SEQRA REVIEW
OF
WESTERN NEW YORK SCIENCE & TECHNOLOGY
ADVANCED MANUFACTURING PARK (STAMP)

Industry Requirements and

Environmental, Health & Safety Report

Generic Environmental Impact Statement

Lead Agency: Genesee County Economic Development Center

MARCH 2011

EXECUTIVE SUMMARY

The Science & Technology Advanced Manufacturing Park (STAMP) project in Genesee County New York is being planned to support a variety of industrial manufacturing operations. The STAMP project is subject to environmental review pursuant to New York's State Environmental Quality Review (SEQR) Act process. Such an environmental review requires information and data pertaining to the industrial facilities' requirements for utilities, chemical use and potential environmental emissions and how such industries implement environmental, health and safety management systems.

The anticipated mix of advanced technology manufacturing facilities envisioned for the STAMP initiative includes the following:

- Photovoltaic ("PV") Manufacturing – 85%
- Flat Panel Display ("FPD") Manufacturing including Medical Imaging Display ("MID") – 5%
- Biopharmaceutical/Nanotechnology-Enable Industries ("Bio-pharm/Nano") – 10%.

The precise composition of facilities that may inhabit the fully developed park is speculative. However, this report develops industry requirements in a bounding case such that an assessment of potential environmental impacts reflects the envelope of considerations that may actually occur with development and build out of STAMP.

This report includes the following descriptions of industrial requirements for the STAMP advanced manufacturing facilities:

- Site and building details;
- Manufacturing technologies used and product descriptions;
- Chemical use and storage include type, estimated annual consumption, and storage and management systems;
- Wastewater generation rates, treatment systems and effluent characteristics;
- Air emission sources, generation rates and treatment systems for regulated air pollutants;
- Solid and hazardous waste sources, generation rates and storage and disposal systems.
- Utility demands for electrical power, water consumption and natural gas usage.

The planned industrial manufacturing activity for the STAMP project initiates and necessitates a variety of regulatory and non-regulatory environmental, health and safety programs. A review of these programs, including the following, is described throughout this report:

- Wastewater effluent limitations;
- Air emission source thresholds and State permitting;
- Hazardous materials engineering, administrative and regulatory controls
- Typical occupational health and safety programs implemented.

New York's State Environmental Quality Review Act requires the preparation of a Generic Environmental Impact Statement (GEIS) for the STAMP project. This report supports the GEIS by identifying industry requirements, including potential environmental emissions, and reviewing environmental, health and safety program associated with these types of industrial activities.

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ACRONYMS

AHJ	Authority Having Jurisdiction
ALD	Atomic Layer Deposition
ARC	Anti Reflective Coating
a-Si	Amorphous Silicon
Bio-pharm	Biopharmaceutical
BOD	Biochemical Oxygen Demand
Cds	Cadmium Sulfide
CdTe	Cadmium Telluride
CF	Color filter
CFR	Code of Federal Regulations
CIGS	Copper Indium Gallium Selenium
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
c-SI	Crystalline Silicon
CVD	Chemical Vapor Deposition
DIW	Deionized Water
DOT	Department of Transportation
EH&S	Environmental, Health & Safety
EPA	Environmental Protection Agency
EVA	Ethyl Vinyl Acetate
Gpd	Gallons Per Day
FPD	Flat Panel Display
H2SO4	Sulfuric Acid
HEPA	High-efficiency particulate air
HF	Hydrofluoric Acid
HMIS	Hazardous Materials Inventory Statement
HNO3	Nitric Acid
HCl	Hydrochloric Acid
IPA	Isopropyl Alcohol
ITO	Indium Tin Oxide
KOH	Potassium Hydroxide
LCD	Liquid-crystal-display
LEED	Leadership in Energy & Environmental Design
MBE	Molecular Beam Epitaxy
MID	Medical Imaging Display
MMCF	Million Cubic Feet
MOCVD	Metal Organic CVD
MW	Megawatt
MWp	Megawatt peak
Nano	Nanotechnology
NIOSH	National Institute for Occupational Safety and Health
NOx	Nitrogen Oxides
NYSDEC	New York State Department of Environmental Conservation
OSHA	Occupational Safety & Health Administration

PECVD	Plasma Enhanced Chemical Vapor Deposition
PM10	Particulate Matter with aerodynamic diameter less than 10 microns
PM2.5	Particulate Matter with aerodynamic diameter less than 2.5 microns
POTW	Publically Owned Treatment Works
PSNS	Pretreatment Standards for New Sources
PV	Photovoltaic
PVC	Polyvinyl Chloride
PVD	Physical Vapor Deposition
QA/QC	Quality Assurance/Quality Control
RO	Reverse Osmosis
SEQRA	State Environmental Quality Review Act
SiN	Silicon Nitride
SO2	Sulfur Dioxide
STAMP	Science & Technology Advanced Manufacturing Park
SWPPP	Storm Water Pollution Prevention Plan
TCO	Transparent Conductive Oxide
TDS	Total Dissolved Solids
TFT	Thin-film-transistor
TKN	Total Kjedahl Nitrogen
TSS	Total Suspended Solids
UL	Underwriters Laboratory
UPW	Ultrapure Water
UV	Ultraviolet
VOC	Volatile Organic Compound

1. INTRODUCTION

The Science & Technology Advanced Manufacturing Park (STAMP) initiative proposes to develop an approximately 1,312 acre site situated near the Town of Alabama, NY with the intention of enabling advanced technology manufacturing operations including the following:

- Photovoltaic ("PV") Manufacturing
- Flat Panel Display ("FPD") Manufacturing including Medical Imaging Display (MID)
- Biopharmaceutical/Nanotechnology-Enable Industries ("Bio-pharm/Nano").

The purpose of this document is to describe the requirements of these manufacturing operations in terms of what reasonably could be anticipated in terms of utilities (electricity, natural gas, water) demand and environmental air emissions, wastewater discharges and solid waste generated to the extent that potential adverse environmental impacts can be identified and evaluated. In addition, this document presents an overview of the advanced technology industry as related to environmental health and safety (EH&S). The requirements of the industry, associated EH&S issues, and how the industry typically addresses these issues in terms of design and operation are discussed together throughout this document as appropriate.

Because these manufacturing technologies and products are emergent and the precise mix of the installed facilities cannot yet be determined, developing a characterization of environmental emissions and discharges requires some speculation. The ultimate goal of this speculation is to develop a bounding case such that an assessment of potential environmental impacts reflects the envelope of considerations that may actually occur with development or build out of STAMP. To that end, the quantitative data described in this report are based on best available knowledge and are intended to document the upper end magnitude of discharges for the purpose of assessing impacts. Specific regulatory permit limits will be established by appropriate regulatory agencies such as the New York State Department of Environmental Conservation (NYSDEC) during the course of permitting the individual manufacturing facilities.

<u>Primary Assumptions</u>

The following describes the primary general assumptions used to develop the data provided in this report.

- All manufacturing facilities will have the capacity to operating 24 hours per day, 365 days per year.
- The total technology manufacturing building area square footage will be approximately 4,000,000 square feet (s.f.).
- For the purpose of quantifying environmental emissions and discharges, the estimated mix of manufacturing technologies expected to be present in the fully developed park is as follows:
    - 85% Photovoltaic

- 5% Flat Panel/Medical Imaging Display
- 10% Bio-pharm/Nanotechnology

- There are four primary photovoltaic manufacturing technologies and for the purpose of characterizing environmental emissions the estimated presence of these PV technologies in the fully developed park are as follows:
  - Crystalline Silicon – 15%
  - Amorphous Silicon – 10%
  - Cadmium Telluride ("CdTe") – 35%
  - Copper – Indium – Gallium – Selenium ("CIGS") – 40%

- For the purpose of providing data quantities, the approximate total building manufacturing square footage for both FPD/MID and Bio-pharma/nano industries is assumed to be 600,000 s.f.

- With regard to these percentage breakdowns, both at the industry level and the PV technology level, certain liberties were taken to develop the bounding case. For example, crystalline silicon PV manufacturing has the potential to emit volatile organic compounds (VOCs) during screen printing operations while amorphous silicon PV manufacturing uses very little VOC materials, but has the potential to emit fine particulates. In the quantification of air emissions from a single factory, both emissions characteristics are described even though they would not typically occur at the same facility.

- For PV manufacturing, the annual plant production capacity is typically stated in megawatts per year. This metric describes the peak theoretical electrical power generation of all the PV modules produced in a calendar year. For example, if 500,000 PV modules are produced in one year and each module has a rated capacity of 200 W, the factories production capacity would be stated as 100 megawatts or 100 MW. For illustrative purposes, several data sets in this report describe emissions or discharges from a "single factory". Because PV manufacturing is anticipated to be the primary technology present in the park, this single factory basis is assumed to be a relatively large factory with an annual production capacity of 200 megawatts (MW).

- As described in Section 3, nanotechnology enabled industries can encompass a very broad range of materials, manufacturing technologies and applications. For the purposes of this report, quantifiable data is based on semiconductor related manufacturing operations to represent nanotechnology.

2. SITE & BUILDING DETAILS

2.1 General Facility Description

STAMP will contain five general building types designed in a manner sympathetic to the rural Western New York setting:

- Technology Manufacturing: A typical technology manufacturing facility consists of a large manufacturing building, a smaller office building, a central utility building, surface parking and paved service/truck loading areas. Overall design and materials are of a high level of quality that is necessary to attract and retain a 'creative class' workforce.

- Technology Manufacturing Support / Flex: Smaller one-level, high-bay 'flex' buildings are typically long and narrow with parking in the front and service/loading areas in the back. Depending on a particular company's business needs, usage of space can range from predominantly office with minimal warehouse/machine shop space to predominantly warehouse/machine shop space with minimal office.

- Office: One or two-level buildings with surface parking.

- Commercial / Mixed-Use / Retail / Hotel: One or two-level structures with surface parking. Typical use arrangement would see retail on the ground level with other uses on the second level.

- Town Hall / Community Center / Museum / Environmental Center: This facility could be developed as a single structure housing multiple functions or as a complex of separate buildings designed around external common areas.

2.2 Building Heights

Building heights within STAMP will vary, but will not exceed the following maximum heights:

- Technology Manufacturing: 110 feet

- All Other Building Heights: 35 feet

2.3 Building Square Footage

STAMP is planned for the following approximate total building square footages at site build-out:

- Technology Manufacturing: 4,000,000 SF

- Technology Manufacturing Support / Flex: 1,400,000 SF

- Office: 500,000 SF

- Commercial / Mixed-Use / Retail / Hotel: 180,000 SF

- Town Hall / Community Center / Museum / Environmental Center: 50,000 SF

2.4 Leadership in Energy and Environmental Design (LEED) Construction

STAMP facilities will be designed and constructed to LEED standards, as applicable.

