Project Roland

Retrofitting a Cleanroom to achieve ISO Class 3: *A Case Study*

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Agenda

- Introduction
- Facility Modifications
- Utility Modifications
- New Tool Set
- Construction Project
- Certification and Commissioning

Existing Cleanroom

- 60,000 square feet of Class 10 (0.3µm)
- Designed 1984, Constructed 1985
- Small chases, accessible only from cleanroom
- Sidewall air return, upflow through chase
- Ballroom in diffusion area, penetrations through waffle slab

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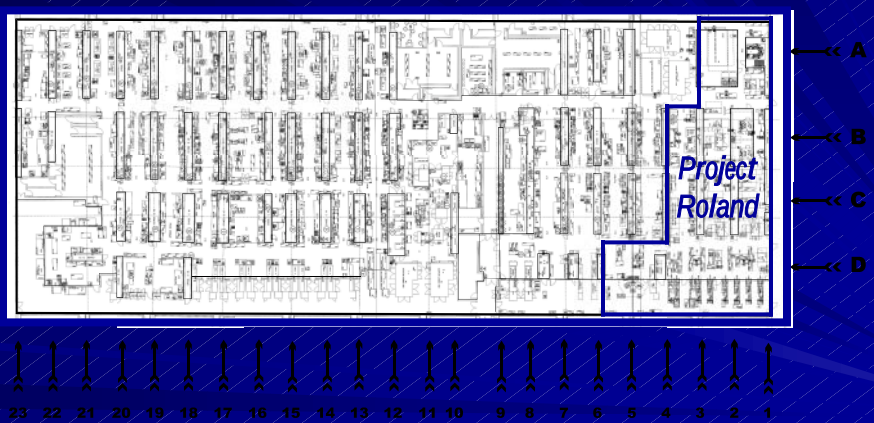
Layout of Fab III



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Photos of Fab III

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Project Goals

- Overall Goal
  - Successfully implement a **new wafer size** and **process technology** that require a **new tool set** and a **higher level of cleanliness**
- Individual Goals
  - Achieve ISO Class 3 cleanroom conditions
  - Perform clean-installation of new tool set
  - Minimize construction cost
  - Bring new process into operation as rapidly as practical

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Process Capability Improvement

ASIC fab with several process families and hundreds of part numbers

- Minimum feature size
  - 1.0 µm => 0.75 µm
- Wafer size
  - 5-inch => 8-inch

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Boundary Conditions

- Maintain operation of existing fab
  - Minimum utility interruptions
  - No cleanliness impact
  - Minimum vibration transmission
- No increase in cleanroom footprint
- Turnaround space must be in existing cleanroom

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Strategy

- Facility Modification
- Utility Upgrade
- New Tool Set
- Clean-Construction Protocol
- Upgrade Operational Protocol in Entire Facility

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Wall Layout

- Minimize area under filter
- Maximize chase sizes
- Bulkhead-mount equipment

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Small Cleanroom Aisles

- Activities in aisle
  - Support functions only
  - Operator traffic
- Comprehend small cleanroom population
- All computer monitors in chases
  - Cleanliness
  - Cleanroom footprint eliminated

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Chase Configuration Before and After

Small chase, big bay
Original facility design

Big chase, small bay
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Bay Configuration *Before and After*

Wide bay with equipment in cleanroom area
Original facility design

Narrow bay, minimal equipment
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Ion Implanter
Before and After

Ion Implanters in cleanroom
Original facility design

Ion Implanter recessed in chase
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Filter replacement

- Original filters
  - Particle-board frame
  - Foam gaskets
  - Fiberglass medium
  - HEPA-rated (99.97%@0.3µm)
  - 15-years old
- New filters
  - Aluminum frame (custom extrusion)
  - Gel seal built into housing
  - Expanded PTFE medium
  - Low-outgassing potting
  - ULPA-rated (99.999%@0.1µm)

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Raised Floor vs. Solid Floor

- Virtually all ISO Class 3 facilities are built with a raised floor
  - Simplified air handling
  - Better unidirectionality
- Retrofit would be awkward
  - Low ceiling height *or* complex overhead rearrangement
  - Step-up from other areas of cleanroom and from perimeter aisle
  - Serious problems in movement of equipment

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Retain Solid Floor

- Minimizes expense
- Simplifies logistics
- Unidirectionality is biggest challenge
  - Imaginative equipment installation
  - Fine-tuning of airflow

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“Fine Tuning” Airflow

- Air return through equipment
- “Raising” equipment
- Maximizing low-return space
  - Door panels
  - Half-size walls (would be blanks)
- Varying supply velocity as required
  - “Blending” changes in velocity

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Centura™ System “On Blocks”

