CLEANROOM
NANO / SEMICONDUCTOR

Modern semiconductor (computer chip) fabrication involves work at a 14nm scale or smaller. Nanomaterials are often smaller still. Human skin cells, a main component of indoor dust, are 30,000nm across, and the average person sheds 30 - 40,000 per hour. Other particulates of concern include bacteria (≈500nm), pollen (≈100nm), and smoke or scents (1–1000nm). A cleanroom exists to create an environment free of these contaminants.

The environment must also be protected against vibration, electrostatic discharge, and ultraviolet light. Additionally, many chemicals used are toxic, explosive, or even pyrophoric, so the space is often classified H5. Visual connection between assembly-classified public space (00) and the cleanroom is often desirable, but requires substantial fire separation (01).

AIR

Clean air is supplied to each bay through a grid of HEPA filters (20). The air flows straight down through the floor (21), before returning up through the floor in the adjacent chase (22). At the fan deck level, recirculating air handlers (RAHUs, 23) recondition the air and send it back down into the ceiling plenums (24). In the cleanest areas (25), this cycle repeats 600 times per hour, and the entire ceiling is HEPA filters. Other areas require only 100 or 200 ACH, and some ceiling panels are blanks (26).

Many chemicals used in the cleanroom are highly corrosive, so exhaust ducts from fume hoods (27) and wet process areas are teflon-coated welded stainless steel (28). Other processes are so corrosive that their exhaust is scrubbed locally (29), after which it can be sent into standard ducts (30) with vacuum pump exhaust (31). Exhaust removes about 10% of the air from each cycle, which is replaced with fresh air (32).

Hazardous process material (HPM) exhausts (33) are often incompatible with other exhausts, and must be ducted directly to a dedicated roof fan.

SERVICES

The most dangerous chemicals used in the cleanroom are pyrophoric (explosive at room temperature on contact with air) or highly toxic, or both. They must be stored in vented storage cabinets (40) in an HPM room (41). This room must be on an exterior wall so that it can blow out in case of an explosion.

Other ordinary laboratory services, like vacuum, nitrogen, compressed air, and RODI water, are needed at higher purities than in a typical lab. Dedicated filters and pumps (42) for each are located in the cleanroom suite. Racks in the chases (43) carry these high-purity services to each bay.

Fire protection plumbing (44) for the clean bays is inside the prefabricated ceiling plenums. HVAC plumbing (45) for the RAHUs is located above, so it can be accessed from the fan deck.

Lab waste is drained by gravity below the floor (46) to an acid waste neutralization (AWN) system.

ISOLATION

The cleanroom is completely finished in non-particulating material such as epoxy paint (60), glass, or metal (no exposed concrete, wood, or fabric). The clean-classified space proper (the area “under filter”) is arranged in bays (61) connected by a clean corridor (62), inside which only gowned personell (63) are permitted. Between the bays, chases (64) are used to access equipment (65) bulkheaded through the wall, and to locate noisy and dirty support machinery (66). A common chase (67) provides a location for less-clean storage or equipment (68).

All windows (69) and lights (70) into the cleanroom are covered with a protective UV-blocking film, to avoid exposing photoresist chemicals.

To minimize vibration, the structure under the cleanroom must be exceptionally stiff (71), and isolated (72) from the rest of the building. Particularly sensitive equipment can be isolated on an inertial plinth (73). All HVAC systems, including the ceiling plenums (74), are suspended from above (75) to avoid vibrating the floor.

ELECTRICAL

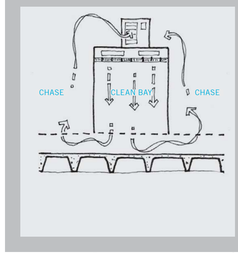
Power (80) and data (81) are distributed in each chase, and all fixtures are surface-mounted on the chase side for frequent reconfiguration. Each chase is served by a dedicated panel (82). The panel and main electrical feeders are located up high to minimize electromagnetic noise at the cleanroom level.

Because of the many hazardous chemicals used in the cleanroom, a toxic gas monitoring system (TGMS) constantly samples the air (83) to check for leaks. If a toxic gas leak or fire occurs, the four-color alarms (84) throughout the cleanroom indicate the nature of the emergency.

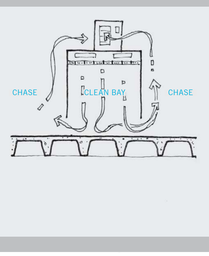
Supply is not the only electrical concern. Static electricity — especially static electrictal discharge (a shock) — can destroy sensetive electronic components, such as the chips being fabricated. Therefore, the entire floor (85) is an electrostatic dissipative (ESD) material, and is grounded. Cleanroom gowns and shoes (86) are designed to be ESD, and to ground the wearer to the floor.

AIRFLOW

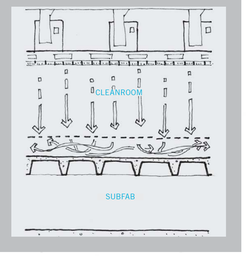
In the cleanroom shown here and below, clean bays alternate with support chases, and air is returned through a raised floor.



In cleanrooms where a raised floor is not possible, the walls of the clean bays end a couple feet above the floor.



Instead of an alternating bay-and-chase layout, production cleanrooms often use a ballroom layout with a subfab below.



CONSTRUCTION

Cleanrooms are built of prefabricated, modular parts on a 2'-0" or 60mm grid.

The suspended ceiling plenum (34/44) is used to deliver air through HEPA filters (40). It also contains fire protection (64), and lighting (30) and supports the recirculating air handling units (43).

To avoid transmitting the vibration from the HVAC system to the floor, the walls are topped with an isolation track (10). The walls themselves are made of aluminum honeycomb (11) or glass (12) panels, slotted into aluminum H-channels (13) and floor track (14).

The panels can easily be cut when installing bulkheaded equipment (25), to maintain separation between the clean bay and the return air / support chase.

PERKINS+WILL

6 September 2016 / Matthew Fickett