3. MANUFACTURING TECHNOLOGY DESCRIPTIONS

3.1 Photovoltaic Manufacturing

The photovoltaic manufacturing industry can be broadly categorized by two technologies relevant to the types of materials used to construct the solar cell – crystalline silicon and thin films. Crystalline silicon can either be single-crystal or multi-crystalline/polysilicon depending on the molecular structure of the silicon substrate used to construct the solar cell. Thin film technology can be categorized as either, 1) amorphous silicon, 2), Cadmium Telluride (CdTe) or 3) Copper – Indium – Gallium – Selenide (CIGS), again depending on the materials used to construct the solar cell. Other technologies and materials are emerging, but this breakdown provides a broad capture of the industries with regard to chemical use and potential emissions or discharges.

Each of these manufacturing technologies is briefly described in the following sections. The purpose of the descriptions is to provide a generalized overview of the potential types of unit operations that occur during manufacturing. Descriptions of associated chemical use, facility support systems including pollution control systems, and potential environmental emissions and discharges are provided in the remaining sections.

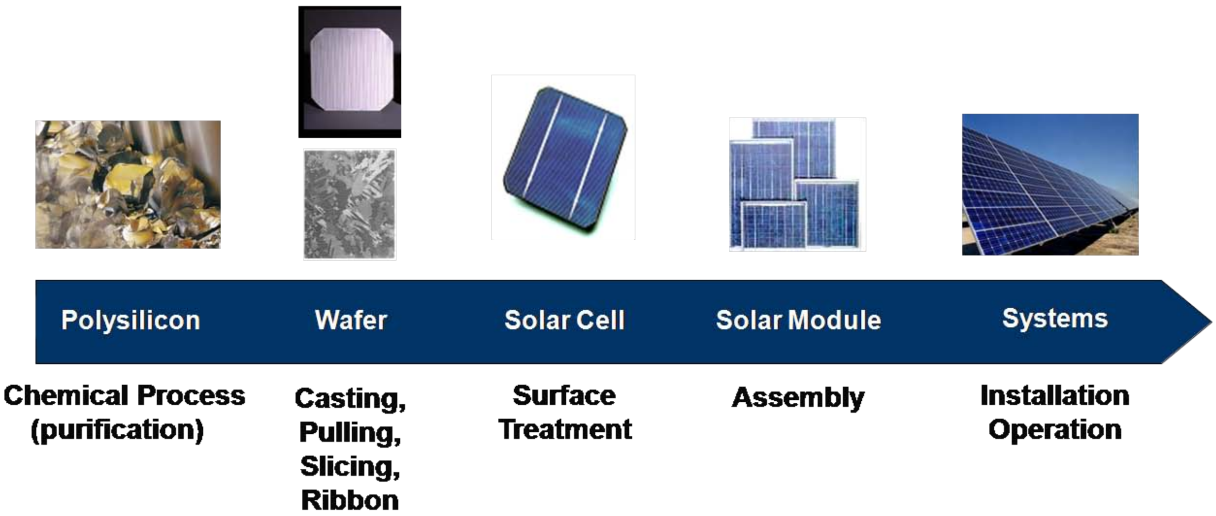
3.1.1 Crystalline Silicon

As shown in the following graphic, the production of crystalline silicon solar modules and power generation involves five operations. However, the core manufacturing technology and the types of operations envisioned for STAMP include the wafer, cell and module operations.

1 – Wafer Fabrication: Produce silicon wafer substrate on which the photovoltaic cell is constructed.

2 – Cell Fabrication: Fabrication of a series of semiconductor layers that facilitate the photovoltaic effect.

3 – Module: In order to produce sufficient current and voltage, multiple solar cells are electrically connected in arrays and encapsulated into weather proof frames. A typical finished module can measure about 2ft by 4 ft.



The following sections describe the major process steps required to fabricate and assemble a solar module from crystalline silicon.

Wafer Fabrication

- The purpose of the wafer fabrication process is to produce a small, thin, silicon wafer substrate semiconductor material on which the solar cell can be constructed.
- Wafer fabrication processes typically involve molten silicon and forming an ingot which is sliced into thin wafers or producing a "ribbon" from the molten silicon which can also be cut into wafers.
- The molten silicon is typically "doped" with materials such as boron and phosphorus to provide certain electrical properties.

Cell Fabrication

- Cell fabrication typically begins with a texturization process. Texturization is a series wet bench operations designed to selectively etch the wafer's surface, maximizing light trapping and improve overall cell efficiency. The process usually involves deionized water, IPA, HF, HNO_3, H_2SO_4 and KOH.
- Pre-diffusion Etch: This is a cleaning step involving HF and HCl.
- Surface Diffusion (Surface Doping): The texture etch process may be followed by a surface diffusion step to inject phosphorus as a dopant. The diffusion mechanism can be either a spray-on diffusion process using a mixture of phosphoric acid and ethanol or a furnace diffusion step using phosphorus oxychloride.
- Post Etch Clean (PSG Etch): PSG etch clean typically using HF is the second wet process that removes an oxidation layer or glass layer that forms during the surface

diffusion step. The etching processes remove a very small amount of material from the silicon wafer.

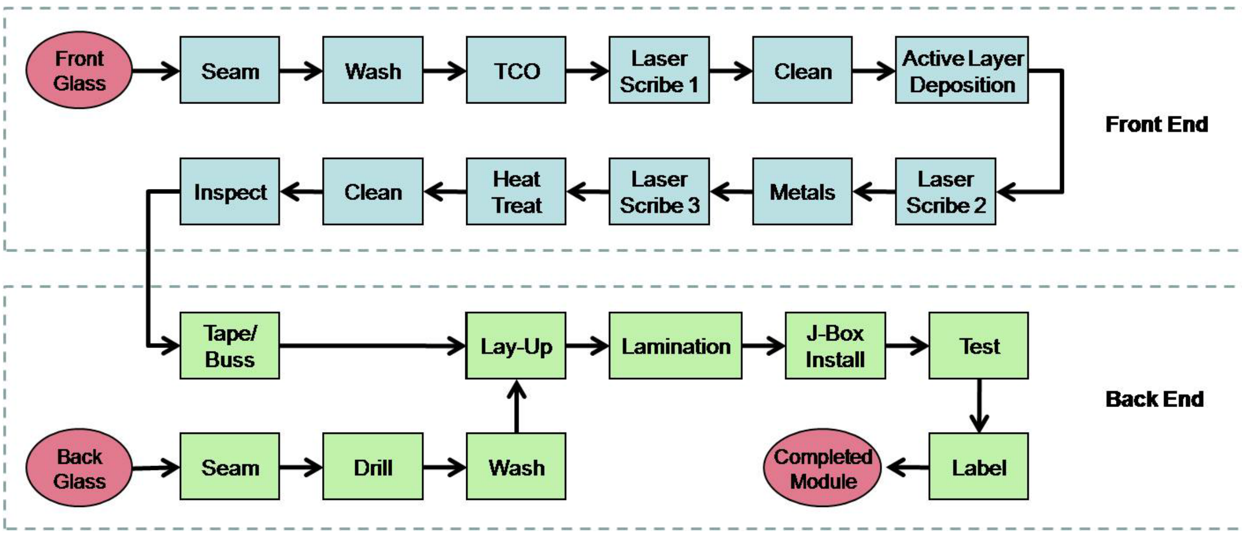
- Silicon Nitride (SiN) Anti Reflective Coating (ARC) Deposition: The Nitride Anti-reflective Coating (ARC) is deposited onto the front surface of the wafer. This is accomplished using a thin-film deposition process within an automated cell. The cell is arranged in a serial or in-line layout.
- Screen Printing: Screen printing is a three-step, inline process that patterns the front side of the wafers with circuitry, the back side of the wafers with connection pads for the stringer, and applies a uniform aluminum or silver paste.
- Metalization (Firing): The Metalization or Firing process step utilizes an in-line furnace that heats the wafer.
- Edge Isolation #1: The edge isolation involves an integrated laser system that utilizes a laser to isolate the junctions on the back surface of the wafer.
- Plating: In the plating step, a thin layer of silver is electroplated onto the surface of the solar cell. This electroplated layer improves the cell's yield and efficiency. The plating baths contain aqueous solutions of silver compounds, acids, bases, chelating agents and surfactants. The plating process is not used in all solar cell manufacturing technologies.
- Edge Isolation #2: The edge isolation involves an integrated laser system that utilizes a laser to isolate the junctions on the front surface of the wafer.
- Cell Test & Sort: The cell test and sorting station is an automated inspection process that bins completed cells according to their power curves.

Module Assembly Process Flow

- Tab/String Application: The tab/string application step typically utilizes an automated machine to solder connecting conductors. Once tabs are applied, the machine then connects cells together, forming the strings that will be placed within the finished module.
- Lay-up Table: The lay-up table is where operators assemble the parts for a completed module. Operators take a glass cover sheet, protective laminate sheets, and multiple strings of cells from the previous process step and overlays them on a table. The operator then connects the strings by soldering on bus bars and performs any soldering touch-up/rework activities. Once complete, the operator sends the assembly to the laminators.
- Lamination: The lamination process step is an automated process that uses heat & vacuum to environmentally seal the sub-assembled module. Once complete, the sub-assembled module is transferred to the trimming and framing station.
- Trimming and Framing: This station is typically an automated assembly cell where flashing from the lamination step is cut off and the sub-assembled module is placed into a metal frame.
- Junction Box (J-Box) Installation: This process step applies a junction box to the back of the module. The J-Box houses the circuitry required to transfer the converted sunlight into a collection system and inverter once the module is installed at a final site. At this point, the module is now complete and functioning.

- Final Inspection and Testing: The final inspection and testing station performs a QA/QC check on the appearance of the module, checks for functionality, and determines the output wattage range for the finished module. Like the sorting of individual cells, modules are also binned and sorted according to their power output.
- Packaging and Shipping: Binned modules are then assembled and shipped to customers.

There are multiple types of thin film PV manufacturing technologies depending on the substrates used and the material layers deposited to construct the solar cell. A generalized thin film process flow diagram is shown below and a more detailed narrative of the primary technologies is provided in the following sections.



3.1.2 Amorphous Silicon

Amorphous silicon PV manufacturing technology is typified by depositing doped silicon layers on a glass substrate. Solar panel sizes can reach 5.7m^2 or larger. Typical manufacturing process steps are described below.

- Glass preparation: The glass substrate coated with a transparent conductive oxide (TCO) has its edges ground, is cleaned with deionized water and detergents and typically undergoes a laser scribing step to cut lines in the TCO layer.
- Chemical vapor deposition (CVD): Various layers of the solar cell are applied inside vacuum sealed chambers. The primary deposition gas is silane and other specialty gases are also used to deposit metals on the substrate to give it correct electrical properties.
- Laser scribe: Various laser scribes occur to produce patterns in the cell to make an electrically connected system.
- Physical vapor deposition (PVD): Also occurring in hermetically sealed chambers, back reflector and metal layers are applied to finish the cell.

