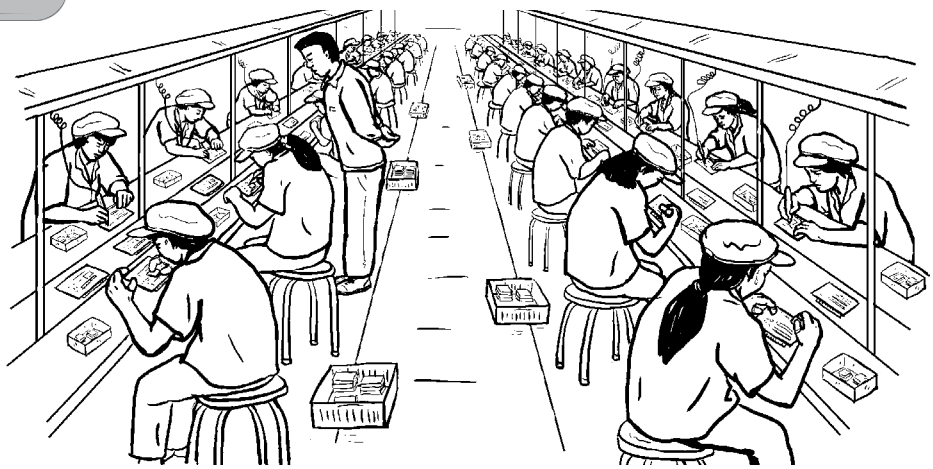
PART 2

Industries

4 Electronics factories



Millions of people work in electronics factories, making the phones and devices we use every day. Our world economies depend on them. So why should workers continue to be made sick by chemicals used in making electronics, repetitive stress injuries, low pay, and bad living and working conditions? Ensuring their health and well-being should be a priority for governments, corporations, and managers of electronics factories.

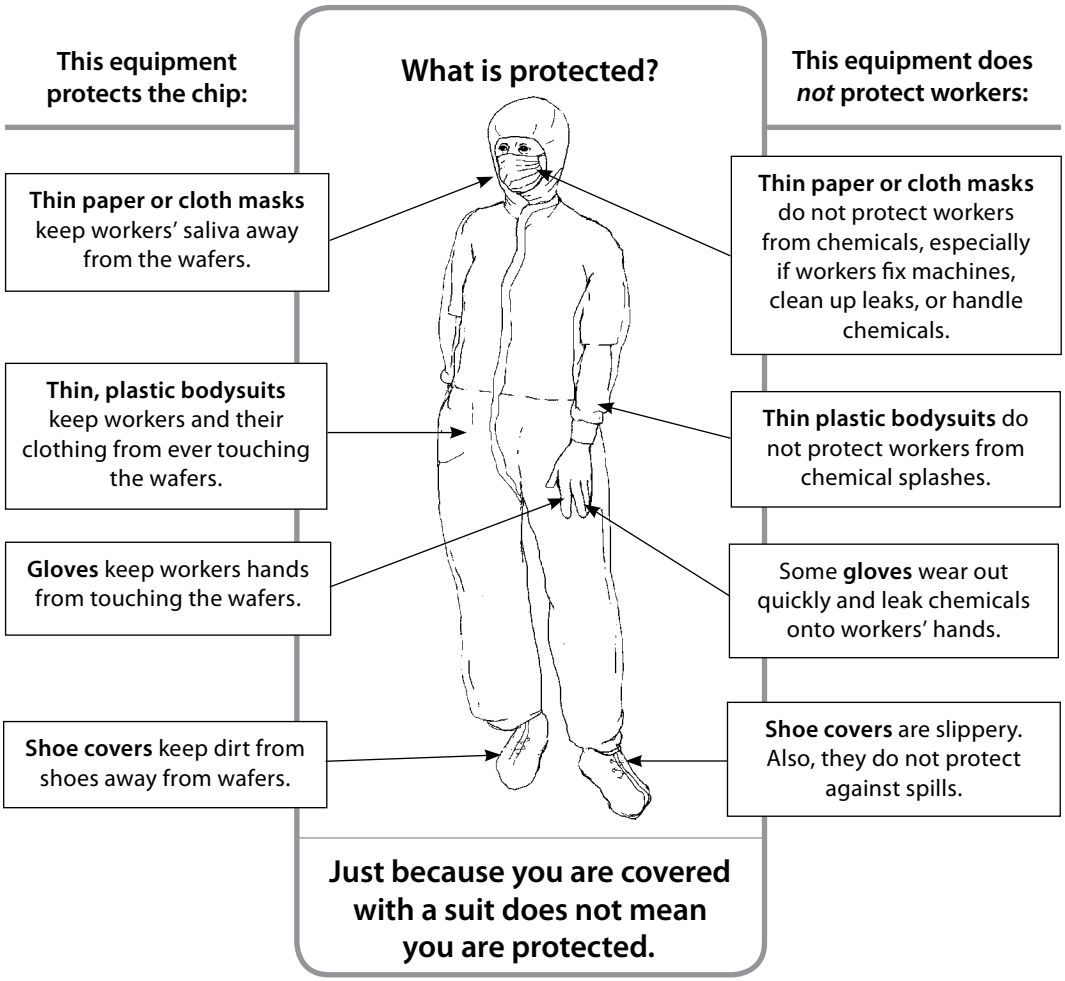
To improve the health of workers in electronics factories:

- **Governments and the ILO** must regularly assess dangers in electronics factories and push factories and brands to improve working conditions. Governments must provide medical and social support for workers made sick by their work and ensure compensation for them and their families.
- **Brands** must make sure factories follow local and international labor, occupational safety and health, and environmental standards. They should design products to be made without toxic materials, to last a long time, and to be safely recycled.
- **Factories** must comply with labor, occupational safety and health, and environmental laws. They should disclose all the chemicals they use, and where and how they are used (including byproducts and disposal) to workers, communities, and the government. They should share monitoring information about exposure and illness with workers, communities, and the government.
- **Workers** must actively monitor their health and factory conditions. They should organize safety committees and unions in electronics factories.

Electronics factories may look safe but they are not

It is difficult for workers to know how they come in contact with chemicals in electronics factories because the factories look so safe. The rooms where many of the processes take place are very clean, with controlled temperature and humidity. Workers are covered from head to toe with special clothing which they are told protects them from dangers at work. Many processes are done by machines.

Electronics factories are set up to protect the delicate materials inside electronics, not necessarily the workers. For information about personal protective equipment (PPE), see chapter 18.



Making and cleaning the wafer

The chips that are the hearts and brains of electronics are made from slices of silicon called wafers.

