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Cost Effective Negative Plenum Cleanroom for Microelectronic Engineering Undergraduate Programme

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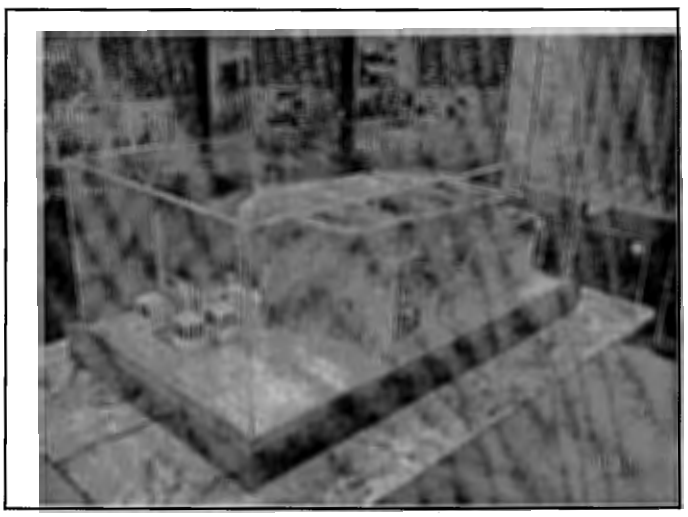
ABSTRACT

The Negative Plenum Cleanroom which is design and built by KUKUM is primarily used for the teaching of the undergraduate microelectronic course. The cleanroom is approximately 115m² in size. The level of cleanliness in the cleanroom ranges from ISO Class 5 (Yellow Room) to ISO Class 8 (Grey Area/Utility Chase). The cleanroom is constructed with a negative plenum to house the fan filter units, which make it different from other commercially available cleanrooms. With negative plenum, maintenance work cost will be reduced and make the cleanroom life longer. The main intention of this project is to expose and teach students to appreciate the stringent cleanroom protocols, health and safety requirement in addition to the formal course works.



Micro Fabrication Cleanroom model and have obtained Gold Medal in ITEX 05 and IPTA Research Exposition 05.

INTRODUCTION

The Micro Fabrication Cleanroom in KUKUM is the first and largest purpose built teaching laboratory constructed by a university in Malaysia. It was completed in December 2003 as shown in Figure 1.The total area is 115m^2 which comprises of a yellow room (ISO Class 5), white room (ISO Class 6), characteristic room (ISO Class 6), preparation room (ISO Class 7), changing room (ISO Class 7), and grey area (ISO Class 8).

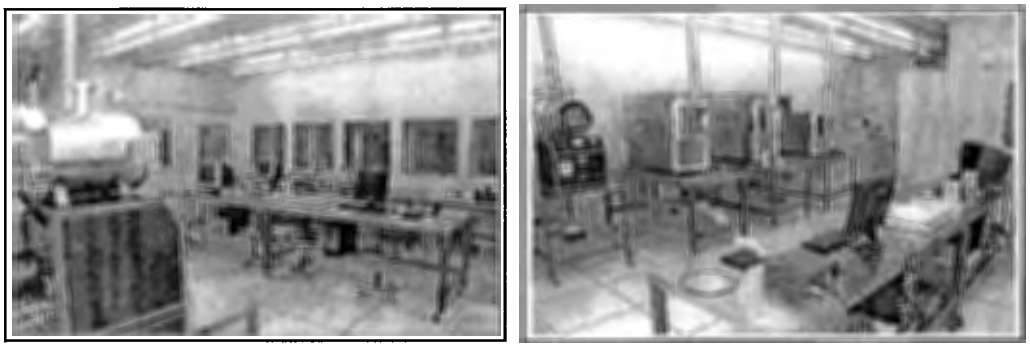


Figure 1: The Completed Micro Fabrication Cleanroom.