- Module finish: Back glass is applied, panels are cut to size, washed and a junction box is connected to house the circuitry necessary for a power producing panel.
- Test, Sort & Packaging

3.1.3 Cadmium Telluride (CdTe) Thin Film

Cadmium Telluride PV manufacturing is another thin film technology that relies on Cadmium semiconductor layers. Typical manufacturing process steps are as follows.

- Glass preparation: The glass substrate coated with a transparent conductive oxide (TCO) is cleaned with deionized water and detergents.
- Patterning and Deposition: This is a series of steps primarily involving physical vapor deposition processes to deposit solar cell absorber layers and back metal contact layers. In between deposition steps, laser scribes provide a route for electrical connectivity.
- Glass, Seam, Grind, & Cut: This step primarily prepares the glass edges prior to lamination.
- Lamination: Lamination typically involves an Ethyl Vinyl Acetate (EVA) sheet being applied to the back of the module to provide a hermetic seal.
- Junction Box (J-Box) Installation: This process step applies a junction box to the back of the module. The J-Box houses the circuitry required to transfer the converted sunlight into a collection system and inverter once the module is installed at a final site. At this point, the module is now complete and functioning.
- Final Inspection and Testing: The final inspection and testing station performs a QA/QC check on the appearance of the module, checks for functionality, and determines the output wattage range for the finished module.

3.1.4 Copper Indium Gallium Selenium (CIGS) Thin Film

CIGS thin film PV technology involves both dry physical deposition processes (to deposit the absorbing layers – Copper, Indium, Gallium, & Selenium) and wet chemical bath deposition processes to deposit a buffer layer, typically Cadmium Sulfide. Glass or plastic substrates are used. Typical manufacturing process steps are as follows.

- Glass preparation: For CIGS product using glass, the substrate cleaned with deionized water and detergents.
- Moly Deposition: CIGS products typically begin with depositing a thin layer of molybdenum on the substrate using a sputtering process. Sputterring processes occur inside sealed chambers and typically involve bombarding a target material with atoms of an inert gas such as argon to knock off portions of the target metal which will deposit on the substrate.
- Laser Scribe: Portions of the moly layer are removed using a laser

- CIGS Deposition: Again using typically a sputter process, these key metal absorbing layers are applied to the substrate typical by a sputtering process.
- CdS Deposition: This is typically a chemical bath deposition process where a cadmium sulfide buffer layer is “grown” on top of the CIGS layer.
- Laser Scribe & Back Contact: Multiple other laser scribe steps are done to connect the layers and a back metal contact layer is also applied. This back layer is usually a zinc tin oxide.
- Printing: In some CIGS applications a silver or aluminum paste is printed on the cell for additional circuitry requirements.
- Module completion: Module completion usually involves edge trimming lamination of a back layer to seal the PV cell, application of a junction box and final testing and packaging.

3.2 Flat Panel or Medical Imaging Display Manufacturing

The primary flat panel display or medical imaging display manufacturing technology used today is referred to as thin-film-transistor (TFT) – liquid-crystal-display (LCD) or “TFT-LCD”. The TFT-LCD fabrication process consists of 3 functionally separate modules, or groups of process steps, commonly referred to as “array”, “color filter (CF)”, and “module assembly”. The array, which is the network of thin film transistors that turn the display pixels on and off, is created on a sheet of glass by a combination of thin film material deposition and patterning with semiconductor-type photolithography processes. The color filter is also made on a sheet of glass, but uses different types of processes, wet coating and simpler lithography techniques. The module assembly steps connect the array and CF sheets together, introduce the liquid crystal material itself, and attach the backlight and drive electronics. Additional details regarding the manufacturing technology for these three primary groups of operations is provided below.

Array Fabrication

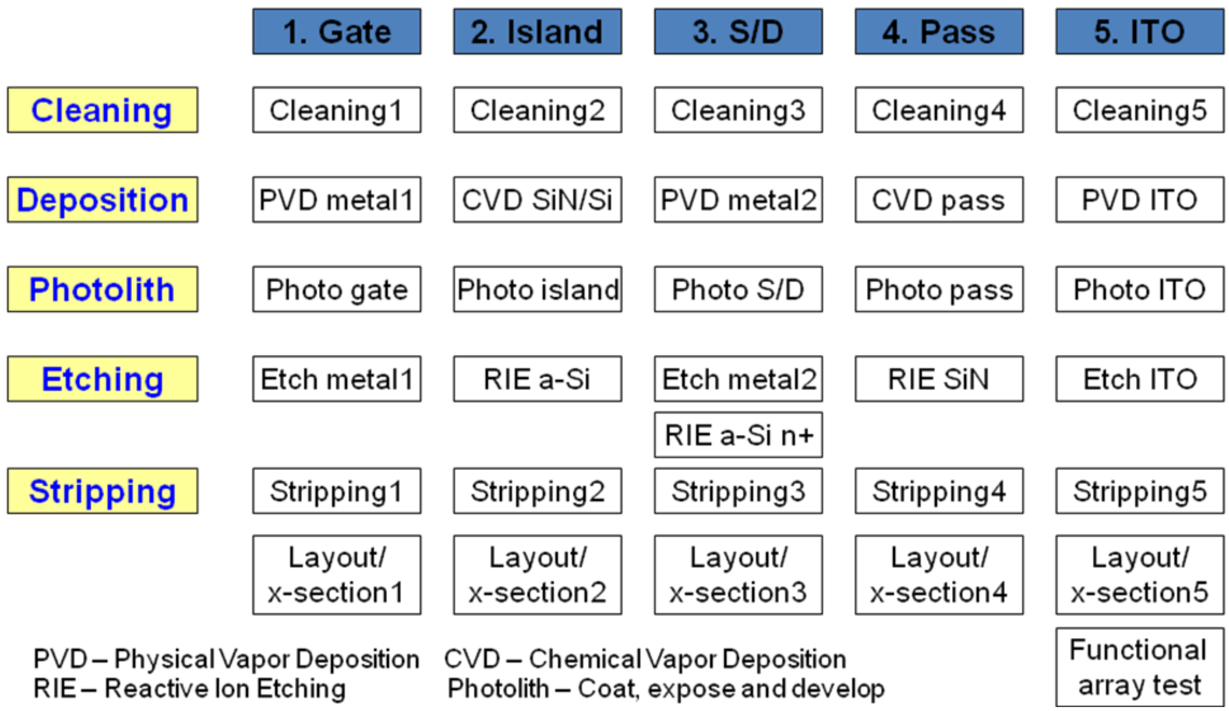


Figure 1 – Basic Process Block Diagram for TFT-LCD Array Fabrication

The array fabrication process creates a network of thin-film-transistors (TFT's) and connecting electrodes on the surface of a sheet of glass. The basic process used is similar to the material deposition and photolithography (photographic patterning) techniques developed for semiconductors.

The incoming glass (the "substrate") could be anywhere from 300 x 400 mm up to 3.6 x 3.2 m in size, and is normally between 0.5 and 1 mm thick. At the start of each process block, the substrate is cleaned with water, detergent, and solvents. Then, the general process is to deposit a material, create a patterned layer on top of it with an organic "photomask", etch away the areas that are not needed, and then strip off the photomask. This process is repeated several times, with variations, in order to build up the necessary three dimensional structure of the functioning device.

In the array process, the first step is to create the gate electrode (blue structure in Figure 2 below), which is connected to the "row" electrode of the display. When the row electrode has an appropriate voltage applied to it, the gate electrodes of all the pixels on that row are energized, and the TFT's on the row "turn on", meaning that they are ready to accept the video data for the pixel they control.

The next step is to cover the gate with an insulating layer (white on top of the blue). Then the semiconductor part of the transistor is applied. This is normally amorphous silicon (a-Si, orange), deposited by a chemical vapor deposition process called PECVD. This is the layer that actually performs the switching action – it will be conductive or insulating depending on the voltage applied to the gate. The a-Si gets patterned into an island by photolithography.

On top of the a-Si, connecting electrodes are formed (green). One of these brings the video data to the pixel, and the other connects that data to a large transparent electrode that cause the liquid crystal material above the pixel to become more or less optically transparent.

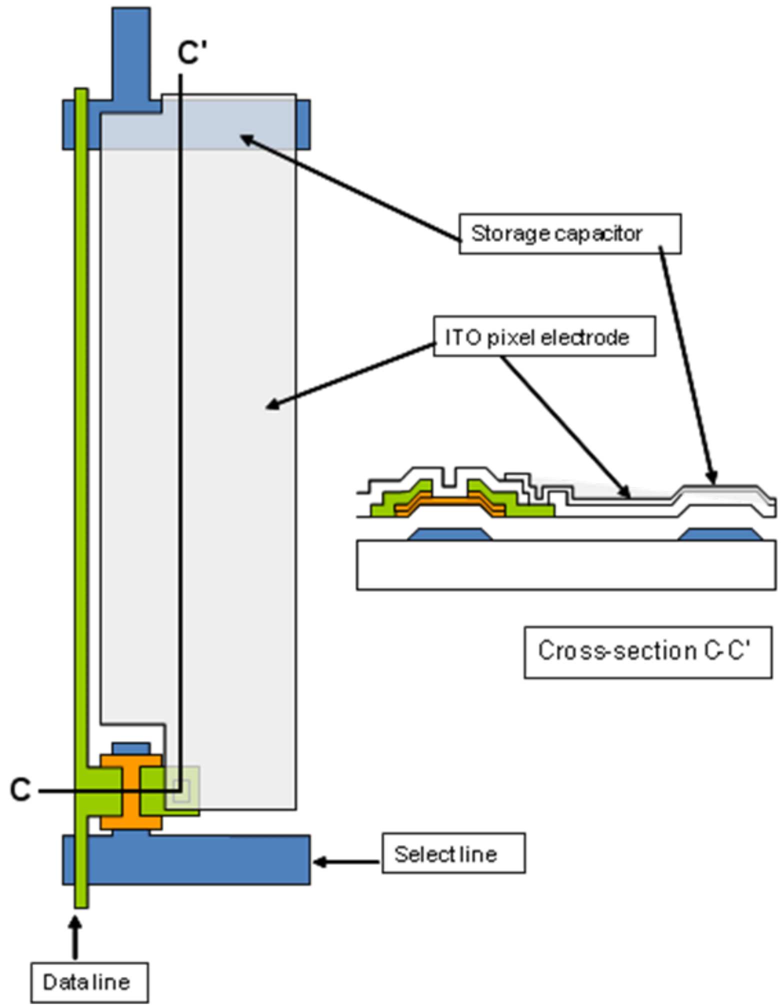


Figure 2 – Basic Schematic of a Completed TFT and Connecting Electrodes

After the electrodes, a passivation layer is deposited over the entire area, and a small window is etched into it in order to allow contact with the pixel electrode. Finally, the pixel electrode material, a transparent conductor made of indium tin oxide (ITO, grey) is deposited and patterned into the shape of the pixel.

