Photocathode Optimization

Photocathode properties:

Peak QE > 50%

Improved UV sensitivity

Uniform over large area

Low dark count rate in high electric field

How to improve QE

Improve the material

- Crystallinity
- Impurities
- Defects
- Surface structure

Reduce electron affinity/surface treatment

Build or apply drift field in cathode

Heterostructures to improve wavelength response

Incorporate reflectors to recover transmitted light

How to improve QE

Tools:

For crystalline and impurity analysis, XRD (maybe LEED), XRF, RBS

For Surface preparation: Kelvin probe, STM, XPS

These tools are available at user facilities – DO NOT need to make large hardware purchases

Need *in situ* growth tools, and materials experts

Ideally theory guided design of band structure and junctions.

Collaborate with other fields!

Parameters, and how to affect them

Increasing the electron MFP will improve the QE. Phonon scattering cannot be removed, but a more perfect crystal can reduce defect and impurity scattering:

$$\frac{1}{\lambda_{MFP}} = \frac{1}{\lambda_{el-el}} + \frac{1}{\lambda_{ap}} + \frac{1}{\lambda_{op,ems}} + \frac{1}{\lambda_{op,abs}} + \frac{1}{\lambda_{impurity}} + \frac{1}{\lambda_{defect}} + \frac{1}{\lambda_{boundary}}$$

Control of surface roughness is critical to minimizing the intrinsic emittance – epitaxial growth?

A question to consider: Why can CsI (another ionic crystal, PEA cathode) achieve QE>80%?

T.H. Di Stefano and W.E. Spicer, Phys. Rev. B **7**, 1554 (1973)

Large band gap and small electron affinity play a role, but, so does crystal quality.