The Micro Fabrication Cleanroom is equipped with distributed process gases such as purified nitrogen, oxygen and compressed dry air and 18.0MΩ ultrapure water system supplied to the three fume hoods. Exhaust air from the fume hood are channeled to the laboratory scrubber system for treatment. The cleanroom is constructed with a negative plenum to house the fan filter units shown in Figure 2, which make it different from other commercially available cleanrooms. Despite being a teaching facility, the cleanroom was designed and specified to keep up with the ISO Class 5 cleanroom standard. It is also provided with features such as air showers, talk through and pass boxes, usually found in similar commercial facilities. The Micro Fabrication Cleanroom Facility Layout is shown in Figure 3 and perspective view of Micro Fabrication Cleanroom is shown in Figure 4.

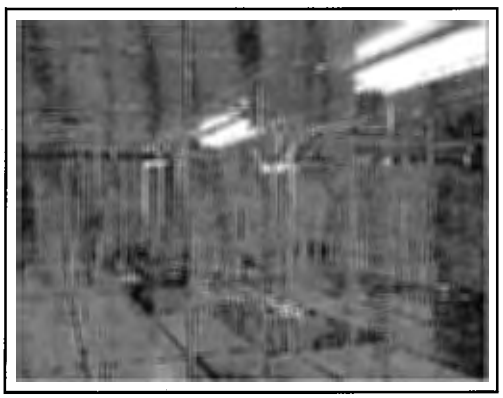


Figure 2: Cleanroom Plenum (negative) with Fan Filter Units.

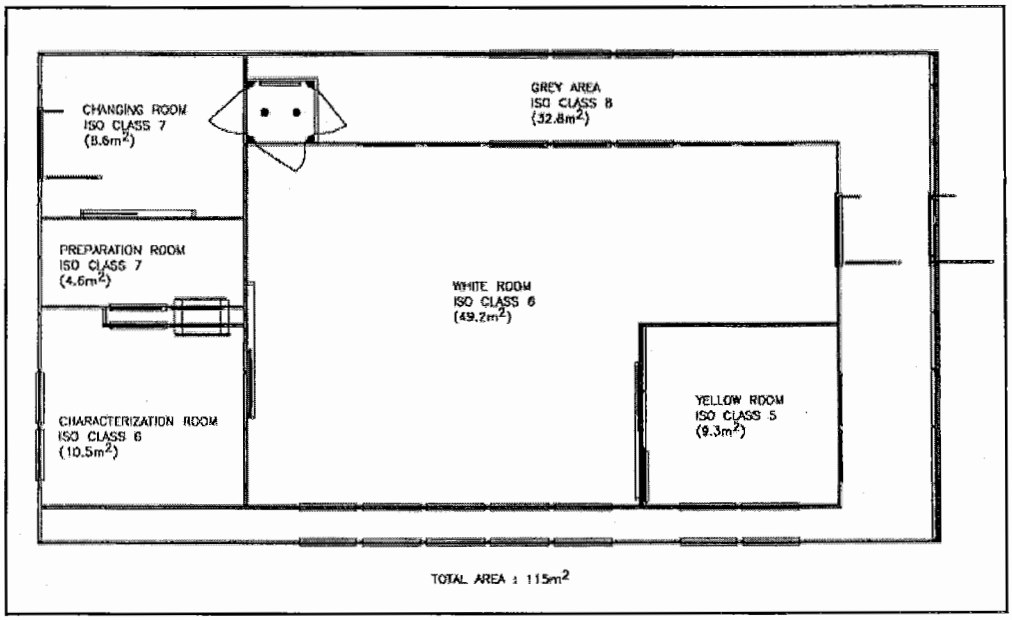


Figure 3: Micro Fabrication Cleanroom Facility Layout.

