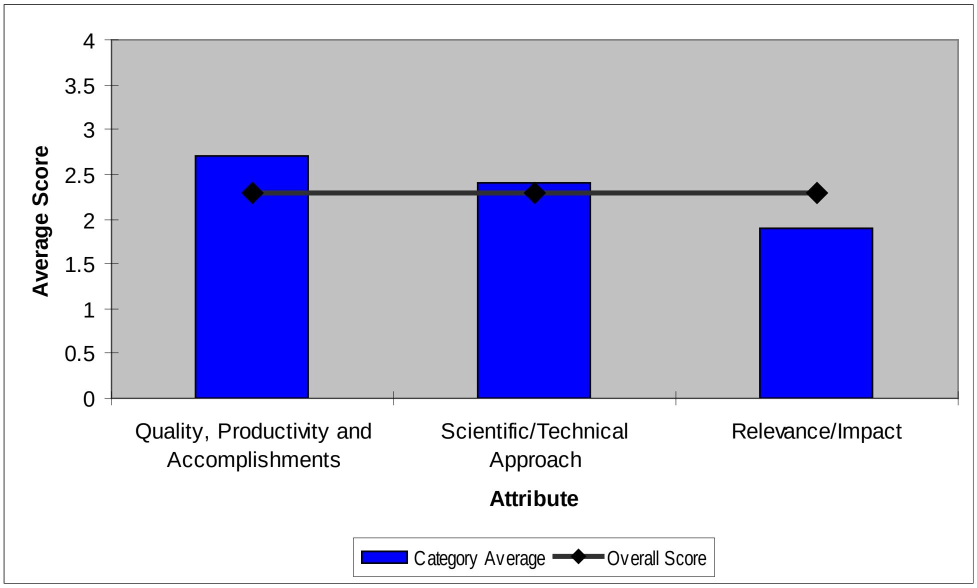
Nanocrystal Solar Cells

Principal Investigator: ***Matthew Beard, National Renewable Energy Laboratory***



Quality, Productivity and Accomplishments (Average Rating 2.7)

Rating	Comments
2.0	This group continues to explore the MEG phenomenon and is well-qualified. Overall, it is frustrating to still have no proof that multiple excitons can be collected after more than 10 years of discussion and many papers and researchers funded on the topic. They have three publications from this project, and expertise in methodologies for characterizing MEG, optical modeling, cell fabrication and characterization. Executed a CRADA for nanocrystals. BES-supported work on basic science of nanocrystals is leveraged.
3.0	[none]
2.5	The NREL team is very strong and takes advantage of local resources. The leverage provided by similar funding in Basic Energy Science. The productivity in BES was notable. For EERE, high photocurrents were observed in colloidal semiconductor thin films. If the technical target is to observe photocurrent quantum yields greater than one, the research has missed the mark.
3.0	Project has shown good progress towards proposal goals. Team is well balanced and has the required expertise. Current progress involved developing processes for deposition, modeling optical properties, and showing MEG evidence.
3.0	Project is based on interactions at NREL – some academic interaction. Has some funding from BES looking at this work. Project to date published in Nano Lett for different portions of research.

Scientific/Technical Approach (Average Rating 2.4)

Rating	Comments
2.0	Would have liked to see a systematic device design for multiple exciton generation and

collection, and consider various possibilities. PI expressed that the design they are pursuing may be wrong approach—this is frustrating.

2.0 Avoid branching into new NC geometries (rods, wires, heterostructures, etc.) until there have more clarity around what is currently used. The surface treatments are difficult to understand, particularly under illumination. More than the spacing is changing as the ligands change (% coverage, functional moiety, surface states, surface chemistry) and removing the ligands through full sintering may offer greater understanding of the system. The team should include a surface chemist to help define the effects of the ligands on your materials and devices. This is a good idea, but there is a significant amount of complexity to the chemistry, processing and device geometry. In order to make significant progress overcoming key technical barriers, the level of complexity needs to be reduced.

2.0 The scientific approach was strong, particularly when MEG was first reported. However, the observation of MEG is now 5 years old and there is not yet any evidence that the "extra" carriers can be collected. The approach here resulted in high photocurrent densities but low Voc and ff. The PI acknowledged that the current architecture was inappropriate. The overall stability of these solar cells is poor. Future research will examine additional junctions.