Once the array processes are completed, the sheet is inspected optically and electrically, in order to identify defects. If possible and warranted, defects can be repaired either by using lasers to remove unwanted material, or by applying addition material where missing.

Color Filter Fabrication

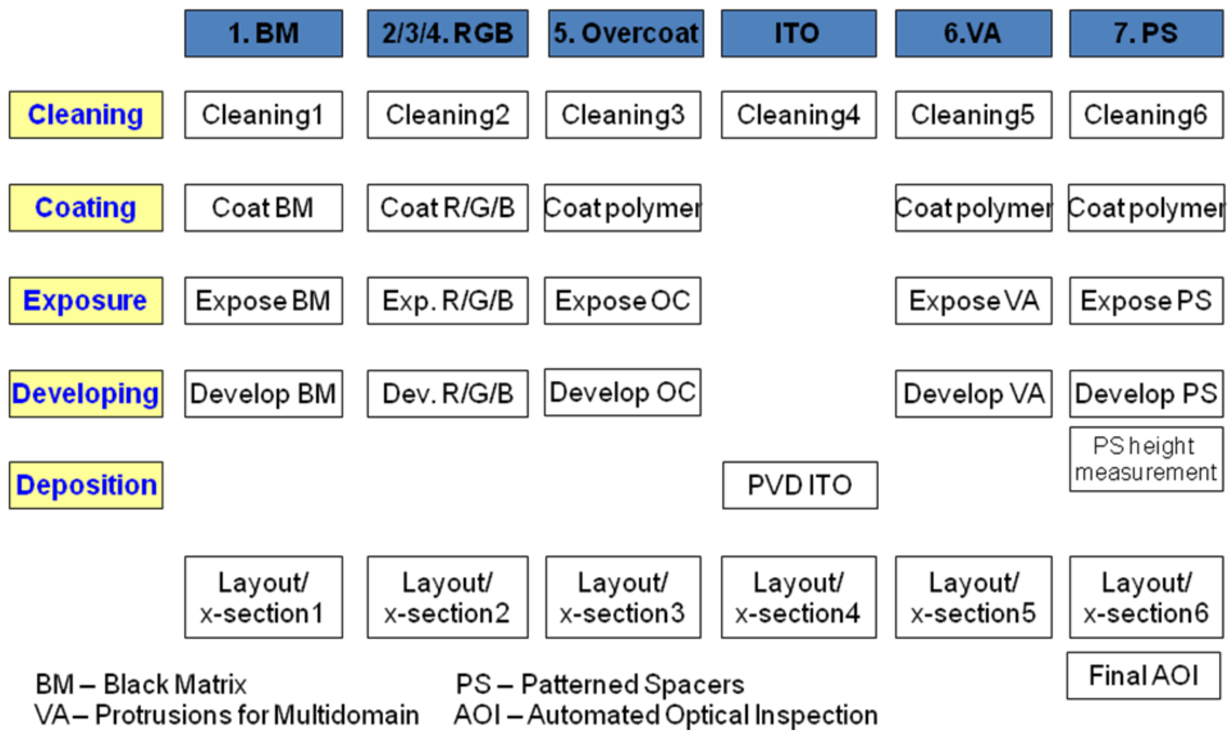


Figure 3 – Basic Process Block Diagram for TFT-LCD Color Filter Fabrication

Color Filter, or CF, fabrication has some similarities with array fabrication, but uses some different processes. A similar glass substrate and cleaning processes are involved, but the deposition and patterning are modified. Instead of the array's deposit/pattern/etch/strip cycles, the CF process is simpler. The materials that make up the device layers are actually photosensitive, and so can be patterned directly, without the need for an additional layer of material to act as a mask. In other words, the process does not need additional coat, etch, or strip processes.

After the initial cleaning, the first step is to create the black matrix (BM, black in Figure 4 below). This layer serves the dual purpose of making the filter darker, reducing ambient reflection, and also acting as a spacer between the color materials that will be added later. The sequence to make the BM is to coat the material by extruding it onto the substrate from a thin slit, expose the layer to patterned light to harden the desired areas, remove the unwanted areas with a developer solution, and then bake the remaining layer to harden it. This set of process steps is repeated for the red, green, and blue layers that make up the 3 primary colors of the finished display.

After the RGB layers are done, a protective overcoat layer (white) is applied, and ITO (yellow) is deposited on that. What happens next depends on the type of display being made, but some type of alignment layer is normally created, which will force the liquid crystal material into the correct optical position. Finally, spacers, which will maintain the distance between the array and CF sheets, may be created, although in some technologies this step is completed during assembly.

As in the array process, completed CF sheets are careful inspected for defects and may be reworked.

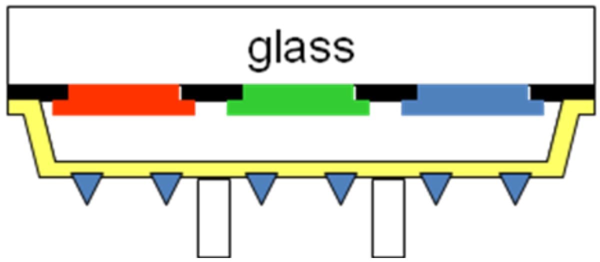


Figure 4 – Basic Schematic of a Completed Color Filter Sheet

<u>**Module Assembly**</u>

Once the array and CF sheets are ready, then module assembly can take place.

Again, the exact steps depend on the technology being used, but in general, the first steps are to create polyimide (PI) layers on the active surfaces of both sheets, and to modify the surface of those layers to cause the liquid crystal materials to assume the correct shape for the needed optical characteristics. The surface modification process typically used is called “rubbing”, and just as it sounds, it involved rubbing the surface of the PI with a cloth covered roller.

Once rubbed, the sheets are ready for assembly. An adhesive material is dispensed around the perimeter of one of the sheets, and the two sheets are placed face to face to allow the edges to become fixed to each other. If spacers were not applied in the CF process, then small plastic balls sized for this purpose will be sprayed onto one sheet before assembly.

Once assembled, the air inside the sandwich is removed through a small gap in the adhesive, and the liquid crystal material is filled in. In more recent facilities, the LC material is dispensed onto one sheet before assembly.

Finally, the adhesive gap is closed, the sheet sandwich is baked, and then the individual displays are cut apart by scribing and breaking. The scribed edges are smoothed, electronic connectors are attached to the edges of the glass, the backlight unit (BLU) is attached, and the driver circuit boards are connected.

At this point, the entire module is complete. It is tested electrically and optically, and a certain number of modules may be selected for long term testing. The finished modules are packed into shipping containers, and sent to TV makers for integration into finished products.

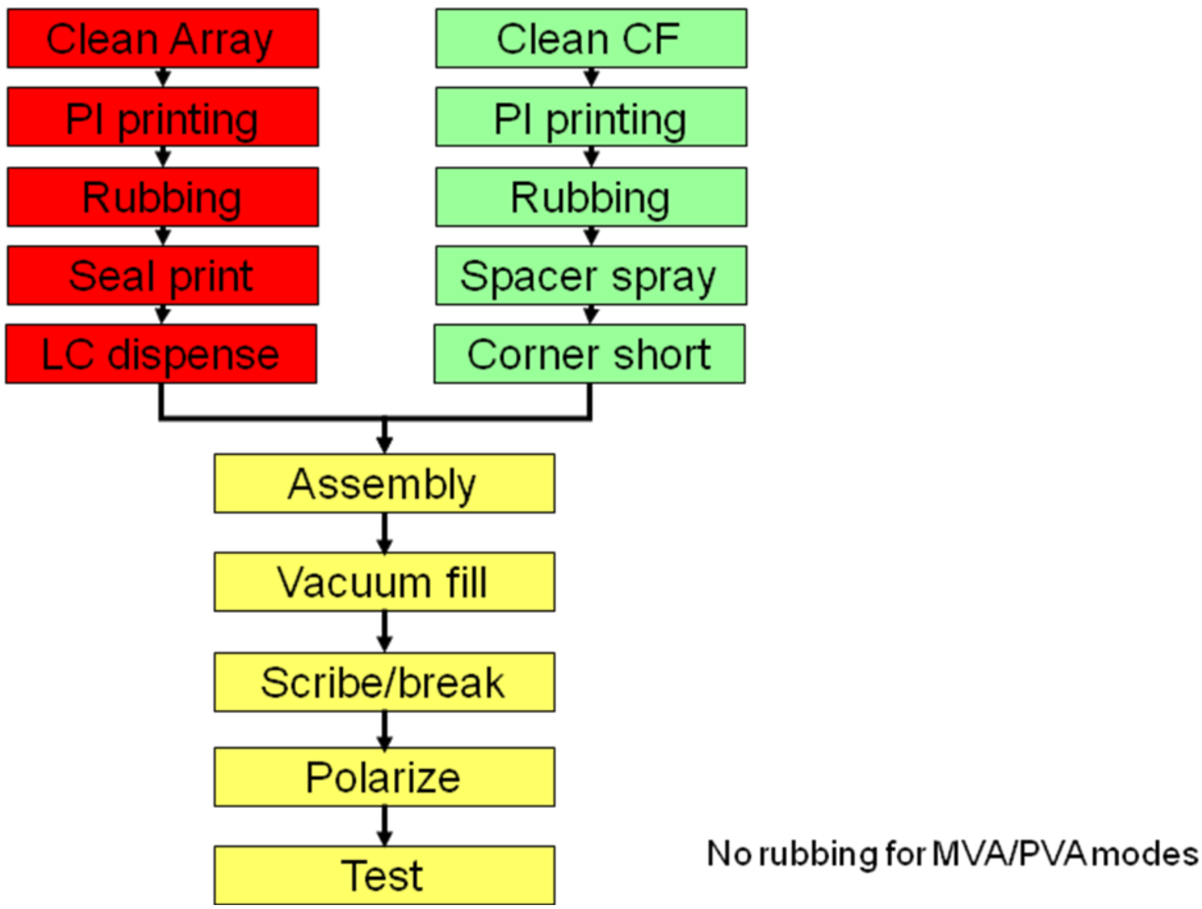


Figure 3 – Basic Process Block Diagram for TFT-LCD Module Assembly

3.3 Nanotechnology Enabled Industries

Nanotechnology is a broad category that includes activities related to understanding and control of any material at dimensions between approximately 1 and 100 nanometers. At this scale, materials display unique properties due to increased relative surface area and quantum effects. These unique properties can enable innovative applications.

