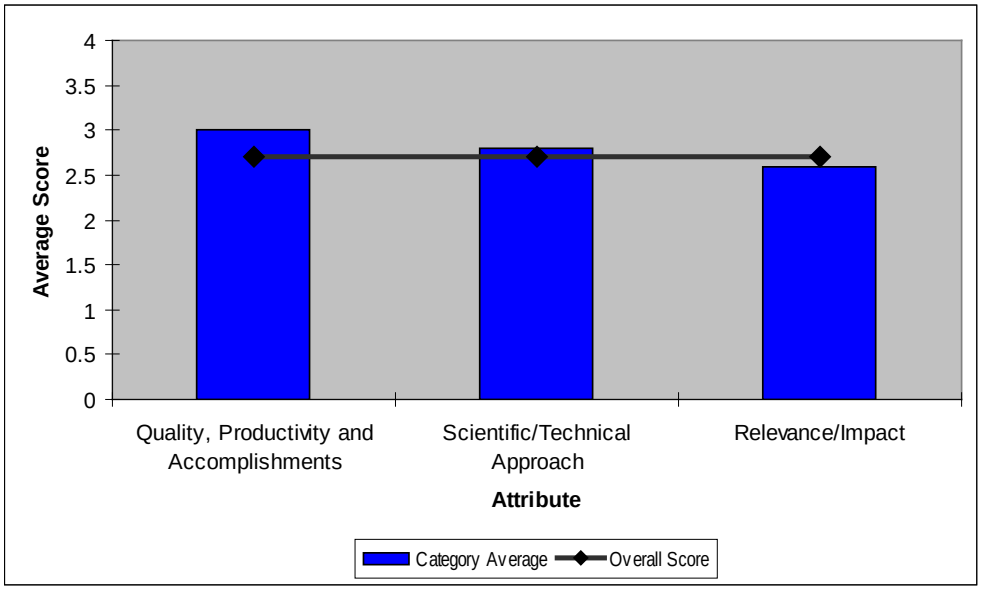
Hybrid Organic-Inorganic Photovoltaics

Principal Investigator: ***Jiangeng Xue, University of Florida***



Quality, Productivity and Accomplishments (Average Rating 3.0)

Rating	Comments
3.0	Given their backgrounds in Materials science and synthetic chemistry, they are doing well. Their device background is either weak or not fully applied. They need to correlate their material parameters to expected (at least estimate) device performance (via known and expanded models). Device aspects are either too weak or too preliminary to be judged. Their inorganic synthesis techniques are strong.
3.0	The stated objectives of this program are consistent with the Exploratory Research goals of SETP, targeting performance increases beyond the short term 5-7% efficiencies and also focusing on developing a fundamental level understanding of polymer/inorganic composites. Research efforts within the period of performance initiated synthesis and characterization of prototype components for the inorganic/polymer composition system, and methods to modify the interactions between the polymers and the inorganic inclusions. During this time, research efforts from the research group resulted in a number of open literature publications and presentations. Qualifications of Research Team and Resources: Prof. Xue has assembled a high quality research team well-qualified for the proposed tasks with a demonstrated record of achievement in the areas of technology. The resources available to the research team are appropriate to task.
2.5	Criterion (a) rates a 3 but criterion (b) rates a 2 at best. Xue, Reynolds and Holloway represent a good team balanced between chemistry and device engineering expertise. The results thus far, however, do not seem significantly better than what others have obtained (e.g. Alivisatos et al. at Berkeley). One particular graph does not bode well for the dispersity of nanoparticles that can be grown and their subsequent impact on device performance.
3.3	A new approach to an old idea. These devices topped out at ca. 3% a few years ago, this team

hopes to bring them farther along – Xue is a good choice to lead such an effort.

3.0 Lots of synthesis to start project off. Device characterization not so strong at this stage.

Scientific/Technical Approach (Average Rating 2.8)

