Version 1.11
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The Tile Vacuum-Assembly Facility

This is a draft of a spec for the assembly of the glass tiles. The purpose is to agree on the specs and move toward costing a real design. This is intended to evolve into asection of the TDR.

1 Considerations of Scope

The facility should:

1. Be innovative and bold in minimizing cost.
2. Be scalable so that it serves as a first prototype-type for a larger or multiple-station facility for industrial production.
3. Not require a clean room.
4. Have a yield > 95% when in standard operation;
5. Be capable of reliably producing an average of the 6 tiles per week, required for a Super-Module. This gives approximately 40 SuperModules per year, enough for meaningful tests for applications such as PET, muon cooling, neutrino detectors, and collider TOF systems. time-of-flight system. To reliably produce an average of 6/week we (somewhat arbitrarily) set the spec for the uninterrupted rate to be 10/week, giving ourselves a 40% allowance for maintainence and process development;
6. Take advantage of the intrinsically simple tile design. The tile has no pins penetrating the vacuum envelope and no internal connections. The tile has subassemblies consisting of the tile base, the MCP 'stack', the getter, and the window. The MCP stack and the tile base can be pre-assembled so that glove-box pre-assembly of all but the window is possible before the tile enters vacuum for the bake, scrub, photocathode deposition, and top seal.
7. Take advantage of the fabrication by ALD of the MCP surfaces from ultra-clean materials, with no unknown contaminants or dirt. We consequently start with the bulk of the surface area being already baked and clean; the surfaces should remain sterile during the transfer to vacuum assembly. We should push to extend this idea to the other interior surfaces: spacers, sidewalls, and anodes, so that all surfaces are man-made at the time of assembly.;
8. Interface cleanly to the large Beneq ALD chamber. The Beneq is well-sized for 8" plates and may provide a basis for some of the standards for vacuum or pure-gas transfer of plates (e.g. the Beneq trays may be a standard tray for subsequent handling, and could possibly interface directly to glove-boxes);
9. Be capable of automated process control and data acquisition (e.g. temperature, time, photocathode quantum efficiency and dark current, etc.) for each internal step;

Table 1 compares the areas of the proposed year's production with the area of 8" and 10" photomultipliers. The 40 SuperModules would have the same photocathode area as 195 10" PMT's or 305 8" PMT's [1]. We note that the production of 10 square-meters per year is starting to approach the scale of the 30 square-meters required for a collider detector such as Atlas or CDF, and would be enough to provide the complete system for a muon-cooling experiment, and also for a test of large-area detectors for a 'near' neutrino detector.

Item	Area: In^2	Area: cm^2	Area: m^2
Tile	64	412.9	0.0413
SuperModule	384	2477.4	0.2477
40 SuperModules	15,360	99,096	9.91
8" PMT	50.27	324.3	0.0324
10" PMT	78.54	506.7	0.0507

Table 1: The area of a single 8"-tile, a SuperModule (6 tiles), and, for comparison, the area of 8" and 10" photomultipliers. Also shown is the area of the proposed 40 SuperModules from a year's production of the prototype facility. We note that the production of 10 square-meters per year is starting to approach the scale of the 30 square-meters required for a collider detector such as Atlas or CDF, and would be enough to provide the complete system for a muon-cooling experiment, and also for a test of large-area detectors for a 'near' neutrino detector.

2 Facility Specifications

We have started a list of specs on the vacuum assembly facility. This is 'strawman'; we can discuss these by email and at the Friday mechanical meetings.

The facility should:

1. Be able to process at least 6 tiles without breaking vacuum[2];
2. Accommodate a transfer from the Beneq ALD machine to assembly in a glove-box and then into the vacuum assembly system without ever exposing the pieces to room air.
3. Allow simultaneous bake-out of at least 6 tiles;
4. Allow simultaneous scrubbing of at least 6 tiles;
5. Allow pipelining and also overlap of the time-intensive steps (e.g. bakeout and scrubbing);
6. Include real-time QA of photocathode deposition, MCP gain and uniformity, anode response;
7. Not invest heavily to be able to accomodate motion backward against the process flow in case of failure on a step, in general;
8. Where possible be modular, with common flanges and pump ports, baffles/shutters, external loading ports, manipulator stages, internal storage/loading magazines;

[1]Although we note that area is just one measure- the SuperModules would have sub-cm space and sub-nsec time resolution.

[2]We use the number 6 here to represent the batch size- we may decide that a larger batch size is necessary to maintain the required average of 6 per week.

3 Process Specifications

This is an attempt to list the Major steps in the process. It should result in a Dean-Jason-Ossy-quality flow chart. Subcharts for the Minor steps can be made as well (this is equivalent to the Top-Level schematic in an electronics Mentor or Cadence design.) Note that all steps after the transfer into the vacuum assembly facility (VAF) are in vacuum until the last one.

1. Tile base fabrication: QA, cleaning, and sealing, of sidewalls and anode plates;
2. QA and preparation of Incom plates and glass spacers;
3. QA and preparation of windows;
4. QA and preparation of getters;
5. ALD of spacers to a resistivity of xxx Ω per square (much lower than the MCP resistivity, so it will dominate);
6. Bonding of Gap-3 spacer to anode in Gap-3 2-mil-tolerance jig;
7. Bonding of Gap-1 and Gap-2 spacers to MCP1 and MCP2,respectively in their 2-mil-tolerance jigs;
8. Bond MCP1 and MCP2 together (both already have their spacers on them);
9. ALD the MCP sandwich to a sheet resistance of $\sim 10^7\Omega$ per square;
10. Pure-gas transfer of ≥ 6 MCP sandwiches from ALD facility to vacuum assembly facility (VAF);
11. ALD the tile-bases at a relatively low resistance (?!);
12. Pure-gas transfer of ≥ 6 tile-bases into VAF;
13. Vacuum baking of tile-bases;
14. Vacuum baking of MCP sandwiches and tile bases; (if can't ALD the bases, have to have a separate chamber for bases and sandwiches to avoid contaminating the ALD surfaces- alternatively load sandwich into clean tile-base and then vacuum-bake both?);
15. Vacuum installation of sandwiches, getter strips into tile-bases (at this point have a complete tile except for the window);
16. Vacuum transfer to scrub stations (can we do 3 or 6 at-a-time stacked up, or do they have to be strung out in a long pipe?);
17. Plasma clean of windows, vacuum bake;
18. Photocathode shoot (will start with Au foil PC- also different for III-V or phonon-based);
19. Vacuum transfer of window and tile to the top-seal chamber
20. Vacuum hook-up HV, DC-ground; electronic test (requires tray-equiv transmission lines below tile);
21. Cold-seal preparation and compression;
22. Test hermeticity *in situ*;
23. Full function test: dark current, QE, gain,.. (back to electronic test module?)
24. Store module in Output magazine/load-lock;
25. Transfer batch to air;

4 Comments

Some miscellaneous comments for discussion:

1. Could we use ALD on the anode and sidewalls too? Will a thin layer of resistive ALD material be fatal to the charge collection on the anode strips?
2. If all surfaces in the tile base (except the getter) are made with ALD, can we first assemble the complete tile-base and then vacuum-bake the completed tile-base assembly?;
3. Scrubbing: we propose to use a fixed MCP itself illuminated by a light source as the source for the scrubbing of the processed MCP's; i.e. there is an MCP that does not change at the top of the stack of MCP's to be scrubbed. An additional question is whether we can assemble the pairs of plates before scrubbing.
4. A magazine should be a standard module, where by 'magazine' we mean a stack of trays that can slide in and out so that MCPs or windows can be stored while one of them is being processed.