The broad term nanotechnology encompasses nanoscale science, engineering, and technology, including imaging, measuring, modeling, and manipulating matter at these scales. However, for the purposes of this report, nanotechnology is limited to manufacturing operations producing or using nanoscale materials. This category will be referred to as "nanotechnology enabled manufacturing".

Within nanotechnology enabled industries, there are 3 general sectors:

- Semiconductors and electronics: nanoscale materials can have unique electrical properties that enable production of less cost, smaller, more efficient, and higher performance computing capacity, memory, displays, and batteries.

- Biotechnology and medicine: nanoscale materials can have unique chemical and physical properties that enable faster, less cost, and more effective drug discovery, production, delivery, and diagnostics. Other applications include improved ability to control and limit toxic and hazardous substances, produce fuels, and grow crops.

- Materials and consumer products: nanoscale material's various unique properties can enable building materials that are lighter, stronger, stiffer, less cost, and more durable, as well as better cosmetics, higher quality optics, longer wearing tools, textiles, and lubricants, lower energy catalysts and fuel cells, and more efficient filters.

Because nanotechnology enabled industries is such a large and diverse platform of materials and process technologies, there is no general or typical manufacturing flow. However, there are some characteristic processes, materials, and product characteristics that typify the technology as described below.

Top Down Methods: processes of creating nanoscale particles or surface features from bulk materials. Top down processes include:

- Mechanical Processes
- Arc Discharge
- Laser Ablation
- Plasma Processes
- Electrochemical Processes
- Lithographic Processes

Bottom Up: processes of building or growing nanoscale particles or surface features from precursor atoms or molecules. Bottom up processes can include:

- Chemical Vapor Deposition (CVD)
- Atomic Layer Deposition (ALD)
- Molecular Beam Epitaxy (MBE)
- Metal Organic CVD (MOCVD)

- Chemical Synthesis and Self Assembly
- Electrodeposition
- Electrochemical Processes

While these processes are important for creating nanoscale materials or for creating nanoscale features, almost any general manufacturing process can be used to process nanomaterials into other products. Manufacturing processes as diverse and traditionally low tech as textile weaving and knitting, sunscreen or cosmetics blending, food packaging, injection molding, and glass forming are candidates to use nanomaterials.

4. CHEMICAL USE AND STORAGE

4.1 Chemical Use

All three of the advanced manufacturing technologies considered in this report involve a variety of chemical substances and will have associated Material Safety Data Sheets representing the specific chemicals made available to employees and agencies. Wet acidic and alkaline chemicals are used for etching and cleaning. Specialty gases are used as dopants and chamber cleaning chemicals. Bulk gases are used as dry seals and purge gases. Organic materials are used as solvents. Various heavy metals are also used, for example, to construct the heart of the PV cell – the absorber layers.

Site management and use of these chemicals involves commercially proven engineering controls including pollution abatement systems, administrative controls including, training, monitoring, inventory control and safety checks, and a host of environmental and safety regulations and procedures to bolster company internal operation and maintenance programs and management systems.

The remaining sections describe the types and quantities of chemicals and component materials involved in PV, FPD/MID and bio-pharma/nanotechnology enabled industries and the engineering, administrative, and regulatory control mechanisms typically used and required by the industries to ensure safe management and an efficient use of these materials. Chemical use estimates are conservative as they were primarily derived from engineering design information which is based on the theoretical maximum production capacity of a manufacturing facility.

Tables 4.2-1 through 4.2-6 provide the estimated maximum annual chemical and component material consumption rates associated with the various manufacturing technologies.

Table 4.2-1 – Crystalline Silicon PV Technology Chemical Use

Component or Chemical Name	Approximate Annual Use (Pounds)	Physical State (G=Gas, L=Liquid, S=Solid)
Ethanol 95%/ Methanol 5%	410,000	L
Solvent (Alcohol) Based Flux	150,000	L

Solvent (Alcohol) Based Solder Paste	700	L
Silver Plating Solutions (silver methanesulfonate)	11,000	L
Boron Trioxide/ Propylene Glycol Monomethyl Ether	2,400	L
Phosphorus Oxychloride	3,200	L
Dielectric Gel	98,000	S
Nitric Acid 69%	670,000	L
Potassium Hydroxide	75,000	L
Ethanol 95%	700	L
Isopropyl Alcohol	28,000	L
Hydrofluoric Acid	9,700,000	L
Hydrochloric Acid	18,300,000	L
Sulfuric Acid (98%)	34,300,000	L
Solvent Based Aluminum Paste	190,000	L
Solvent Based Silver Paste	28,000	L
Ammonia	500	G
Argon	6,500,000	G
Nitrogen	6,700,000	G
Oxygen	290,000	G
Hydrogen	12,000	G

The annual consumption amounts are estimated based on an annual production level of 170 MWp. A typical large cSi manufacturing facility would have an annual production level of perhaps 200 MWp.

Table 4.2-2 – Amorphorous Silicon PV Technology Chemical & Component Material Use

Component or Chemical Name	Approximate Annual Use (Pounds)	Physical State (G=Gas, L=Liquid, S=Solid)
Glass	49,500,000	S
Silane	200,000	G
Phosphine (0.5% in Hydrogen)	800	G
Trimethyl Borate (0.5% in Hydrogen)	200	G

Nitrogen Trifluoride	260,000	G
Nitrogen	36,600,000	G
Argon	130,000	G
Hydrogen	720,000	G
Helium	36,000	G
Methane	1,200	G
Silver	6,500	S
Zinc Oxide	1,400	S
Nickel/Vanadium	2,700	S
Polyvinyl Butyl (PVB)	3,800,000	S
Epoxy/Sealant	33,000	S
Solvent	70	L
Solder Flux	90	L
Bus Bar (Copper Core)	18,000	S
Junction Box (Plastic)	110,000	S
Mounting Rail (Galvanized Steel)	3,300,000	S
Water-based Glass Cleaning Agents	510,000	L

Chemical and component material annual consumption rates are estimated based on a 140 MWp production level which would be typical of a large a-Si facility.

Table 4.2-3 – CdTe PV Technology Chemical & Component Material Use

Component or Chemical Name	Approximate Annual Use (Pounds)	Physical State (G=Gas, L=Liquid, S=Solid)
Glass	62,000,000	S
Zinc/Tin Alloy	34,000	S
Cadmium Sulfide	28,000	S
Cadmium Telluride	140,000	S
Cadmium Chloride	55,000	S
Ethylenediamine	990,000	L
Copper (II) Acetate	1,700	L
Methanol	800,000	L

Negative Photo Resist	400,000	L
Propylene Glycol Mono Methyl Ether Acetate	190,000	L
Sodium Carbonate	220,000	L
Graphite conductor paste	220,000	S
Nickel Vanadium Alloy	44,000	S
Aluminum	66,000	S
Vinyl Tape	420,000	S
Aluminum Foil	17,000	S
Ethyl Vinyl Acetate	3,600,000	S
Copper wire & polymer	1,700,000	S
Nitrogen	27,400,000	G
Oxygen	1,900,000	G
Argon	4,800,000	G
Helium	1,800,000	G

Chemical and component material annual consumption rates are estimated based on a 280 MWp production level. A typical large CdTe facility would have a production level of perhaps 140 MWp.

Table 4.2-4 – CIGS PV Technology Chemical & Component Material Use

Component	Approximate Annual Use (pounds)	Physical State (G=Gas, L=Liquid, S=Solid)
Ammonium Hydroxide (28%)	5,100,000	L
Thiourea	9,700	S
Cadmium Sulfate	26,000	S
Hydrochloric Acid (37%)	9,500,000	L
Water Based Detergents	99,000	L
Copper	59,000	S
Indium	100,000	S
Gallium	17,000	S

Selenium	130,000	S
Molybdenum	150,000	S
Zinc/Indium	110,000	S
Nitrogen	66,700,000	G
Helium	190,000	G
Argon	4,300,000	G
Oxygen	1,600,000	G
Glass	43,300,000	S
Aluminum	28,300,000	S

The annual consumption amounts are estimated based on an annual production level of 690 MWp. A typical large CIGS manufacturing facility would have an annual production level of perhaps 200 MWp

Table 4.2-5 – Flat Panel Display Technology Chemical & Component Material Use

Chemical	Approximate Annual Use (lbs)	Physical State (G=Gas, L=Liquid, S=Solid)
Nitrogen	24,000,000	G
Oxygen	520,000	G
Argon	25,000	G
Hydrogen	3,400	G
Helium	1,100	G
1% Phosphine in Hydrogen	700	G
Chlorine	2,800	G
Nitrogen Trifluoride	4,300	G
Ammonia	4,300	G
Sulfur Hexafluoride	2,000	G
Hydrofluoric Acid (25%)	940,000	L

Hydrofluoric Acid (49%)	100,000	L
Silane	1,600	G
Phosphoric/Acetic/Nitric Etch	1,100,000	L
Acetic Acid	23,000	L
Nitric Acid	33,000	L
Ferric Chloride (25%)/HCl(5%) Etchant	760,000	L
N-Methyl-2-pyrrolidone	1,000,000	L
PGME (30%)/PGMEA (70%)	1,600,000	L
TMAH (0.4 - 25%)	4,500,000	L
Potassium Hydroxide (10-20%)	2,000,000	L
Potassium Hydroxide (0.05%)	5,800,000	L
Detergent	40,000	L

Table 4.2-6 – Nanotechnology Chemical & Component Material Use

Chemical	**Approximate Usage Per Year** (Gallons)	Physical State (G=Gas, L=Liquid, S=Solid)
Acids		
Sulfuric acid	64,000	L
Hydrochloric acid	19,000	L
Phosphoric acid	8,400	L
Hydrofluoric acid	6,500	L
Copper plating bath	2,900	L
Sulfuric acid (8%)/hydrogen peroxide (8%)	2,200	L
2-propenoic acid	600	L
Ammonium fluoride	62,000	L
Methane sulfonic acid	1,100	L
Caustics		
Ammonium hydroxide	24,000	L

Tetramethyl ammonium hydroxide (1 - 3.5%)	170,000	L
Potassium Hydroxide (5%)	1,700	L
STI CMP slurry	3,300	L
Copper CMP slurry	11,000	L
Solvents		
2-Methylaminoethanol	500	L
Isopropyl alcohol	7,500	L
Tetraethyl orthosilicate	1,200	L
Ethyl lactate	44,000	L
Acetone	900	L
Dimethyl sulfoxide (95%)	3,700	L
Normal methylpyrrolidone	2,100	L
Hexamethyl disilazane	200	L
Octamethylcyclotetrasiloxane	300	L
Cyclopentanone	22,000	L
Chemical Mechanical Polish (CMP) Slurries		
Tungsten polish	6,200	L
Copper polish	88,000	L
Barrier polish	60,000	L
Dielectric polish	10,000	L
Oxide polish	28,000	L
Oxidizers		
Hydrogen peroxide	110,000	L
Nitric acid	4,800	L
Ammonium peroxy disulfate	300	L
Specialty Gases		
Arsine	10 lbs	G
Diborane/Hydrogen Mix	20 lbs	G
Methyl Silane/Hydrogen Mix	90 lbs	G
Germane/Hydrogen Mix	30 lbs	G
Diborane/Nitrogen Mix	30 lbs	G