3.0 Overall, technical approach of project is good. The proposed approach should provide enough evidence to determine usefulness of MEG in devices. Clearly outlined next steps. Demonstration of MEG in individual dots only good for evaluating QD quality but otherwise just repeating already well-established results. While films show reasonable efficiencies, not clear how efficiencies can be improved. Not clear concept on how to improve electron and hole collection. Project needs to focus on high priority issues like demonstration of MEG in devices.

3.0 Main goal is to show that they can collect MEG-enhanced photocurrent in air stable device. Need to develop a further understanding of doping and transport. Can produce high photocurrents in their cells but the devices are not air stable. Wants to start looking at rods instead of spheres – synthesis of nanorods and how this relates to cost? Need to develop new chemical treatments of the surface.

Relevance/Impact (Average Rating 1.9)

Reviewer Rating Comments

2.0 Reason to use nanocrystals (NCs) is their excellent crystallinity / low defect populations to ideally improve charge collection, and to leverage quantum confinement and expectation of multiple excitons that may be harvested in the blue-UV spectral region. Cells based on the materials show very high photocurrents (10 mA/cm2) and low voltages (~200mV). Main goal is to exhibit IQE of >100%. PI suggests that other pathways, such as a Gratzel cell or OPV configuration, may be more successful in demonstrating multiexciton collection.

2.0 I would rate this project as Fair, not because the rate of accomplishments is slow, but because the useful information that could contribute to the development of solar energy technologies is buried beneath layers of complexity. Rather than produce device after device (requiring understanding of multiple interfaces, optical effects, electronic effects, chemistry, etc.), the investigators should take a step back and reduce the scope of this project.

1.5 This research is a far way from practical applications. The more basic research is funded by BES. Organizing materials capable of MEG into solar cells moves the research away from BES to those more suitable for EERE/practical type applications. The observation of high photocurrents was a promising first step in this regard.

2.0 Could provide important advance in high efficiency PV cells. Not clear if the two most challenging topics can be resolved. Path to success is not clear. Too early to determine success of approach.

2.0 Impact is ok – still significant problems to overcome with respect to MEG, air stability, and the surface chemistry. I would like to see a more systematic examination of different types of surface ligands and the effect of linking chemistry on the performance. It would also be useful to examine the possible application of polymers in these systems, particularly the ability of polymers to prepare nanoparticles in close proximity to each other. There still seems to be some issues regarding how the current problems will be addressed and the way forward to produce better devices. Not sure I see an organized plan to address these issues.

Overall (Average Rating 2.3)

Rating	Comments
2.0	MEG harvesting has not yet been demonstrated. May be pursuing wrong device configuration.
2.0	I would suggest focusing attention on separating the effects of changing surface chemistries on the effects of NC spacing and avoid complicating the problem by adding in new syntheses or working on the air stability.
1.5	This is a case where the cart is ahead of the horse. MEG has been observed spectroscopically in the laboratory, but there is no evidence that the excess carriers can be abstracted. Can one measure photocurrents greater than unity in a quantum dot/colloidal semiconductor solar cell? If so, research directed toward optimization is well justified. If not, the research would be of possible academic interest only. In other words, without such a preliminary research result, the likelihood for significant impact of this research is very small and the continuation of the research should be carefully re-evaluated by the DOE. A preliminary result showing that this approach is valid is needed to justify this research program. The obvious ideas for such a demonstration have been tried. There appear to be no more directed ideas and the continued search for new materials and/or surface functionalization is somewhat of a fishing expedition.
3.0	[none]
3.0	Overall this is a good project that addresses a very interesting issue. As discussed above, the main concern I have with this project are the significant problems that have yet to be overcome with respect to demonstrating MEG. The investigators should have a more systematic focus on the surface chemistry of their systems and the effect these ligands have on device performance. This is a very important issue not only for their systems but for the community as a whole. The use of alternative nanostructures in their systems is interesting but needed to be explained in more detail to enable the reviewers to fully understand the impact these alternative structures may have.