Note blocks used to raise system and allow increased air-return area

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Baseline Utility Study

- Capacity
  - Model existing tool set
  - Compare to actual usage
  - Model new tool set
  - Project new usage level
- Quality
  - Applies to process gasses
  - Point of generation / Storage location
  - Building entry point
  - Point of use

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Quality Metrics

- Particle concentration
- Moisture level
- Oxygen concentration
- Metals

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Add New Quality Level For Process Gasses

- Additional process system
  - Fed by existing high-purity mains
  - Adds to utility-grade and high-purity-grade systems
- Used selectively
  - Based on engineering judgement
  - Wafer-contact fluids only
  - Critical process tools

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Certified Quality Of Installation

- Third-party certifier
  - Special training for installers
  - Twice-per-shift weld certification
- State-of-art fabrication methods
  - New welding equipment
  - Dedicated fabrication cleanroom
  - Special purging methods/materials
- Commissioning of each line

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New Tools

- 8-inch wafer capability
- Bulkhead mounting (most)
- Low particle additions
  - Wafer
  - Room
- High MTBF

Refurbished Tools

- Refurbished by manufacturer
  - In factory
  - On site
- Same specifications as new tools

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Construction Goals

- Maintain operation of existing cleanroom
  - 24-7 operation
  - Class 10 environment
- Minimize downtime of relocated equipment
  - Schedule around production needs
  - Maximize resource allocation when tool taken out of service
- Final cleanliness is paramount
- Cost control and efficient construction techniques

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Developing the Task List

- Train construction workforce
- Relocate equipment in construction area that will be used elsewhere in the fab
- Isolate construction area
- Demo construction area
- Relocate walls as required
- Perform filter modifications and replacement
- Complete utility fit-up
- Install equipment
- Perform final cleaning
- Commission cleanroom
- Commission equipment

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Chronological and Physical Phasing

- Develop completion schedule by area
  - Tool delivery
  - Physical access to areas
  - Process needs
- Develop contingencies for delays
  - Tool delivery
  - Construction
- Utilize critical-path management techniques

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Phasing of Cleanliness

- Determine contamination caused by various stages of construction
- Build protocol sequence based on
  - Task list
  - Contamination generated
  - Cleanliness needs
- Develop training and enforcement plans

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Cleanliness Phases

- Tool Relocation
  - Full gowning and protocols
- Demolition
  - No gowning requirements
- Wall and Filter Modification
  - No gowning requirements
  - Restricted practices
- Fit-up
  - Frocks, hair covers, gloves
  - Highly restricted practices
- Equipment Installation
  - Full jumpsuits - polyester
  - Cleanroom protocols
- Commissioning and Punch List
  - Full production gowning and protocols

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Cleaning After Construction

- Cleaning follows protocol levels
- By end of construction, little to no visible contamination
- Intensive training of cleaning personnel
- Final clean is iterative
  - Vacuum, mop/wipe, vacuum
  - Measure with wipers/blacklight and Q3
  - Repeat as required

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Filter Certification

- Media leakage
  - PSL challenge
- Seal leakage
  - Gel seal
  - Gasket seal
- Flow

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Cleanroom Certification

- Parallelism
  - Continue “fine tuning” of airflow
- Airflow
  - To “custom velocity” map
- Cleanliness

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Utility Certification

- Evaluate at sample locations to established specification
  - Quality
  - Pressure
  - Volume

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Tool Certification

- Processing performance criteria
- Particle additions to wafers
- Airflow contributions
  - Positive and negative
  - Hand-in-glove with parallelism
- Particle additions to room
- MTBF

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Gowning Procedure

- Improved pregowning
- Better training for gowning process
  - Retrained entire workforce
  - Produced video for occasional cleanroom personnel
  - Institutionalized processes
- Increased enforcement
  - Especially during first week
    - habit formation
    - supervised gowning

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Cleanroom Garments

- PTFE-laminate garments
  - Significant improvement in cleanliness
  - Lower contaminant “add-ons”
- Garments assigned to individuals
- Upgraded laundry facilities

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Cleanroom Cleaning

- Instituted new cleaning procedures throughout fab
- Upgraded cleaning materials and equipment
- Retrained cleaning workforce

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Protocol Refresher Training

- Retrained workforce on cleanliness needs and product impact
- Reasserted importance of protocol compliance
- Stressed operator empowerment to enforce protocols
- Reiterated critical protocols

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Protocol Enforcement

- Retrained leadership team
  - Cleanliness needs/product impact
  - Importance of protocol compliance
  - Criticality of personal example
- Enhanced enforcement during beginning of program
  - Setting positive habits
  - Communicating seriousness of intent to operators

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Results

- Certified to ISO Class 3
- Process capability projections exceeded
- Yield far above targets

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