Phosphine/Hydrogen Mix	80 lbs	G
Boron Trichloride	300 lbs	G
Ethylene	40 lbs	G
Hexafluorobutadiene	300 lbs	G
Difluoromethane	200 lbs	G
Methyl Fluoride	100 lbs	G
Chlorine	500 lbs	G
Carbon Monoxide	600 lbs	G
Dichlorosilane	300 lbs	G
Fluorine/Argon/Neon	20 lbs	G
Fluorine/Krypton/Neon	40 lbs	G
Hydrogen Bromide	700 lbs	G
Hydrogen Chloride	4,100 lbs	G
Nitrogen Trifluoride	900 lbs	G
Ammonia	2,500 lbs	G
Silicon Tetrachloride	100 lbs	G
Silicon Tetrafluoride	700 lbs	G
Silane	900 lbs	G
Trimethylsilane	400 lbs	G
Tungsten Hexafluoride	1,300 lbs	G
Helium/Nitrogen Mix	300 lbs	G
Argon/Xenon/Neon Mix	400 lbs	G
Perfluorocyclobutane	300 lbs	G
Tetrafluoromethane	3,300 lbs	G
Fluoroform	900 lbs	G
Krypton/Neon Mix	10 lbs	G
Sulfur Hexafluoride	100 lbs	G
Sulfur Dioxide	200 lbs	G
Carbon Dioxide	1,200 lbs	G

4.2 Hazardous Materials Management – Engineering Controls

All three of the manufacturing technologies considered typically have similar commercially proven engineering control systems to allow for the management of hazardous materials in a manner that is protective of human health and the environment. The storage, use and management of hazardous materials described below typically applies to all three of the manufacturing technologies under consideration.

Hazardous process chemicals will be stored and/or used at several locations at a typical facility including outdoor areas, the chemical storage rooms, manufacturing process areas, and other indoor areas. The types and quantities of chemicals stored or used in each of these areas are typically documented in a Hazardous Materials Inventory Statement (HMIS) which is provided to the local Authority Having Jurisdiction (AHJ) as part of the safety and emergency planning efforts for a project. The following narrative describes the hazardous materials management practices and engineering controls typically provided for the advanced technology manufacturing facilities considered in this report.

OUTDOOR AREAS

Hazardous process chemicals are typically delivered and stored and/or used in the following outdoor areas:

Bulk gas yard:

The bulk gas yard would consist of steel tanks designed for storing cryogenic gases including argon, nitrogen, hydrogen, and oxygen. The tanks are typically located within a fenced area on a concrete pad. A truck offloading station is typically located adjacent to the tank pad on a concrete apron. The cryogenic gases stored at the bulk gas pad are non hazardous with respect to surface or groundwater contamination, and do not pose a risk to waters in terms of spill control and containment. A majority of the bulk gases used at these facilities are inert and do not pose a threat of a toxic release to the atmosphere. Silane gas, while not toxic is pyrophoric and is a source of silicon for thin film PV manufacturers. There are International, National and State codes and standards with respect to the design, construction, storage and use of silane. These include pressure regulation and emergency relief valves, separation distances to protect people and structures from an inadvertent release, flame and gas detection and fire protection deluge systems.

Emergency Generator Area:

Emergency standby back-up power is typically provided by several diesel fired emergency engine generators also located in an outdoor yard area. Each generator typically involves several thousand gallons of diesel fuel with secondary containment that consists of a rupture basin sized for 125% of the primary storage tank. The generator, tank and rupture basin is normally totally enclosed to prevent rainwater intrusion. Diesel deliveries typically occur over a concrete apron sloped to a catch basin to collect drips or spills that could occur during filling operations. The storage and use of this volume of oil is regulated by the Federal Spill Prevention Control and Countermeasures (SPCC) rules and NYSDEC regulations for the bulk storage of petroleum. These rules require oil storage to have secondary containment and facility owners to prepare, implement and have certified an SPCC Plan.

Bulk Fuel Oil Storage Area:

Depending on the findings of a natural gas supply reliability evaluation, some STAMP industry tenants may require bulk storage of fuel oil as a back-up fuel supply for the boiler systems. A typical bulk fuel oil storage and delivery system would include the following features:

- Full passive secondary containment for the tanks
- Double-contained transfer piping
- Leak detection
- Visual and audible alarms triggered by low and high fuel level indicators

Air Pollution Control and Wastewater Treatment Areas

Air pollution control systems typically include wet fume scrubbers to control acidic or alkaline vapors, ammonia or oxides of nitrogen, thermal oxidizers to control VOCs and baghouses or other filters to control particulates. Wastewater treatment systems typically involve heavy metal filtration and/or ion exchange, fluoride treatment (precipitation) and pH adjustment (neutralization).

The wet fume scrubbers are typically located in a secondary containment basin sized for 110% of the primary sump capacity plus 24 hours of rainfall from a 2-year storm event and equipped with a sump, sump pump, and level sensors. Any leak from the scrubber system to the containment area could be pumped to the wastewater treatment system. The containment area is typically coated with chemically resistant coatings to seal and protect the concrete and prevent leaks or spills from migrating through cracks and into the soil or groundwater below. Chemical piping to the scrubbers and drain piping from the scrubbers is normally double contained and equipped with low point leak detection. Mechanical connections on the piping are located inside a valve box enclosure also equipped with leak detection.

Wastewater treatment tanks are typically located inside a concrete containment area sized for 110% of the largest tank plus 24 hours of rainfall from a 2-year storm event. The containment area is typically coated with chemically resistant coatings to seal and protect the concrete and prevent leaks or spills from migrating through cracks and into the soil or groundwater below. Chemical or drain piping into or from these areas are typically in welded steel or chemically resistant tubing routed inside clear PVC secondary containment piping. Mechanical connections on chemical piping are located inside containment areas and/or valve boxes equipped with leak detection.

<u>Bulk Chemical Storage Area:</u>

Bulk chemical storage may include raw acids or concentrated acid waste. The material would be stored in lined steel tanks and equipped with high level sensors and vented to the air pollution control systems. The tanks would be provided with a containment basin coated with chemically resistant coatings and equipped with sumps, sump pumps, and leak detection. Chemical piping to and from the tanks could be either lined steel or chemically resistant tubing inside of secondary containment piping equipped with low point leak detection. Mechanical fittings in the piping systems are typically located inside ventilated valve box enclosures equipped with leak detection.

CHEMICAL STORAGE ROOMS

Hazardous chemicals used in these facilities are typically delivered to central a chemical storage & distribution room via a dock. These docks are typically designed such that delivery trucks back into the dock below a covered awning so that the material transfer operation is protected from the weather. The dock itself is normally surrounded by curbs and trenches and sloped towards the central chemical storage room such that firewater and/or leaks or spills drain into the central chemical storage room containment area.

The truck apron adjacent to the dock is often equipped with a trench that drains to a concrete containment sump or dedicated containment tank. The containment sump and surrounding area would be coated with chemically resistant coating to protect the concrete and prevent migration of leaks or spills. Either the sump or containment tank arrangement is typically designed to contain 125% of the largest container handled plus rainwater from a 2 year, 24 hour storm and if necessary 20 minutes of fire water flow. A sump would also be installed and equipped with a normally closed valve. Material collected in the sump and/or trench would be sampled and analyzed to determine appropriate disposition. If rainwater only is collected in the sump, operators would open the valve to allow drainage to the storm water collection system. If a spill occurs or analysis indicates the presence of hazardous material, operators could manually initiate sump pump operation to pump the material to the appropriate wastewater treatment system.

Other chemical storage rooms are designed to store all hazardous chemicals not in use or ready for use in the manufacturing or facilities areas. The rooms are typically designed with sloped concrete trenches and sumps to contain spills and firewater. The concrete is coated with chemically resistant coating to prevent leaks or spills from damaging the concrete or migrating through it. The trenches and sumps are sized to contain 110% of the largest container plus 30 minutes of firewater. Each area includes a low point sump and sump pump. Sumps are designed with level sensors to initiate sump pump operations and notify personnel of spills. Sump pumps can be piped to the appropriate wastewater treatment system. Typically there would be no floor drains in the chemical storage room that lead to either the sanitary or storm water systems.

MANUFACTURING PROCESS AREAS

Certain areas of the manufacturing process may rely on bulk chemical delivery systems as opposed to container (i.e., totes, 55-gallon drum, and bottles) transport and delivery of chemicals. For example, a majority of the hazardous process chemicals used in PV manufacturing occurs at the texturization process. From the chemical storage rooms bulk chemicals are pumped to the process areas via chemically resistant tubing inside clear secondary containment PVC piping. The secondary containment piping is equipped with low point drains and leak detection. Mechanical connections (valves) are located inside exhausted valve box enclosures equipped with leak detection.

Lower use hazardous process chemicals may be delivered in containers via carts and/or pallets designed with containment for 110% of the largest container being delivered. The containers are then transferred from the carts to bulk chemical delivery units (pumping stations) located inside the process areas where the chemicals are then pumped to the production tools via chemically resistant tubing inside clear secondary containment PVC piping. The pumping stations and mechanical fittings (valves) are located inside exhausted enclosures equipped with leak detection.

Chemicals are normally contained inside the production tools in holding vessels and/or processing tanks (wet benches). The production tools are ventilated to either point of use abatement systems or central air pollution control systems. The holding vessels and processing tanks are located inside enclosures designed to contain leaks or spills. Spent chemicals are pumped from the processing tanks on the wet benches to lift stations via chemically resistant tubing or piping inside clear secondary containment PVC piping. Lift stations consist of lined and unlined fiberglass reinforced plastic tanks and dual diaphragm pumps located in a coated secondary containment pan designed to contain 110% of the tank volume plus 30 minutes of firewater. Wastewater collected in the lift stations is pumped to the appropriate wastewater treatment system via chemically resistant piping or chemically resistant tubing or piping inside clear secondary containment PVC piping. The secondary containment piping is equipped with low point leak detection.

OTHER INDOOR AREAS

Hazardous process chemicals used in other indoor areas may include low volumes of acids, bases, solvents, and miscellaneous production and facilities chemicals. Locations where these materials are used may include manufacturing support areas such as laboratories and the central utilities building.