Wafers are made by melting and spinning silicon into tubes called "ingots." Workers cut ingots into wafer-thin slices and then clean them with chemicals.

The chemicals used to clean wafers include solvents (pages 517 to 529) and acids (pages 474 to 476). These chemicals can irritate and burn your skin. Absorbed directly through the skin or from regular exposure by breathing, they can harm your internal organs. One of the most dangerous chemicals used to make and clean wafers is hydrofluoric acid (see box below).

If your skin is splashed with a chemical:

- immediately rinse the area with flowing water for 15 minutes or more.
- remove any protective equipment or clothing that was splashed so more chemicals will not drip onto you.

See First aid when a chemical touches your skin or eyes on page 175. Do not go back to work before getting new and clean personal protective equipment.

First Aid

First aid for hydrofluoric acid (HF) burns

HF burns often do not cause immediate pain, but burn deeper than other chemicals. Inhaling HF causes burns inside the body and can kill.

1. Immediately remove any contaminated clothing or gloves and rinse the skin with a lot of water for 5 minutes.
2. If you have calcium gluconate gel, put it on the skin. Do this even if you cannot see or feel a burn.
3. If you do not have calcium gluconate, rinse the area for 15 minutes or more, until a health worker can help you. You can also use an icepack to slow the burn. See First Aid on page 175.
4. In the clinic, they will soak and cover the area with calcium gluconate. If the burn is severe, the doctor might inject calcium gluconate directly into the burn.

What should be available in your factory

All workstations where people work with HF must have emergency showers and calcium gluconate in case of emergencies.

For more on treating burns, see page 217. For more on HF, see pages 475 to 476.

Prevent chemicals from getting in your nose and mouth

Electronics factories use so many chemicals they need to have well developed and well maintained ventilation systems to clean the air or bring fresh air into your work area. See more about Heating, Ventilation, and Air Conditioning (HVAC) systems on page 249.

Even when air is filtered and refreshed with clean air, you might still have health problems from chemicals in the air. Pay attention to signs you might be breathing chemicals:

- You see or smell a chemical. But many chemicals do not smell or you might be used to them.
- You have problems breathing, skin or eye irritation, feel dizzy, confused, or nauseous.
- You have health problems that might be caused by the chemicals you are working with.

If you breathe in chemicals, leave the workplace immediately and get fresh air. Seek medical attention. See First aid when you breathe in a chemical, on page 174.

Your factory should also have an emergency plan for chemical releases, including where to find and how to use emergency PPE. If your factory does not have an emergency plan or has not trained you on what to do, leave an area where there has been a spill as fast as you can.

Breathing chemicals can cause health problems

Heath Info

Chemicals in the air can irritate your nose, throat, and lungs and cause breathing problems, making it harder for your body to get the air it needs. Your chest might feel tight, as if you cannot take in enough air or full breaths. Many people also get a cough that does not go away or one that only goes away when they are not working.

If you have any of these signs, especially if you have been breathing chemical vapors, see a health worker. She might do an X-ray or lung function test to check how well your lungs work, and test your blood to see how much oxygen is in it. Treatment varies for breathing problems: breathing oxygen from a tank or taking cortico-steroids or other medicines may reduce breathing problems. Staying away from chemicals and not smoking cigarettes always helps. Antibiotics do not.

Although widely used, sometimes cortico-steroids are used in harmful ways. See page 51 of *Where There Is No Doctor* and page 503 of *Where Women Have No Doctor* for more information.

Cleaning wafers gave Yu-mi the cancer that killed her

When workers get sick from exposure to chemicals at work, they often have to fight for their illnesses to be recognized as work-related.

That's what happened to my beautiful daughter. Yu-mi was only 21 when she got leukemia, cancer of the blood. She worked cleaning wafers at a Samsung semiconductor plant in Korea. Soon after Yu-mi was diagnosed, so was another woman in the same work area. Samsung offered to pay their medical expenses but said their illnesses had nothing to do with work. They said it was a personal problem. Yu-mi fought the leukemia for many months, but the disease was too advanced. She passed away in 2007.

Yu-mi got leukemia from working at Samsung. Her plant used chemicals that cause leukemia. Other families of Samsung workers also lost their children to cancer from working there. We decided to fight to make Samsung take responsibility, and stop poisoning workers and destroying families.

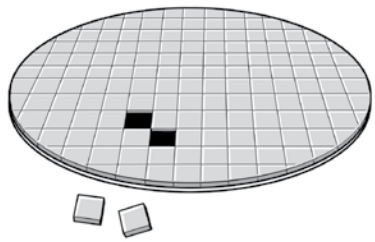
SHARPS (Supporters for the Health and Rights of People in the Semiconductor Industry) brought together Samsung workers, former workers and their families, unions, and human rights groups. We held rallies, protests, and campaigns. We met with groups from all over the world that fought the electronics companies poisoning the workers. Academics and scientists began studies to find out which chemicals were making workers sick. We went to court many times, asking the Korean government to recognize workers' cancers as work-related. But Samsung is very influential in Korea, and the courts kept ruling that workers' cancers did not come from work.

In 2011, a Korean court ruled in our favor. Since many of the chemicals and byproducts were known to cause cancer, they said it was likely that Yu-mi got cancer at Samsung. Samsung immediately hired a consulting firm called Environ to "prove" Samsung workers had no more cancer than any other group in Korea. They got the court to change its ruling. But we appealed again. Finally in 2014, it was decided that Yumi's leukemia was caused by her work at Samsung.

The ruling was a big win for us. It showed that people standing firm can challenge the most powerful electronics company in the world. We will continue to fight for the Samsung workers, and for the memory of my daughter Yu-mi.

Making the chip on the wafer

To make individual chips on the silicon wafer, workers put the wafers through several machines that cover them with chemicals and expose them to ultra-violet (UV) light. The chemicals and the light build the design for each individual chip on the wafer. The process of layering chemicals and exposing them to light is called "photomasking." The process of removing unwanted chemicals to complete the design is called "etching."



Even though photomasking and etching happen inside closed machines, workers can be exposed to chemicals when:

- **machines, pipes, and vents have leaks or are not working well.** Leaks can be found by regularly inspecting all equipment, and checking and replacing air quality monitors. Then leaks can be fixed as soon as they are noticed. A planned maintenance schedule keeps workers, production, and communities safer than just responding when there is a failure. Factories that run 24 hours a day in shifts might not respond to leaks as well or as quickly as factories that have time to repair a machine without affecting production.
- **workers open machines, pipes, and vents to clean and repair them.** Maintenance workers or engineers who open the machines and come into direct contact with chemicals face the most danger, but all workers are affected when chemicals get in the air.