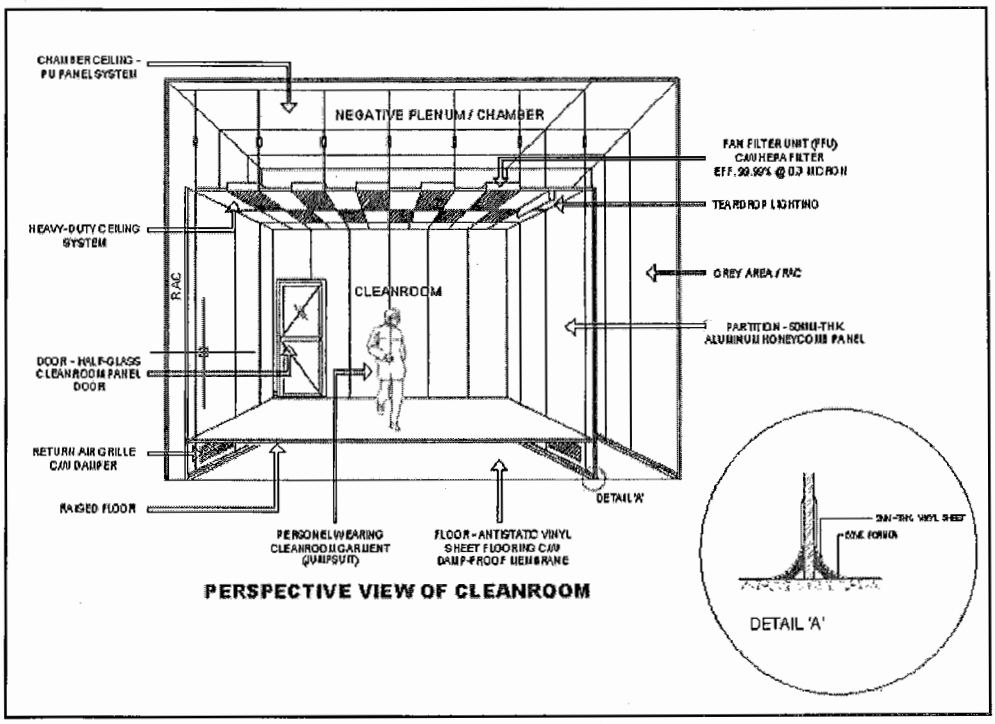


Figure 4: Perspective View of Micro Fabrication Cleanroom.

CLEANROOM

Cleanroom is defined as a specially constructed room which the air supply, air distribution, dust/airborne particle, room pressure, temperature and humidity are environmentally regulated to meet appropriate cleanliness level. This cost effective Negative Plenum Cleanroom for Microelectronic Engineering Undergraduate Programme consists of three main elements: a) Cleanroom design and specifications, b) Cleanroom Facility and c) Negative Plenum Vs Positive Plenum System.

a) Cleanroom design and specifications

i. Cleanliness At 0.1 µm/m^3: ISO Class 5 (Yellow Room), ISO Class 6 (White Room And Characterization Room), ISO Class 7 (Changing Room), ISO Class 8 (Grey Area)
ii. Air Change: 30-240/Hr
iii. Air Velocity: 0.45/s ± 15
iv. Relative Humidity: 50 ± 5%RH
v. Temperature: 23 ± 2°C
vi. Noise: < 70 Db
vii. Lighting: > 450 Lux
viii. Plenum Type: Negative Plenum
ix. Room Pressure: ± 30% to the Adjacent Area
x. Floor Type: Antistatic Vinyl Sheet and Perforated Raise
xi. Room Height: 3 Meter
xii. Partition/Panel Type: Aluminum Honeycomb Panel.
xiii. Ceiling Type: Cleanroom Heavy Duty

b) Cleanroom Facility

i. Gas Distribution System
ii. De-Ionized (DI) Water System
iii. Air Handling Unit (AHU) and Air Conditioning System
iv. Electrical and Safety System
v. Exhaust and Scrubber System
vi. Fan Filter Unit
vii. Air Shower
viii. Damper

c) Negative Plenum Vs Positive Plenum System

Table 1: Negative Plenum Vs Positive Plenum System.