Manufacturing Support Areas:

Typical features of the containment systems for these areas include storage of small quantities of solvent in cabinets designed for solvent storage and the absence of floor drains in the manufacturing or nearby support areas.

Chemicals used in a laboratory would typically be delivered to the area in 1 gallon bottles via containment carts designed to contain 110% of the largest container transported. Chemical containers are stored in cabinets designed for their hazard class. Chemicals used in the labs are used in exhausted hoods or sinks equipped with collection containers or tanks. Chemicals used in the labs that are compatible with the site's wastewater treatment systems are discharged to the appropriate collection system and non-compatible materials are collected and managed for offsite disposal at a licensed facility. There are typically no floor drains in laboratory areas.

Central Utilities Building:

Chemicals are used for water and wastewater treatment in the central utilities building. Higher consumption utility chemicals are normally stored in the chemical storage room and pumped to the wastewater treatment systems. These utility chemicals would be routed via welded steel piping or chemical resistant tubing. Mechanical connections are located in valve box enclosures equipped with leak detection or in containment areas.

Lower volume chemicals used for water and wastewater treatment are typically delivered to the usage area in their original containers. Areas where these chemicals will be used are equipped with containment (curbs and/or trenches) and/or area sumps for collection of spills or leaks.

Wastewater treatment systems are located in concrete containment areas equipped with curbs or perimeter trenches designed to contain 110% of the largest tank. Containment area concrete is normally coated with chemically resistant coatings. Sumps in the wastewater treatment area are also designed with level sensors to initiate pump operations and notify personnel of spills. Sump pumps are piped to the appropriate collection, containment, or treatment tank for appropriate disposition. There are usually no floor drains in the wastewater treatment areas.

4.3 Hazardous Materials Management – Administrative & Regulatory Controls

A wide variety of environmental, health and safety laws and regulations and corporate standards or governance guide the design, construction, and operation of these facilities in a manner that minimizes adverse impacts to human health and the environment. Section 4.2 described the types of areas that may include the storage and use of hazardous materials and petroleum products and associated typical engineering controls. In New York, several regulatory programs are applicable to bulk chemical storage, bulk petroleum storage and waste management. These regulatory programs are as follows:

- Hazardous Substance Bulk Storage Program (6NYCRR Parts 595-599)
- Regulation of Petroleum Tanks (6NYCRR Parts 612-614)

Fundamentally, these two regulatory programs establish standards to mitigate adverse impacts to human health and the environment including groundwater and surface water resources. In general, the regulatory standards address:

- Tank registration
- Secondary containment
- Integrity testing
- Leak Detection
- Inspections
- Material compatibility
- Monitoring and recordkeeping

A summary of other EHS regulations and programs typically applicable to the types of industries considered in the report is provided below.

Daily operations at the manufacturing facility will involve the storage, handling and transporting of hazardous materials. The risk to public health and safety is greatly reduced through the use of a variety of regulated hazardous materials storage and use practices, the aforementioned engineering controls and compliance with applicable building, safety and environmental laws and regulations. All hazardous materials would be transferred to and from the site in Department of Transportation (DOT) approved containers by licensed chemical transporters. Facility system design and daily operations at the facility would comply with the Uniform Fire Code, Uniform Building Code and a site specific Hazardous Material Management Plan approved by the local fire department. Employees handling hazardous materials or waste will be trained in accordance with OSHA and RCRA regulations and supplemental corporate requirements.

Multiple Environmental, Health & Safety programs will be implemented at the facility to comply with code, EPA, and OHSA regulatory requirements. These are briefly described below.

- OSHA Hazard Communication (HAZCOM) – Hazard communication in accordance with 29 CFR 1910.
- Flammable Liquid & Hazardous Chemicals – Storage in Underwriters Laboratory (UL) approved flammable containers. Compliance with State Hazardous Substance Bulk Storage program as applicable.
- Hazardous/Flammable Vapors – Ventilation to achieve safe occupational exposure limits
- Compressed Gas Cylinders – Secured storage and appropriate valve protection caps.
- Confined Space Entry – Defining confined space and entry/retrieval protocols.
- Control of Hazardous Energies – Lockout/Tagout program for servicing energized equipment
- Personal Protective Equipment – Applicable to energized electrical work and hazardous materials handling.
- Emergency Response/Evacuation – Safe evacuation procedures and arrangements with local emergency response agencies.
- Ergonomics – Work procedures to minimize musculoskeletal disorders (MSD)
- Fall Protection
- Forklift Operation – Operator training and safety inspection checks.
- Incident/Injury Investigation Prevention & Reporting
- Labeling – Labeling of chemical containers with OSHA approved labels.
- Ladders & Scaffolding – OSHA approved ladders and Scaffolding
- Non-Electrical Hotwork – Permit program for protocols involving any open flame or spark producing equipment.
- Safety Showers & Eye Washes – Located during facility design.
- Storm Water/Groundwater/Surface Waters – Implement General Industrial Storm Water Permit conditions including Storm Water Pollution Prevention Plan (SWPPP), comply with NYSDEC bulk hazardous substance, bulk petroleum storage and waste management regulations.
- Air Quality – Implement air permit conditions. Track and report air emissions.
- Hazardous Waste – Employee training, implement contingency plan, waste manifesting and recordkeeping.
- Wastewater – Wastewater monitoring, sampling and submission of a monthly discharge monitoring report.

4.4 Nanotechnology Specific Considerations

Because the properties of nanoscale materials differ not only based on molecular identity, but also based on size and shape, a comprehensive understanding of nanomaterial risks and control strategies is still being developed. As such, margins of caution and safety are typically used when potential exposures to nanoparticles may occur.

Below is a brief summary of considerations provided by the regulatory agencies and institutes evaluating the environmental health and safety aspects of nanoscale particles.

<u>EPA</u>

Nanoscale materials can qualify as fundamentally new chemical substances, and the EPA requires manufacturers to determine if their materials are new or previously classified based on molecular identity.

If the nanoscale materials are determined to be new, a review is required to determine what action, if any, is required to ensure that the material does not pose unreasonable risk to human health or the environment. Since 2005, the EPA has received and reviewed around 100 new chemical notices under the Toxic Chemical Substances Act (TSCA) for nanoscale materials, including carbon nanotubes. The Agency has taken a number of actions to control and limit exposures to these chemicals, including limiting the uses of the nanoscale materials, requiring the use of personal protective equipment, limiting environmental releases, and requiring testing to generate health and environmental effects data.

If the nanoscale material is determined to be existing, regulatory review by the EPA may still be required, specifically if the use of the material qualifies as a significant new use. Under this case, the EPA may require Significant New Use Notice to provide detailed data on the nanoscale material and its role in production.

<u>OSHA</u>

The Occupational Safety and Health Act (OSHA) treatment of nanomaterials is generally covered under their General Duty Clause (Section 5(a)(1)). A few key OSHA standards that might apply to production situations involving nanomaterials include, but are not limited to, the following:

- 1904, Recording and reporting occupational injuries and illness
- 1910.132, Personal protective equipment, general requirements
- 1910.133, Eye and face protection
- 1910.134, Respiratory protection
- 1910.138, Hand protection
- 1910.141, Sanitation
- 1910.1200, Hazard communication

- 1910.1450, Occupational exposure to hazardous chemicals in laboratories
- Certain substance-specific standards (e.g., 1910.1027, Cadmium)

NIOSH

The National Institute for Occupational Safety and Health (NIOSH) provides guidance on the occupational safety and health implications and applications of nanotechnology.

NIOSH generally regards nanomaterial enabled bulk products that incorporate nanoparticles or nanoscale features to have a low risk due to their non-inhalable size (e.g. composites, integrated circuits). NIOSH offers precautionary measures to mitigate potential environmental, health and safety risk associated with nanomaterial processing and it is anticipated these and other measures would be evaluated by STAMP tenants at a minimum. NIOSH precautionary measures include the following:

- The control of airborne exposure to nano-aerosols can be accomplished with standard engineering controls similar to those used to control general aerosols.
- Implement a risk management program to mitigate nanomaterial exposure. Program elements would include the following:
    - Evaluate hazards based on available physical, chemical, toxicological and health-effects data.
    - Assess worker job task to identify potential exposures
    - Educate and train workers in the proper handling of nanomaterials
    - Establish criteria for evaluating engineering controls (exhaust ventilation and control) at areas where exposure potential exists
    - Develop procedures for selecting proper personal protective equipment
- Well designed exhaust ventilation systems with high-efficiency particulate air (HEPA) filters can effectively remove nanomaterials.
- Implement good work practices include the use of HEPA vacuum pickup and wet wiping methods.
- Evaluate the use of respirators in additions to engineering and administrative controls.

5. WASTEWATER

5.1 Wastewater Sources and Treatment

All of the industries considered in this report have the potential to generate wastewater from manufacturing process and process support systems. Wastewater generated on the various sites will be collected prior to treatment and will be treated to meet the applicable requirements of the Clean Water Act, as codified with Title 40 of the Code of Federal Regulations and local sewer use ordinances. Federal categorical pretreatment standards may apply to certain dischargers. For example, PV or semiconductor manufacturing can involve wastewater discharges subject to 40 CFR Part 469 – Electrical and Electronic Components Point Source Category. STAMP industries will discharge to a POTW and Pretreatment Standards for New Sources (PSNS) would typically apply. These standards include limits on pH and total toxic organics. Wastewater generated by these industries requires relatively conventional and commercially proven treatment technologies.

Table 5-1 provides a summary of the typical wastewater constituents and treatment technologies prevalent in the industries considered.

Table 5.1-1 – Typical Wastewater Constituents and Treatment Methods

Constituent	Treatment Method
Inorganic acids & bases	Acid/Base Neutralization
Fluorides	Precipitation, flocculation & filtration
Metals	Precipitation and/or filtration with ion exchange
Metals (low concentrations)	Ion exchange

5.2 Wastewater Characteristics

After treatment, wastewater will be discharged to the local municipal sanitary sewer in accordance with pretreatment standards, local effluent limits and permit conditions. Typical estimated wastewater constituent concentrations associated with each of the industrial manufacturing groups is summarized in Table 5.2-1 below.

