **Community Collaboration.** Several ideas for more effective collaboration within the CdTe community emerged. Most important, following the lead of NREL's national teams from several years ago, is the maintenance of the annual Workshops and the initiation of the working groups described below. Another key recommendation is that we make more effective use of fabrication and measurement facilities currently in place at various laboratories have, and that going forward, we make shared facilities a larger part of the planning process for CdTe research and PV generally.

- **Critical Mass.** There is concern that funding for CdTe research, and hence the number of researchers, is relatively small compared to the current CdTe role and its potential in U.S. manufacturing. It is recognized that PV research funding in general has been limited compared to its importance and that all involved have a responsibility for broad communication of the importance of PV. It also appears to the participants that greater coordination among funding sources could have a positive effect similar to greater coordination among researchers.

- **15-Year Vision.** The vision for cell-level development of current structures includes further reduction of interfacial defects, incorporation of more effective band offsets, and success with a more complete device model that incorporates an expanded set of experimental probes. The broader vision beyond current structures includes additional alloys, tandem cells, thinner absorbers, possible lift-off strategies, and greater awareness of the LCOE and stability advantages of the CdTe technology.

Working Groups

Building on the strong consensus that additional structured communication within the CdTe research community is needed, five working groups have been established:

(1) Front contacts (2) Absorbers (3) Back contacts (4) Characterization (5) Future focus

Each working group is charged to have a monthly phone discussion, and at least in some cases, initiate additional collaborative work. Most of the Workshop participants have committed to one of these groups, and there is an open invitation for others to join. Five leads have been designated, and they will join overall coordinators Gang Xiong and Randy Ellison for quarterly assessments of the working-groups' progress.

Next Workshop. The CdTe Workshop for 2020 is being planned for late September in California with First Solar as the primary host. In the meantime, as described above, the five working groups will hold monthly discussions and expand their collaborative work on CdTe research.

Thanks. The Workshop success was due to a true team effort by many of the participants, but special thanks go to Wyatt Metzger for facilitating the physical arrangements, and to NREL, First Solar, and Colorado State for providing the lunches, dinners, and refreshment breaks.

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