To protect all workers, maintenance workers should:

- follow all shut down, lock out, and tag out procedures when they repair machines (see page 201).
- wear the highest level of protective equipment (see chapter 18: Personal protective equipment).
- make sure other workers leave the area if chemicals may be released.

Photomasking dangers: photoresist chemicals

Workers, activists, and health professionals believe photoresists are one of the most toxic chemical mixes used in making electronics. The companies that make photoresists usually refuse to disclose which chemicals and how much of each are in them, saying that is a "trade secret." However, the danger they pose to health is no secret.

Photoresists contain a mix of chemicals from 4 basic categories: sensitizers (chemicals that react to heat or light), solvents, polymers, and additives. When exposed to light, some of the chemicals in photoresist break down into other chemicals, called byproducts. These chemical byproducts can also be very harmful to workers' health.

Photoresist is quickly absorbed by the skin. Wear the right kind of chemical-resistant gloves, clothing, and respirators to protect against photoresist and its byproducts (see chapter 18: Personal protective equipment).

Some of the toxic chemicals in photoresist

There are so many different chemicals in and released by various photoresists that it is difficult to know which ones are causing health problems in your factory. Some of the chemicals of concern are:

- **phenol formaldehyde,** a polymer commonly known by its trade name, *Novolak* resin. When heated, phenol formaldehyde releases formaldehyde, which causes asthma and cancer. It also releases aromatic hydrocarbons such as benzene, toluene, and xylene when heated. These aromatic hydrocarbons damage the liver, kidneys, brain, and nervous system, and some cause cancer and reproductive health problems. (See: polymers, pages 511 to 513; formaldehyde, pages 496 to 497; and aromatic hydrocarbons, pages 522 to 523.)
- **glycol ethers,** solvents which have been banned in many countries because they are so harmful. Several glycol ethers cause reproductive health problems. Alternative chemicals for glycol ethers used in photoresists include xylene, butyl acetate, acetone, and methyl chloroform. These also harm people. (See: glycol ethers, pages 527 to 528; xylene, pages 522 to 523; butyl acetate, page 526; acetone, page 529; and methyl chloroform, pages 524 to 525.)
- **aliphatic hydrocarbons,** solvents used as sensitizers. They can affect the brain, causing headaches and dizziness. Some may damage the liver and kidneys. High doses of some aliphatic hydrocarbons can kill you. (See aliphatic hydrocarbon solvents, pages 520 to 521.)

Photomasking dangers: UV lights

The UV lights inside photomasking machines are supposed to turn off when the machine is open and workers are loading or unloading wafers. UV light can quickly damage your eyes, even in an enclosed machine. Workers in this area need UV-protected polycarbonate goggles, nitrile gloves, and face masks (see chapter 18). Clothing must cover the entire body, especially the wrists. Even a small gap between shirt cuff and glove can let UV light burn any exposed skin.

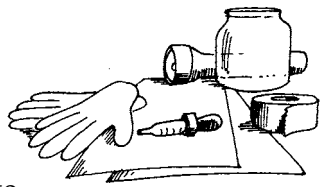
UV light bulbs break easily. As they contain mercury, a broken UV light not only poses a risk injury from cuts, it also exposes workers to mercury.

When a UV light breaks, small pieces of mercury scatter. This is also true with compact flourescent lights (CFLs), but these contain much less mercury. Turn off any machines, heaters, fans, and air conditioners. Leave the area and make sure all workers are out before closing the door. Inform the supervisor so maintenance can clean up the spill.

How to Clean up a mercury spill

If you have to clean up a mercury spill, you will need gloves, an eyedropper, 2 pieces of stiff paper or cardboard, 2 plastic bags, sticky tape, a flashlight, and a glass container with a lid and with water in it.

1. Do not touch the mercury.
2. Remove watches and jewelry. Mercury sticks to other metals.
3. Shine a flashlight on the area to make the mercury easier to see, even during the day.
4. Wear chemical-resistant gloves if possible. If you have only latex gloves, wear 2 pairs.



5. Use small pieces of stiff paper or cardboard to gather the mercury and broken glass into a small pile.
6. Use an eyedropper to suction up the mercury beads, and put the mercury in the glass container with water.
7. Pick up any mercury that is left using sticky tape.
8. Place tape, eyedropper, gloves, and cardboard in a plastic bag.
9. Label the bag “mercury waste” and put the bag in the glass container with the water in it.
10. Seal and label the container. Put it inside another plastic bag.
11. Dispose of it as toxic waste.

Etching dangers: wet etching

Wafers are dipped into several baths containing nitric, acetic, and hydrofluoric (HF) acids to remove photoresist. This work area must be enclosed and have strong local exhaust ventilation (see pages 250 to 251).

Acids can quickly burn your skin, eyes, and insides, so you need acid-resistant protective equipment, including respirators if your ventilation is not good enough or if you move materials between workstations. There must be a shower and eye wash station nearby (see First Aid on page 175).

Etching dangers: dry etching

Wafers are sprayed with fluorinated hydrocarbons and heated with radio-frequency (RF) radiation. The heat from the radiation causes the gases to move, "attack," and remove the photoresist chemicals. RF radiation can harm your nervous system and cause reproductive problems. The best way to protect yourself from radiation is to limit how much time you work with it and use barriers and PPE to shield yourself from it (see Radiation, pages 514 to 516).

Fluorinated hydrocarbons are dangerous because they accumulate in our bodies. Over time, even small amounts can build up and make us sick. People who breathe or touch them might have problems breathing and skin irritation. Some cause heart problems, reproductive problems, and cancer.

Protect workers from etching chemicals:

- Regularly check that machines seal completely. Fix leaks immediately.
- Ventilation must be strong enough to remove all chemical fumes. There should be emergency ventilation in case of a spill.
- All workers should have PPE. Maintenance workers need special PPE. An OSH professional can help identify the PPE you need.
- Etched wafers should sit in a ventilated "waiting area" before they are removed, to reduce the amount of fumes in the air for everyone.
- Pregnant women should not work with fluorinated hydrocarbons. These chemicals can harm babies inside the womb.

I work for Ericsson in Batam, Indonesia. Of all the stations in the factory, the workers in dry etching get colds most often. When a worker gets sick, they are 'rolled' into a different job in the factory and a new worker comes into the etching room and stays until he starts to get sick. They don't tell us why we get sick, they just move us.

Adding more layers and special qualities to the wafer

Wafers pass through several processes to:

- add more layers onto the chips already designed on the wafer (oxidation).
- make some of the layers more conductive to electricity (ion implantation).

