

# PhotoCathode Godparent Review Summary

Review held: 25-APR-2011

Members: Kathy Harkay (ANL), Alexey Lyashenko (Yale), Anton Tremsin (SSL), Gary Varner (Hawaii), Matt Wetstein (ANL)

The committee acknowledges the significant and fundamental progress that has been made since the last review in October. In particular the following, crucial year 2 milestone has been accomplished:

**1. Design and costing of a photocathode characterization facility**

- a. Large area evaporation capability is a driving component of this facility
- b. Integrated Preparation, Growth, Characterization and Testing capabilities

Moreover, we note the following significant accomplishments:

1. Fabrication at SSL of KCsSb bialkali photocathodes, approaching 20% at 400nm on a Borofloat B33 borosilicate window
2. Completion of the SSL 33mm test sample program, with all steps successfully completed
3. Determination that ITO is not a good choice for a photocathode resistance reduction mesh, tested NiCr deposition instead
4. Preparation for commissioning of an 8.7" photocathode deposition chamber at SSL, where Inconel striping and Na<sub>2</sub>KSb on a borosilicate window have been adopted as baseline
5. The Burle equipment has been made operational and first test samples successfully prepared using the Burle KCsSb recipe
6. A "chalice" evaporator design to fabricate a 4" x 4" intermediate-size has been finalized and the glass shell of this structure has been fabricated -- a true piece of artwork
7. Thanks to the concerted efforts of the project and lab management the Photocathode laboratory at Argonne is now ready for occupation and the equipment will be moved in soon
8. Successful fabrication of amorphous GaInN photocathodes on various substrates and extension to 400nm wavelength response with increased Indium incorporation, after repeated Cesium, and demonstration that amorphous cathodes have good long-term stability
9. Initial surface roughness measurements of SiO<sub>2</sub> and SiN<sub>x</sub> as an interlayer for bonding GaAs photocathodes onto B33 glass
10. First XPS studies on GaAs activation at BNL
11. First in situ x-ray characterization measurements during photocathode growth -- a huge and exciting step forward. A number of excellent publications from this ground-laying work are expected. Moreover these results start to make a science of this field by addressing the most fundamental of questions quantitatively: ***what makes a good photocathode?***

The committee makes the following recommendations and requests for further information.

1. To fully comprehend and exploit the measurement results from the exciting new tools being developed in the photocathode lab and the user facility effort, further theoretical input is needed. We recommend redoubling efforts to strengthen such collaboration with theorists, perhaps through invitations to university-based groups. In particular we would like to see the topic requested: *Theory-Driven Materials & Simulation* actually addressed.

2. The committee notes there was no presentation on dark current and noise rates for the photocathodes presented. Since this is a rather important or even dominant factor in the development of a large area photodetector, we request that a white paper on this subject be prepared by the time of the next review.
3. Outfitting, commissioning and maintaining the equipment in the Photocathode Laboratory looks to be a very large endeavor. The committee raised concerns that dedicated engineering and technician staff be committed to this project, to ensure that sufficient technical support is available to permit the scientists to make optimal use of their time and the facilities.
4. Given the complexity and interplay required for a combined sample preparation, growth, testing and characterization lab, the committee requests a document from the management detailing how the lab will be organized, who will be involved, and how the decision-making process will be realized.
5. Compatibility of the photocathode fabrication with the broader sealed-tube assembly process is a critical issue that should be addressed in close coordination with the development of the vacuum assembly design. In particular, the difference in the temperatures required for the photocathode deposition and tube sealing and necessary cool down periods need to be investigated. We request a detailed test program from the ANL effort that addresses the issues raised.
6. While the plans and milestones for the SSL and ANL photocathode labs were clearly presented, those for the efforts at Wash U and UIUC are much less so. We request that a resource-loaded schedule, with milestones, be provided by these two groups for year 3. In particular, if there are additional resources needed to enable these goals to be realized, they should be requested.
7. Tighter coordination of the GaInN fabrication with measurement capabilities at ANL, perhaps through more regular visits by Daniel Leopold to the lab, is strongly encouraged.