DESCRIPTION	NEGATIVE PLENUM SYSTEM	POSITIVE PLENUM SYSTEM
SYSTEM CONCEPT	Aircon Unit provides Cooling Air only. Fan Filter Units (FFUs) provides Circulation Air inside cleanroom. Therefore Supply &Return Air Ducting System for Aircon Unit is smaller.	Aircon Unit provides both Cooling Air & Circulation Air. Therefore, Supply & Return Air Ducting System for Aircon Unit is larger.
CONSTRUCTION CONCEPT	Cleanroom ceiling to Negative Chamber on top does not need to be 100% airtight. Air going into the cleanroom will only go through the Fan Filter Units. Can access Chamber from cleanroom for replacement of Filters, etc. Filters mounted on cleanroom ceiling does not need to be sealed 100% all round.	Cleanroom ceiling to Positive Chamber on top has to be 100% airtight so that air going into cleanroom is 100% filtered through the Filters. Cannot access Chamber directly from cleanroom. Filters mounted on cleanroom ceiling has to be sealed 100% all round.
MAINTENANCE	Easy to remove & replace filters without any sealant to remove or reapply from inside Chamber. Interruption to Cleanroom System operations is minimal.	Sealant around the filters has to be removed in order to change filters and reapplied after installation of new filters. Interruption to Cleanroom System operations is more.

AIRFLOW VELOCITY, TEMPERATURE, HUMIDITY &PARTICLE COUNT DISTRIBUTION	Each FFU airflow velocity can be adjusted by built-in speed controller of FFU to control even airflow velocity, therefore temperature, humidity & particle count distribution is better.	Airflow velocity of each Filter cannot be controlled individually. There will be differences in airflow velocities near the wall perimeter to centre of room, therefore temperature, humidity & particle count distribution is affected.
UPGRADING FLEXIBILITY	No. of FFUs can be increased or decreased to suit level of cleanliness required easily without any change in cleanroom ceiling, duct sizes, etc. Easy to upgrade or downgrade	Any increase or decrease in no. of filters will affect cleanroom ceiling airtightness, Aircon Unit capacity & supply / return air duct sizes. Difficult to upgrade or downgrade
SYSTEM RELIABILITY	Cleanliness level inside cleanroom can still be maintained even when a few FFUs breakdown. Shorter breakdown time as replacement of FFU components is fast. Spare Parts will be kept for convenience.	Total cleanroom system failure happens when Aircon Unit breakdowns. Longer breakdown time as replacement of Aircon Unit parts is slower & involve dismantling of duct work.

Basic Principle of Cleanroom

In order to maintain cleanliness in cleanroom, 'Four Principles' shown below must be observed.

a. Not to Bring Any Dust

It is to make sure that no dust leakage from HEPA filters and frames. Installation filter leak test can be carried out for clarification. Positive pressure in the room to be maintained all time, as to make sure that the direction of the air is always moving towards outside of the room. One of the main issue of particle generation is human,

therefore persons are to enter into the room after changing clothes and shoes, and through Air shower. Followed by, to bring materials and equipment into the room after cleaning through pass box or pass through.

b. Not to Generate Any Dust

Persons are to wear Dust- Free garment as to cover the area of body. Besides that, any materials or equipment which easily generates dust is not permitted to use. It is to be substitute with special equipments. Persons are also required to minimize their motions, which is not to move unnecessarily. Lastly, not to bring disused articles.

c. To Remove Any Dust Quickly

Design plays an important part in removing dust efficiently. This can be done by increasing the Air Change rate, to provide exhaust apparatus near the dust generation source, to make appropriate Airflow Pattern that prevents dust adhesion on the products.

d. Not to Accumulate Any Dust

Lastly, not to make any such corner or surrounding of equipment which makes works difficult. If possible, try not to expose duct or piping in the room and to observe standardized routine cleaning work

CONCLUSION

The facilities provided for this cleanroom are on par to other commercially installed cleanrooms. It can be said KUKUM Micro Fabrication Cleanroom is the best in its class as a teaching laboratory. It was built with the aim to expose our undergraduate students to the 'real-life' cleanroom environment, the protocols and environmental, health and safety requirements and practices within cleanrooms.

ACKNOWLEDGEMENT

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