Rating	Comments
2.0	This does not go very far beyond what Alivasatos has done with similar materials. The materials utilization vs CdTe should be compared and justified vs. efficiency and cost expectations. This project's efficiencies are around 2%. Not much different than what can be found in the literature. Not outside the box compared with extensive international efforts. Stability is still in question. Proprietary process was mentioned but was not described in enough detail. Unclear where charge carriers are generated. Unclear if polymer is unstable. Unclear if a selective contact is required. One should carefully compare and contrast this work with what is being done in the similar project by D. Ginley of NREL (another SETP funded project).
2.8	While the general research plan and approach are well thought-out and logical, specific details of the research direction should be addressed to be able to address the long term goals of the SETP initiative. The identification and development of the system used is an interesting choice for the inorganic component; could make scaling up bench level prototypes problematic. These variabilities would introduce a degree of heterogeneity in the electronic properties of the polymer/inorganic composite. A second question on the heterogeneity issue comes from the size dispersion of the nanospheres. Third, certain polymers tend to be unstable in air, and it is assumed that the PI is either using one of these materials as a model system or an unspecified protective system is under consideration. The PIs should be particularly careful about the ordering effects in their polymer/inorganic composites. Even at this limited aspect ratio, there appears to be a potential efficiency increase associated with ordering of the nanorods.
2.0	Two aspects of the proposed work are interesting. However, some of its aspects are similar to previous work, and that work leaves me unable to be entirely convinced that alignment and bandgap engineering will improve these devices to the point where they are competitive with other technologies. I am also uncertain that the geometries proposed for higher efficiency devices can be achieved in a polymer system (where damage to underlying layers as higher layers are deposited is a problem). The target for optimized devices in 2015 is about 18% (admittedly outside the scope of this project but I see no clear link as to how they will get there from here and the number seems somewhat divorced from reality). The size distribution graph on slide 20 shows a very broad distribution apparently inconsistent with the label . This is confusing and raises the concern that any significant size variation in the quantum dots will lead to larger dots acting as lower energy traps for both excitons and charge carriers. Perhaps this explains some of the results?
4.0	Very broad approach to this problem. Nice combination of project attributes. Very comprehensive. I HOPE this works!! My concern is that a lot of people have already given up on certain aspects included here. Will this effort be any different?
3.0	This project aims at same objective of at least 30 previous studies by multiple groups .It would be nice to demonstrate alignment of nanorods, or at least a calculation showing that electric field-induced alignment is possible. In fact, this section needs many more details: how will the nanorods be attached to substrate? Also, what is the aspect ratio required to make this work?

Relevance/Impact (Average Rating 2.6)

Rating	Comments
2.0	Next, they need to clearly demonstrate oriented CdSe materials (as tasked) or higher efficiencies. They should be able to do this in the next 6 – 9 months. Understanding other success and prior work ultimately won't put our researchers and companies ahead – there is not a clear strategy for catching up and then surpassing. There is too much work that is reaffirming known barriers, without having a clear path to overcoming them. Note to project/program manager: one needs uniformity in reporting of results. If certain results are reported, they need to be done under standard conditions. A common set of material parameters is relevant to all exploratory projects. This includes mu, tau, L, eta, IPCE, eqe, lifetime/stability). Some attempts should be made in some projects to estimate these parameters and use known, or modified models, to estimate efficiency and performance. This is a badly needed framework that is lacking in the program, but does have established anchor points in the literature.
2.2	It is too early to provide a definitive assessment of the future impact and relevance of the technology under development. As detailed in Section 2, there are a number of technical issues yet to be resolved, and care will be needed to prioritize technical needs against available resources. At this point, it is unclear what the practical upper limit of efficiency that would be obtainable for this technology.
2.0	The PIs should better differentiate their work from preceding efforts at Berkeley and clarify how they will succeed in making high efficiency devices where other efforts have, apparently, gone nowhere.
4.0	IF these investigators can pull off truly vectorial charge transport in these nanorods, they will have achieved a great deal. Not clear from the presentation how exactly this will be accomplished. Especially nanorods which span the full thickness of the device layers. Very challenging, but the type of thing this initiative should support. Be more aggressive!! Be ready for next DOE review.
3.0	This ground has been trod by many others previously. What is different about this approach relative to Alivasatos, for example? Also, taking the big picture, why should we use the proposed nanorods rather than bulk films of the same material? Nanorod interfaces will only worsen charge transport. Can we really expect the nanorods to be much cheaper (materials and fabrication costs)? Some discussion in terms of the published CdTe cost model (Zweibel, et al.) would be instructive.

Overall (Average Rating 2.7)

Rating	Comments
2.0	They mentioned a proprietary process for stable material. Need more info and details on that. Needs to model performance and materials parameters. Next - Clarify need for selective contact and establish/state stability. Need to perform work in context of a general/generic cost structure to drive selection of materials.
2.8	This program is a mixture of research directions . Initial efficiencies and mobilities are promising, but still are just competitive with other current technologies. One of the larger difficulties for this program is the relative lack of relevant information on the behavior of composite materials of similar nature, an area which this program will directly address through a series of careful, systematic studies. The fundamental basis provided by these studies will be valuable beyond the particle/polymer interaction phenomena, and would be applicable to anticipated challenges posed by nanostructured electrodes with solid polymer electrolytes.
2.0	If the team hits its milestone of > 5% efficiency without playing coy with numbers (i.e. AM1.5 over a reasonable area) then I will happily reconsider my skepticism.

3.5 This is a good project, and a good group of investigators. They have lots of competition - IF they pull this off, it will be a great accomplishment. I think they need to focus on the science that will eventually enable such an approach – any success in this regard will lead to other breakthrough technologies, using other pigments, polymers, etc.

3.0 This project will raise many important scientific questions. But I'd like to see a more rigorous justification of the approach relative to existing thin film technologies.