Dangers from dopant gases

Dopant gases such as arsine, phosphine, diborane, and boron are heated by RF radiation so they will form layers with different electrical properties on the surface of the wafer. Workers are exposed to dopant gases when loading and unloading wafers from the machines, when changing gas cylinders, and when repairing or cleaning machines.

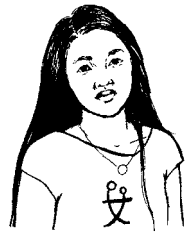
Dopant gases might make you feel weak, tired, sleepy, or confused, and might give you a headache or muscle cramps. They can also make you have problems breathing, faint, or feel paralyzed. If you have any of these signs:

- Leave the area immediately.
- Remove your protective equipment and clothes, and wash your entire body with water and soap.

Don't wait until you feel sick to put on protective equipment or stop production to get a machine fixed.

See First aid when you breathe in a chemical, on page 174.
See pages 482 to 484 for information on dopant gases.

We noticed a strange smell and complained. Tests showed high levels of arsine. It turned out the wafers were releasing the gas when they came out of the machine. They gave us fancy respirators after that. But what would have happened if arsine didn't smell?



Arsine smells like garlic. If you can smell it, you are exposed to levels that can cause harm. See arsine on pages 482 to 484.

Dangers from heat and fire

Dopant gases burn easily. Some explode when heated or when they accumulate, so vents and machines must be cleaned often, on a planned maintenance schedule. Some machine parts, such as pumps, must be cleaned frequently because the oil in the pumps absorbs gases and can harm workers. Also, the machines can get very hot. Workers in this area can get burned from accidentally touching the machines. See First Aid for burns on page 217.

Dangers from X-rays

The combination of RF radiation and dopant gases generates X-rays, a form of radiation that can cause cancer and severe damage to the reproductive system for both women and men. X-rays are also used during inspection of the wafers, to see if they have enough metal. See pages 514 to 516 for more information on the health effects of X-rays and other radiation.

Dangers from adding metals to the wafer

To make electrical connections between the different parts of the chip, metal is added to the wafer. Aluminum is most commonly used, but so are chromium, copper, tin, lead, nickel, gold, silver, titanium, and platinum. Some metals cause more harm than others, but all are easier to breathe or accidently ingest as gases or vapors. Find information about metals on pages 503 to 505.

Protect workers from:

- **Dopants:** Make sure all dopants are extracted before opening machines. Maintenance workers who clean or repair the machines should have air-supplying respirators and personal protective equipment for chemical exposure and heat (see chapter 18: Personal protective equipment).
- **X-rays:** Machines should have X-ray shields. All workers in areas where X-rays are present need badges that detect X-ray levels. Shielding and badges must be checked regularly. If badges show high levels of X-ray exposure, workers need to be transferred out of the area and given access to medical services.

Banning lead and toxic chemicals

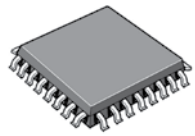
The **European Union Restriction of Hazardous Substances Directive (RoHS)** bans the use of 6 of the most harmful materials used in electronics sold in Europe:

- lead
- mercury
- cadmium
- chromium hexavalent – Cr(VI)
- polybrominated biphenyls
- polybrominated diphenyl ethers

Removing these chemicals from production helps protect workers, the community, and the environment. Although the RoHS only covers countries of the European Union, knowing a chemical is banned in one country can help you fight to get it banned in yours. The RoHS has influenced laws in other countries, including China, Japan, Thailand, Australia, South Korea, and the United States.

Making the individual chips

The chips built up on the wafers are then cut into individual chips and glued onto ceramic or plastic frames. Very tiny electrical connections are soldered or bonded to the chip, and dozens of metal connectors are soldered onto the base frame. The chip is then covered with plastic or epoxy which is heated and melted to form a shell. The chip on a frame is called an integrated circuit (IC).



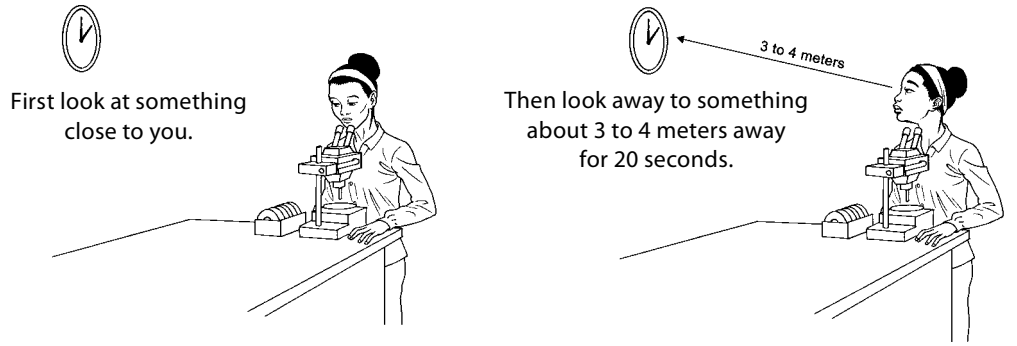
Chemicals and repetitive work are important dangers workers face in this area. ICs can also break and release chemicals into the air.

Soldering and wire bonding: Workers are exposed to chemicals in solder and flux, and to the degreasers and solvents used to clean the soldered connections (see Soldering on pages 80 to 82, and metals and fluxes in Appendix B).

Encapsulation: Brominated- or phosphorous-based flame retardant chemicals are added into the plastic shells to make them more resistant to heat (see Flame retardants on pages 488 to 492). Workers are exposed to chemicals in the epoxy as it is heated.

Trim and form: Cutting, forming, and tooling the wires to a specific shape can cause repetitive motion strain injuries (see chapter 7: Ergonomics). Workers are also exposed to solvents used to clean tools.

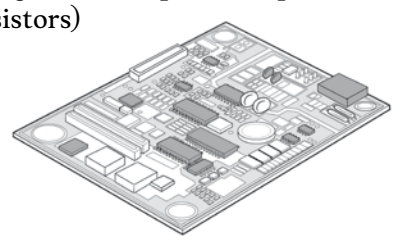
Marking, testing, packaging, and inspecting: The chip will be marked with ink or lasers, tested and packaged. Workers inspect wafer and ICs with magnifiers, computers screens, or X-ray machines. Inspection is hard on the body, especially the eyes. Keep your eye muscles strong and reduce strain by regularly looking away at something across the room. While this is no substitute for regular rest breaks, it is a good way to supplement them and protect your eyes.



Do this a few times each hour. Also, scan the room: hold your head still and move your eyes up one wall, around the ceiling, and down the other wall.