Table 5.1-1 – Typical Wastewater Constituents

Primary Manufacturing Technology Exhibiting these Characteristics	Wastewater Constituent	Anticipated Level or Concentration at Monitored Point of Compliance	Typical Local Limit
All	pH	6.0 - 9.0	5.0 - 11.0
All	TSS	100 - 300 mg/l	300 mg/l
All	TDS	< 1500 mg/l	
All	Appearance	Clear, no color or odor	
All	COD	< 300 mg/l	500 mg/l
All	BOD	< 300 mg/l	400 mg/l
All	Temperature	< 80^{O}F (26.6^{O}C)	< 140^{O}F (<60^{O}C)
All	Total Toxic Organics	n/d	1.37
All	Oil & Grease	< 50 mg/l	< 100 mg/l
cSi	Nitrate	< 350 mg/l	n/e

All	Sulfate	< 150 mg/l	n/e
FPD/ Med Imagining	Phosphate	< 15 mg/l	n/e
All	Chloride	< 100 mg/l	n/e
All	Fluoride	< 15 mg/l	n/e
CIGS	Ammonia (as NH3)	< 285 mg/l	n/e
CIGS	TKN	< 250 mg/l	n/e
All	Antimony	n/d	10 mg/l
All	Arsenic	n/d	0.3 - 1.4 mg/l
All	Beryllium	n/d	0.3 mg/l
All	Cyanide (total)	n/d	0.3 - 1.5 mg/l
All	Chromium	n/d	2.0 - 5.0 mg/l
CIGS, CdTe	Cadmium	0.025 mg/l	0.04 - 0.3 mg/l
Nano	Copper	<1.0	1.0 - 4.0 mg/l
Nano	Lead	<0.3	0.5 - 1.1 mg/l
All	Nickel	n/d	0.8 - 2.0 mg/l
cSi	Silver	0.01 mg/l	0.02 - 0.40 mg/l
All	Zinc	n/d	0.5 - 5.0 mg/l
All	Selenium	n/d	2.5 mg/l
All	Mercury	n/d	0.001 - 0.008 mg/l

n/d = non-detect (below detection limits)

n/e = Local limit not typically established

5.3 Wastewater Generation Rate

The estimated maximum average daily wastewater generation rate from the proposed facilities is provided in Table 5.3-1 below. These estimated flow rates include all treated process wastewater, wastewater generated from utility systems (i.e., cooling tower blowdown) and sanitary wastewater and thus represents the estimated wastewater discharge rate delivered to the municipal sewer system.

Table 5.3-1 – Typical Wastewater Generation Rates

Manufacturing Technology	Maximum Gallons Per Day (gpd)	Production Capacity Basis (MW)
PV – Crystalline Silicon	460,000	170
PV – Amorphous Silicon	200,000	140
PV – CdTe	450,000	280
PV – CIGS	520,000	690
FPD/ Med Imaging	420,000	200,000 s.f. or ~15,000 sheets/mo

Nano	340,000	400,000 s.f. manufacturing area
Totals	2,390,000	

6. Air Emissions

6.1 General Description

In general, the sources and types of regulated air emissions across the proposed technology manufacturing facilities considered are as follows:

Industry	Air Emission Source	Types of Regulated Air Pollutants	Typical Control Strategies
All	Combustion sources including: • Boilers (natural gas with potential fuel oil back-up) • Emergency Stand-by Generators (diesel fueled) • Thermal Oxidizer VOC Abatement (Natural gas) • Point-Of-Use toxic gas abatement (Natural gas)	Criteria Pollutants including: • Particulate Matter • Sulfur Dioxide • Nitrogen Oxides • VOCs • Carbon Monoxide Minor source of Hazardous Air Pollutants (HAPs)	Multiple strategies including: • Use of natural gas as a clean fuel • Low Nox burners and/or flue gas recirculation for boilers • Optimized combustion mechanics for emergency generators to comply with Federal EPA New Source Performance Standards
PV – Crystalline Silicon	• Volatilization of solvent from screen printing operations	• Volatile Organics Compounds (VOCs) • HAPS (typically glycol ethers)	• Thermal oxidation can typically achieve an overall VOC destruction/removal efficiency of 90%.
	• Cell Texturization and cleaning steps using adicic and alkaline wet chemicals including for example nitric acid, hydrofluoric acid, hydrochloric acid	• HAPS (HF & HCl) • Nitrogen Oxides	• Wet scrubbing using chemical adsorption can remove at least 90% of these emissions
PV – Amorphous Silicon	• Silicon deposition processes using silane. Non-deposited silane can form silica, a fine particulate	• PM2.5	• Point-of-use (POU) abatement providing oxidation with scrubbing/cooling section followed by central house wet

			scrubbing can remove at least 90% of these pollutants.
	• Chamber cleaning using Nitrogen Trifluoride	• Hydrofluoric Acid	• Point-of-use (POU) abatement providing oxidation with scrubbing/cooling section followed by central house wet scrubbing can remove at least 90% of these pollutants.
PV – CdTe	• Metal deposition processes including Cadmium deposition	• PM • HAPs (cadmium)	• High Efficiency Particulate Absorbing (HEPA) filters can remove at least 99% of these contaminants.
	• Photoresist operations or spray on metal deposition operations	• VOCs • Methanol	• Thermal oxidation can typically achieve an overall VOC destruction/removal efficiency of 90
PV – CIGS	• Metals deposition processes, e.g., sputtering	• PM	• High Efficiency Particulate Absorbing (HEPA) filters can remove at least 99% of these contaminants.
	Cadmium Sulfide Chemical Bath Deposition & associated cleaning steps.	• Acid gases including HCl • Ammonia • Hydrogen Sulfide	• Wet scrubbing using chemical adsorption can remove at least 90% of these emissions
FPD & Nano	Photoresist operations and cleaning with organic solvents	• VOCs	• Thermal oxidation is capable of destroying at least 90% of these pollutants.
	Cleaning & etching steps using acidic and alkaline wet chemicals including for example nitric acid, hydrofluoric acid, hydrochloric acid	•	• Wet scrubbing using chemical adsorption can remove at least 90% of these emissions
	Material handling operations	• PM 2.5	• High Efficiency Particulate Absorbing (HEPA) filters can remove at least 99% of

			these contaminants.

6.2 Air Emission Characteristics

The estimated annual emissions (potential to emit) of regulated air pollutants from any single stationary source constructed in the Park is anticipated to be below major source threshold, i.e., less than 100 tons per year (tpy) of any single criteria pollutant, less than 10 tpy of a hazardous air pollutant, or less than 25 tpy of combined hazardous air pollutants. Table 6.2-1 provides the estimated annual criteria pollutant emissions from fuel combustion sources for a single representative factory and the combined facilities. Table 6.2-2 provides the estimated post abatement criteria pollutant and HAP emissions from manufacturing process operations for a single representative factory and the combined facilities. A single representative factory is considered to be a 200 MW solar PV plant (considering the air emission characteristics of all PV technologies in a single plant) and the combined facilities represents full build out of all STAMP manufacturing operations using the mix assumptions provided in Section 1.0.

Table 6.2-1 –Criteria Pollutant Emissions from Fuel Combustion Sources

Pollutant	Single Factory Emission (tpy)	All Facilities (tpy)
Nox	22.4	164.1
CO	16.8	123.4
SO_2	6.2	45.8
PM_{10}	1.7	12.8
$PM_{2.5}$	1.7	12.8
VOC	1.2	8.5

Table 6.2-2 – Criteria Pollutant & HAP Emissions from Manufacturing Processes Operations

Hazardous Air Pollutant	Single Factory (tpy)	All Facilities (tpy)
Hydrofluoric Acid	5.8	10.6
Hydrochloric Acid	5.3	11.8
Glycol Ethers	4.0	4.0
Methanol	5.6	9.0
Cadmium	0.00061	0.00061
Phosphine	0.0100	0.014
Chlorine	nil	1.1
HAP Total	20.7	36.5
Criteria Pollutant		
VOC	47.6	102.3
NOx	20.0	20.0
PM2.5	14.4	14.6

Hydrogen Sulfide	0.1	0.4
Criteria Total	82.1	137.3
Other		1.2
Ammonia	6.8	24.9

7. Solid and Hazardous Waste

7.1 Generation Rates

Estimated solid and hazardous/regulated waste generation rates are provided in Table 7.1-1 below.

Table 7.1-1 Solid and Hazardous Waste Generations

Hazardous or Regulated Waste Stream	Single Factory (lb/mo)	All Facilities (lb/mo)
Solvent/Metals contaminated debris	700	2,900
Broken Glass contaminated with metals	2,900	14,000
Metals contaminated steel plates	300	3,200
Corrosive liquids	3,200	200,000
Metals contaminated bead blast media	300	700
Metal contaminated filters	400	3,700
Spent Organic Solvents	1,000	260,000
Corrosive liquids with metals	70	2,800
Cadmium Contaminated Debris	7,100	7,100

Other Solid Waste		
General Manufacturing Waste	120,000	2,300,000
Calcium Fluoride Sludge	2,000,000	6,000,000

Major Recycle Streams		
Broken/Off-Spec Glass	6,200	50,000
Polyvinyl Butyl Scrap	22,000	22,000
Cardboard, paper, plastic		varies

8. Other Utilities

8.1 Water

All of the prospective industries for the STAMP project require a relatively pure and consistent supply of water. Deionized water (DIW) or ultrapure water (UPW) is the primary cleaning liquid used in all of these facilities. Anticipated water treatment technologies used may include reverse osmosis (RO), filtration, ultraviolet (UV) sterilization, ozonation and ion-exchange.

Water reuse is also a typical consideration during facility design. Dilute process rinse waters can be recycled back through the UPW system or used as utility make-up water for cooling towers or scrubbers. Anticipated water demand for the proposed manufacturing facilities is provided in Table 8.1-1 below.

Manufacturing Technology	Maximum Gallons Per Day (gpd)	Production Capacity Basis (MW)
PV - Crystalline Silicon	650,000	170
PV - Amorphous Silicon	280,000	140
PV - CdTe	450,000	280
PV - CIGS	750,000	690
FPD/ Med Imaging	460,000	200,000 s.f. or ~15,000 sheets/mo
Nano	400,000	400,000 s.f. manufacturing area
Totals	2,990,000	

8.2 Natural Gas

Natural gas will be needed for the following facility systems:

- Fuel for boilers which provides both process and building heat
- Fuel for hot water for sanitation and showers
- Fuel for Point of Use (POU) air pollution control systems
- Fuel for VOC abatement system.

The estimated annual consumption of natural gas for the combined facilities is 2700 MMCF/yr.

8.3 Electricity

The estimated electrical demand for all the manufacturing facilities including their associated support systems is 174 MW.

8.4 Fuel Oil

Distillate oil (No. 1 or No. 2) will be used to power emergency standby generators or used as a back-up fuel supply for the boiler systems in the event of a natural gas outage. Estimated fuel oil demand for all combined facilities with the park is provided in Table 8.4-1 below. These estimates assume boilers would operate on back-up fuel for up to 14 days per year each and the emergency standby generators would operate 100 hours per year. With respect to fuel oil consumption these are expected to be maximal conditions. Under normal operation, without interruption of the natural gas or power supply, the boilers and emergency generators would likely operate on fuel oil for less than 20 hours per year for testing and maintenance.

Table 8.4-1 Maximal Fuel Oil Consumption

System	Gallons/yr
Boiler Fuel Oil Back-up	1,300,000
Emergency Standby Generators	140,000

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