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Electron Gun Group

Photocathode Active Area Definition by Solvent-free Anodization

The polarized source group at Jefferson Lab has been anodizing the edges of photocathodes to define an active area and to suppress photoemission from all but the center of the cathode. The theory behind this is that electrons emitted from the edges of the cathode will not travel in the same trajectory as those from the center, and will hit walls causing vacuum activity and shortening cathode lifetime.

The back of the cathode is protected during anodization to ensure electrical and thermal connection between the photocathode and the negatively biased stalk. The previous method for anodizing photocathodes involved attaching the GaAs chip to a glass slide using "kwik-stick" acetone soluble glue. To remove the glue, several rinses in acetone and methanol were performed. With the bulk and strained layer photocathodes, this solvent cleaning was followed by exposure to atomic hydrogen in the hydrogen cleaner to finish removing any organic contamination from the surface of the photocathode.

As we started to use superlattice cathodes, desirable for their high QE, higher polarization and low analyzing power, we found that the traditional way to anodize the cathode was not working. Studies found that the hydrogen cleaner would destroy the QE of the cathode with even minimal exposure time. Repeated attempts to ensure no contamination with the "glue" process were attempted with no success.

In an effort to eliminate the organic glue and the solvents, a method has been developed that streamlines the process and enables anodization of the superlattice cathodes. The streamlined method replaces the organic glue with indium foil. The indium foil is melted between the wafer and the glass slide in a nitrogen purged glove box rather than in air, as was done with the glue. After anodization, the cathode is rinsed in DI water and blown dry with nitrogen, and the glass slide is removed within the glove box again. The organic glue and solvents are completely removed from the process, and good QE has been observed on superlattice cathodes in the source lab and on a strained layer cathode prepared in the same way in gun 3 in May-June 2005. The first successfully anodized superlattice cathode was installed in the tunnel in gun 3 in July, 2005.

Supplies:
Microscope cover slides (pre cleaned)
Indium foil
Dry nitrogen purged glove box
DI water (Millipore system in ARC lab)
3 beakers: 1 250 mL and 2 50 mL, cleaned
Lint-free wipes
Tweezers (cleaned)
Gloves
Kepco power supply and leads with alligator clips
DI water
O-rings rinsed in methanol and dried with nitrogen
Gold wire

Procedure:

1. Load wafers and In foil into glove box and make sure that it is well purged with N2 gas (I load through the hand holes to not introduce unnecessary air into the chamber)

2. Heat hot plate to ~200C (monitor temperature with thermocouple), using heater setting 3 or 4.

3. Put cover slip on clean Al foil on the hot plate, then melt In foil on cover slip. Set GaAs wafer on indium and press to assure good contact (only touch the corners of the wafer with the tweezers).

4. Take cover slip and wafer off hot plate as quickly as possible to limit time at temperature.

5. Test adhesion of wafer to cover slip – slight tweezer pressure or N2 gun should not be able to remove wafer from glass.

6. When cool, place back in wafer carrier and remove from glove box.

Go to ARC lab.

7. Set up Kepco power supply with leads: use "+" and "–" rather than "+" and "ground", since ground loops can cause problems. Turn on the supply to warm up the tubes, but do not turn on the output.

8. Set up clean area to work, wiping down work surface if necessary and covering the fume hood surface with Al foil and lint free wipes. Set holder for wand in beaker out and set it on several lint free wipes to further prevent ground loop problems. Get out clean tweezers[1].

9. Turn on Nitrogen tank primary and secondary valves, allowing the flow to be started with the center regulating valve. Cover regulating valve knob with clean foil.

10. Set up beakers: Triple rinse previously cleaned[2] beakers with running DI water, then fill with DI as follows. 200 mL DI + 4 drops Phosphoric acid in 250 mL beaker, and DI in both other beakers.

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[1] Clean tweezers with microclean, followed by acetone and methanol rinses. Finish with DI and dry thoroughly. Store wrapped in a lint free wipe and aluminum foil or in dedicated toolbox.

[2] Cleaning beakers: Starting with all new glassware, clean first in microclean in ultrasonic cleaner, then rinse with DI and methanol, then leach in boiling DI water. Mike Kelly suggests Isopropyl instead of other solvents for cleaning glassware.

11. Get the o-ring onto the end of the anodization wand (JLab print 39300-C-0164, modified for 005 o-ring). This step is critical – the o-ring must be flat and should be pushed far into the o-ring groove so that water is not sucked under the edge of the o-ring during anodization. I center the o-ring, press, then tap several times on a piece of clean aluminum foil. Tapping on a wipe leaves fibers which can defeat the seal.

12. Attach gold wires to alligator clips on the end of the voltage leads. If you are re-using wire, making sure that there is no oxide layer on them. Set them on a lint free wipe.

13. Set out cathode, and center o-ring on it with valve on wand closed. Open valve after contact is made. Make sure to touch the o-ring down only since moving the o-ring will leave a mark on the cathode and give bad QE at the spot where o-ring touched.

14. Immerse wafer in water, tilting as the wafer goes into the water so that no air bubbles are trapped near the o-ring. Secure the wand to stand.

15. Turn on voltage, place the +100 V lead on the cathode. When the negative lead is placed in the beaker, there should be bubbles. Move the negative lead near the edges of the wafer, making sure not to touch the wafer. As one corner turns blue, move the positive lead to another corner and repeat to get an even coating.

16. Remove the leads, turn off the power supply and remove the wafer from the acid beaker

17. Rinse wafer in one beaker, then hold just above the surface of the water in the second beaker and release the vacuum.

18. Remove from water beaker and blow dry with nitrogen gas, trying to ensure that the center area has no drops drying on it (water should sheet off this area)

19. To do another wafer, replace water in two rinse beakers and blow dry the end of the wand – I find that once an o-ring is well seated, it is best to re-use it. The risk of having a badly seated o-ring is higher than any possibility of cross contamination between wafers.

20. Place dry wafer and cover slide in holder for transport back to EEL lab

Return to the EEL lab

21. Load wafers in glove box and turn on nitrogen flow. Turn the heat on but do not put the wafer on the hot plate.

22. When the thermocouple reads approximately 180-200C, put the wafer and slide on the hot plate, wait a few seconds for the indium to melt and slide the wafer off of the cover slide. Place it, when cool enough, in a carrier.

23. If the indium foil is adhered to the back of the wafer, it will need to be heated under nitrogen purge on the end of the stalk before putting a Ta cup on. Otherwise, load on the stalk with un-melted indium foil underneath the wafer, put the Ta cup on and put in a transport tube.