Making the printed circuit board

The chips, or integrated circuits (ICs), are attached to a larger panel called a printed circuit board (PrCB). The PrCB and many other components (parts including ICs, electrical connections, and transistors) together make the electronic product. Many of the processes to make a chip are used to make a PrCB, so many of the dangers, such as photomasking (page 70), etching (page 72), and adding more layers (page 73) are similar but on a larger scale.



Any time larger quantities of chemicals, metals, or potentially dangerous processes are used, it is more likely workers will be harmed. It also creates more waste and pollution.

Making the board

The printed circuit boards are made of fiberglass epoxy (a thin plastic sheet that contains threads of glass to make it stronger) and a thin sheet of copper pressed on each side. Sometimes aluminum, nickel, and other metals are used.

Excess copper is stripped from the board to leave behind metal connections for the components. Different kinds of boards are used: 1-sided, 2-sided, and multi-layered (with electrical connections inside and components on the outer sides).

Health Info

Dangers of fiberglass

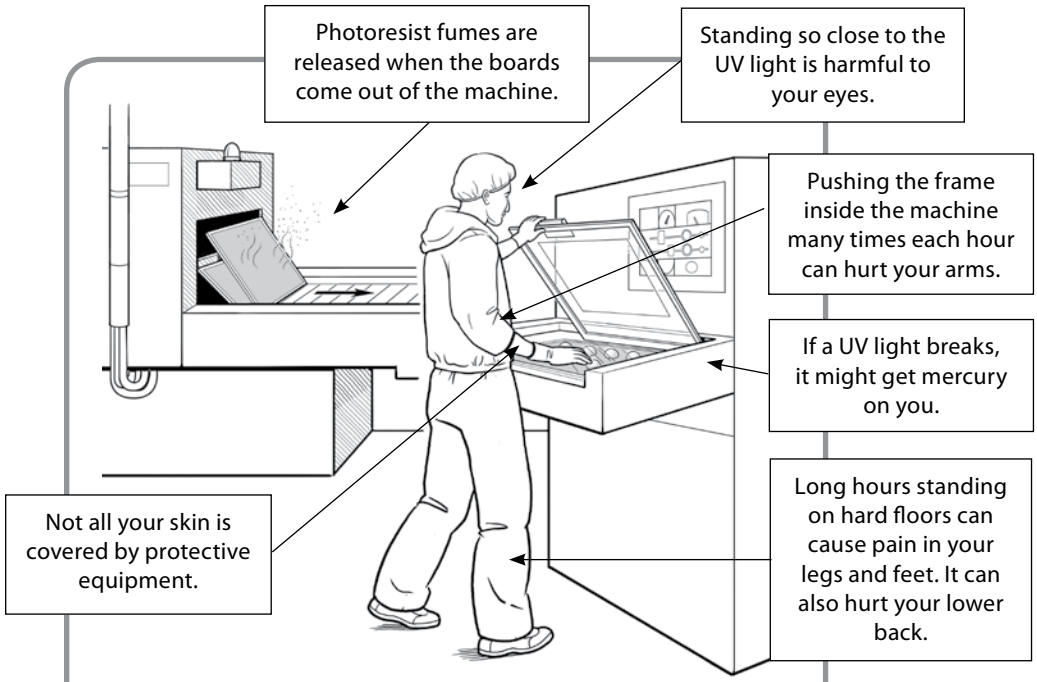
Fiberglass dust on PrCBs can get on your skin, nose, and throat. You can develop an itchy rash anywhere on your body. A doctor can see fiberglass on your skin with a microscope.

To prevent fiberglass injuries:

- Do not let the fiberglass touch your skin. Use long sleeves and pants.
- Vacuum newly cut boards and clean fiberglass dust from the edges.
- Use gloves made out of rubber or neoprene.
- Use a dust mask.

Dangers of Photomasking PrCBs

PrCBs go through a photomasking process that covers the areas of copper required for the design. This layer over the copper hardens when exposed to UV light, leaving the unwanted material soft and easy to remove.



Photomasking PrCBs is more dangerous than photomasking wafers.

- Good ventilation is needed to protect workers from being exposed to photomasking chemicals while working with this machine and when handling PrCBs after they come out of the machines (see pages 250 to 251).
- Workers need protective equipment including chemical-resistant clothing and UV glasses. See chapter 18: Personal protective equipment.
- Shock-absorbing mats to stand on and enough rest breaks will prevent muscle pain and strain and overuse injuries (see chapter 7: Ergonomics).

Dangers in the DES (Develop, Etch, Strip) Processes

A conveyer belt usually moves the printed circuit boards through multiple machines in the large DES work area. Many chemicals are put on and then removed from the boards, and can create problems for all workers in the area.

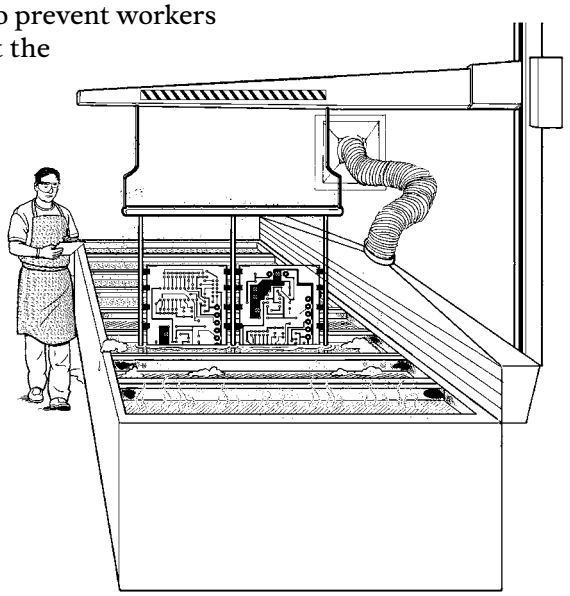
First the photoresist is removed with potassium carbonate or sodium carbonate monohydrate. Then the copper is removed with cupric chloride or ammonium chloride (see pages 479 to 481). There are several cleaning stages before the last step, which is to remove the hardened photomask that was protecting the copper. All of these chemicals are harmful when you breathe them in or if they get on your skin.

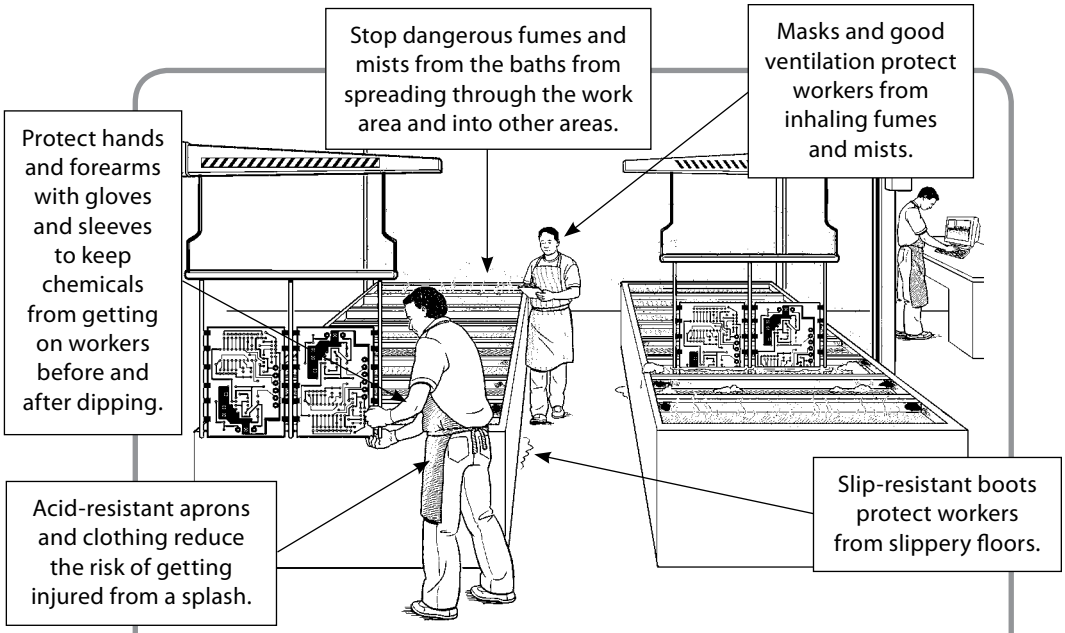
More layers of copper are added during "plating." The boards are clamped on a rack and dipped in chemical cleaning baths and then dipped in either electrified baths to add copper or nonelectrified baths to add nickel. Finally, they are dipped in tin or tin/lead.

Some metals cause more harm than others. Lead is banned in many countries. It may cause cancer and should not be used. Nickel causes allergies for many people and it also may cause cancer. Fumes and mists from metals and acids are always dangerous to breathe. For more information on metals, see pages 503 to 505.

Protect workers in DES and plating areas

- Local ventilation must be both strong and focused enough to pull the fumes from the chemical baths and each machine out of the work area.
- Respirators may be needed to prevent workers from inhaling the fumes that the ventilation does not remove.
- Acid-resistant clothing, boots, gloves that are changed every day, eye protection, and other gear will be needed to protect workers from the dangers of splashes, burns, slips, and other injuries related to working with acids, solvents, and other chemicals.





These workers in the plating area do not have all the protective equipment they need.

Making a board ready for components

Before going to assembly factories, the boards may go through a number of processes from which employers must protect workers, taking similar precautions as in the DES area. These processes include:

- **Solder mask:** The boards are coated with a chemical to protect the non-metal areas from the soldering process.
- **Legend:** The boards are printed with ink or lasers to show where components will be placed during assembly and to help during repair.
- **Removing tin/lead:** The tin or tin/lead is stripped with a mixture of nitric acid and ferric ion to expose the copper.
- **Final surface finish:** Parts are polished so components can be glued on. Boards are dipped in nickel and gold so they better conduct electricity.

Assembling the printed circuit boards

The components are added to the PrCBs by hand or by machines. Both workers and machines use flux to prepare the metal surfaces of the parts and the board to better accept the solder which makes the electrical connection between them. Flux is a mix of chemicals, including solvents and acids (see Fluxes on pages 493 to 495).

Soldering

Soldering means melting a little bit of metal to make a bridge connecting 2 different components. Solder is usually tin, a mixture of tin and lead, or a lead-free mix of copper and other metals (see pages 503 to 505). Soldering can be done manually or by machines.

Hand soldering

Workers who solder by hand need mounted extractors on the soldering iron, strong local extractors, and respirators. If you notice signs that you are breathing in chemicals (see page 73), stop working and improve your ventilation or PPE.

Machine soldering

Wave soldering machines and other machines that solder should have strong local ventilation. PrCBs should rest in a well-ventilated area after they are soldered until they stop off-gassing.

Soldering can hurt workers' health

Flux and solder contain chemicals which can irritate your skin or lungs, immediately or later. They also contain chemicals that can cause chronic health problems. Rosin in flux and lead in solder are 2 of the chemicals that we know cause health problems in the soldering area.

Heating flux and solder releases fumes. Signs you are breathing the chemicals in flux and solder are:

- headaches
- nose bleeds
- problems breathing
- feeling tired and weak
- sore throat
- red and irritated eyes
- skin rashes

If you have any of these or other problems, tell your health and safety committee and boss. Talk to a health worker about where you work, what you do, and the chemicals you are exposed to. Smoking or just being around smoke will worsen these problems.

If your boss makes no changes to the workplace and you keep breathing the chemicals in flux and solder, you are likely to develop other health problems.

Record all health problems and changes in solders and fluxes in your health notebook (see page 46).

Protect workers from the dangers of soldering

Soldering is safer when flux does not contain rosin and solder does not contain lead. We know these materials are too dangerous to use.

Soldering can be made safer when workstations have good local and general ventilation (see chapter 17: Ventilation) and workers have the correct, well-fitting personal protective equipment for the chemicals they use (see chapter 18). When workers can tell the boss and the health and safety committee about safety issues, and get them resolved, everybody is safer.

Soldering can also be made safer by:

- turning the heat down on the soldering iron, so less fume is released into the air (see page 167).
- "following the air" (see the activity on page 253) to check your local ventilation, and organizing to improve ventilation for everyone.
- finding out the dangers of the chemicals in your flux and solder. Look them up on pages 493 to 495, get an SDS (see pages 180 to 182), try other resources (see page 464), and organize to get safer flux and solder.

Is lead-free solder really safer?

After the European Union banned the use of lead in solder and other materials used to make electronics for Europe (see page 74), some companies resisted the change. They claimed lead could be used safely, that it was "necessary" for production, and that lead-free products were not as good and were more expensive.

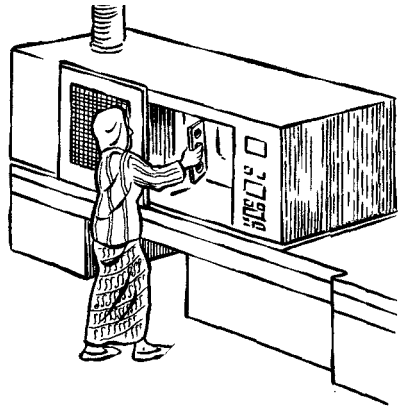
But they lost the argument: any electronics company that wanted to sell to Europe after 2006 had to prove they were not using lead.

Alternatives to lead solder began to appear and chemical companies produced them quickly. One uses copper, tin, and nickel instead of lead.

But as with any new process, the new solders brought new problems: lead-free solder uses more flux (see pages 493 to 495), which can contain harmful chemicals, is heated to higher temperatures, and may release more particles than lead-based solders. Few of these new solders and fluxes were studied to show if they were safer for workers than lead.

Making the production of electronics safer and more sustainable should mean that dangerous chemicals are replaced by chemicals proven to be safe – not just different and hoped to be safe.

Testing the PrCBs



Workers check the boards and their components visually and electronically before they are assembled or packaged for shipping. Lifting, checking, and removing the PrCBs can lead to muscle strain and overuse injuries. Often, to prevent static electricity from damaging the boards, workers are required to wear grounding wrist cords. The wrist cords contain nickel, a chemical that can irritate the skin.

- Adjust carts, work tables, and chairs to limit the amount of lifting and twisting you must do. (See chapter 7: Ergonomics.)
- Wear gloves to protect your hands from the hard edges of the fiberglass boards.
- If you already have or develop an allergy to nickel (see pages 504 to 505), ask for a nickel-free grounding cord.

Assembling electronics

On long assembly lines, workers glue, solder, and screw together all the pieces that make the electronic product. Workers then clean, polish, and test them. Products that do not pass the tests are sent to a fixing area, where workers reopen the defective piece and repair it manually.

When people assemble electronics at home, it can lead to health dangers for workers, families, and neighbors. (See chapter 20: Doing factory work at home.)

Making other components

Non-electronic parts are made in other factories and become part of the final product in the assembly area. Making these components is also dangerous for workers and the environment.

Plastic shells and casings: Electronics use plastic outer shells because they are lightweight, durable, and cheap. Many dangerous chemicals are used to make the shells stronger and fire resistant. Companies can make less toxic shells by:

- **using alternative chemicals** and replacing brominated flame-retardants with phosphorus- or nitrogen flame-retardants (see pages 491 to 492).
- **changing materials so they do not need flame-retardants,** for example, making shells with aluminum instead of plastic.

Batteries: Whether electronics use disposable or rechargeable batteries, all batteries contain toxic materials. The workers who make the batteries (and their families) suffer the most, but the dangers begin even earlier for the workers who mine the metals used in them. And after the product is thrown away, the chemicals in batteries leak into and pollute our water. Safer batteries and designing products to use less power will reduce the spread of toxics from batteries.

Wires and cables: Cables and wires are made from copper covered with plastic. Polyethylene and PVC (polyvinyl chloride) are the most common plastics. Most plastics are safe to touch, but heating them releases toxic chemicals that can irritate your nose, throat, lungs, and skin and may cause cancer.

Monitors and screens: The CRT, LCD, plasma, and LED screens used in electronics are often welded and glued together with a chemical that hardens when exposed to UV light. They may be filled with liquid crystals or neon and xenon gas. While most of the processes are automated, workers in screen factories are exposed to harmful gases while producing and testing screens, and maintaining factory machinery. Larger TVs and monitors weigh more and cause more muscle strain for workers.

Battery workers fight the company that poisoned them

Workers making nickel-cadmium batteries for Gold Peak Batteries in China were poisoned with cadmium. Cadmium is a toxic metal that damages the lungs, kidneys, and bones, and causes cancer. When a Gold Peak worker told her doctor she was suffering from pain, the doctor did some blood and urine tests. They showed very high levels of cadmium in her body. Other workers had dizzy spells, headaches, nausea, and miscarriages. When they were tested, their levels were also high. As word got out, many more workers, their children, and families were tested and found they were poisoned.

Gold Peak workers believed the company should take responsibility for poisoning them. They demanded treatment and compensation for their lost health.

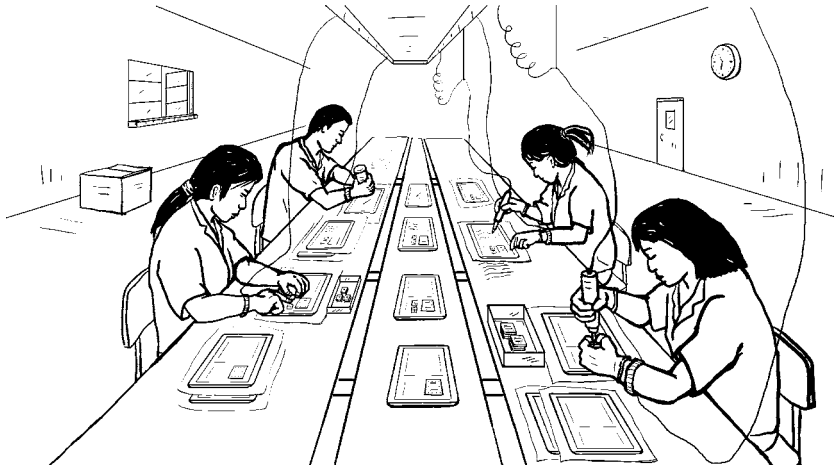
The company tried to quiet them down. They falsified tests to show lower cadmium levels, claimed they could remove the cadmium, subjected people to ineffective, painful treatments, and fired the most vocal workers. They also closed several factories and moved them to more remote towns.

Workers held protests, sued the company, appealed to the local and national government, gathered support from non-governmental organizations, and educated others about cadmium poisoning. The company was forced to start a fund to cover yearly testing and medical expenses for former and current workers. But every year more workers are found to be poisoned with cadmium and they struggle to get compensation.

In 2006, cadmium was banned by the European Union and now lithium-ion and nickel-metal hydrate batteries are more common. However, China still allows the production of cadmium batteries. Gold Peak produces them in remote parts of China where workers still lack proper protections and information about cadmium poisoning. In 2015 Gold Peak will stop paying for workers' yearly tests and will only offer compensation to workers who can prove they were poisoned.

Fast assembly lines

Work in assembly factories is very repetitive and very fast. The stress and strain this creates causes many injuries. Some ideas to change your workplace are in this section, and many more are proposed in chapter 7: Ergonomics.



To meet the quotas, workers have to place parts every few seconds.

The Foxconn suicides and death from overtime

Workers in a Foxconn factory in China make mobile phones and other products for many big electronics companies around the world. The factory has rules, like other factories in China: "No talking!" "No looking away from work!" People can take breaks only for meals. Supervisors and managers yell and insult workers to make them work even when they are in pain or sick. The factory forces them to work overtime, sometimes keeping workers on the job for 24 hours or more.

In 2010, a young technician, Yan Li, died from exhaustion after being forced to work 34 hours straight. That same year, 18 workers tried to kill themselves to escape their inhumane working conditions.

Foxconn made excuses about why workers were committing suicide and why Yan Li died. Instead of addressing the main problem — bad working conditions — they made small changes. They raised wages a little, put nets around buildings to prevent people jumping from the roof, and opened some recreation rooms. But when they build larger facilities in other cities, Foxconn continues the same working conditions that led to the suicides in the first place. And the suicides continue.

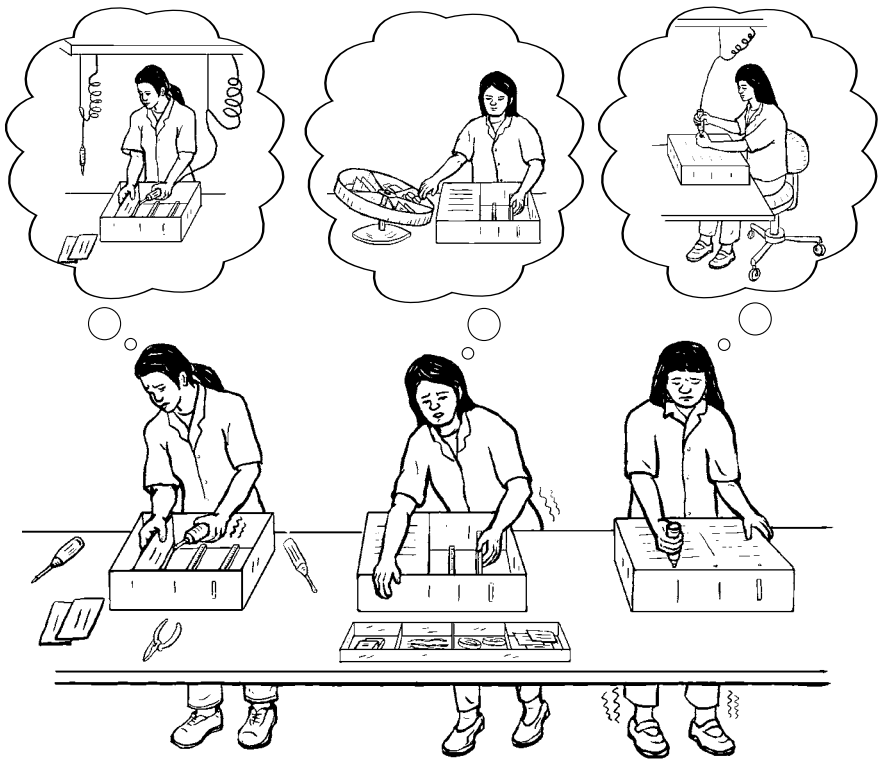
Changing the workplace to reduce muscle strain and overuse injuries

Having everything you need close at hand to do a job strains your body less, especially when you repeat movements hundreds of times during a shift. Supporting the part of your body that is moving, such as your wrists, fingers, and elbows, and having a chair and table that fit your body can also help reduce pain and injury from work.

Look at your workstation to see what is causing your aches and pains:

- How far do you have to reach to get the components and the tools you need?
- How far do you have to reach to get the product from and to the assembly line?
- How heavy is the product you are picking up and putting back on the line? Are the parts heavy? Your tools?
- How does your chair or stool fit you? Or do you work standing up?
- Do you rest your arms or wrists on a sharp edge or a padded surface?
- How comfortable is the workstation?

You can find suggestions about making changes to your workstation in chapter 7: Ergonomics.



Changing jobs to reduce injury

Sometimes your work makes you repeat the same movements too many times and for too long, and no amount of change in equipment or stretching will prevent pain and injury. Workers can protect themselves by taking more control over the work process itself. Talk with your co-workers and bosses about:

- slowing down the speed of the line and adding more workers.
- changing jobs a few times a day so no set of muscles gets overused.

Better protective equipment

Some factories do not give workers protective equipment or clothing. Others give all workers the same equipment regardless of the dangers specific to their work or whether a worker's body is large or small. When necessary, employers should provide:

- **anti-static and dust-proof clothing**, including hats and wrist bands. They protect the product from static and dust, but must also protect you from metal dust.
- **gloves and finger covers.** Protecting your hands and skin can lessen irritation from dust, small cuts, and scrapes. Workers in the cleaning and polishing area need gloves that protect them from the cleaning chemicals they use (see pages 262 to 265).
- **masks and respirators.** Paper masks prevent breathing in large dust particles, but they will not protect you against fumes from plastics, glues, solder and flux, small dust particles, and the new, tiny nanoparticles (see page 94). More information about which respirator protects best for your work can be found on pages 271 to 272.
- **ear protection.** Most assembly factories are so loud they harm workers' hearing. If you have to shout to talk to a person 2 arm lengths away, the area is loud enough to cause hearing loss. (See chapter 13: Noise.)
- **face shields or eye protection** should be used by workers in areas where dust is created, such as grinding, packaging, and shipping.

Cleaning finished products

Workers clean electronics with different methods and chemicals, including pressurized air, polishing machines, isopropyl alcohol (IPA), and other solvents and degreasers that contain methanol or other harmful chemicals.

Cleaning chemicals can get on your skin, causing irritation and rashes. Some can be absorbed through the skin, harm your internal organs, and cause blindness. Breathing their fumes can make you dizzy, tired, or give you a headache or stomachache. Some are flammable and can cause fires. Polishing metal casings generates a lot of dust.

- Good ventilation will remove fumes and dust (see chapter 17: Ventilation).
- Wear gloves, eye protection, and other protective gear to protect against chemicals used in cleaning and polishing. See pages 517 to 529 for more information on solvents and degreasers.
- Filter masks, not paper masks, may be needed to protect against dust (see pages 266 to 270).

Factory saves money by poisoning workers

I worked at the Wintek electronics factory in China, cleaning computer screens. We used to clean them with IPA alcohol, but one day the factory owner gave us a new chemical. A few weeks later, I started feeling dizzy and weak. I was not the only one. Many of us complained to the supervisors that the new chemical was making us sick, but they just told us to keep working with it or quit.

One day I woke up and couldn't move my body. My family took me to the clinic and we found many of my co-workers there too. The tests showed we had been exposed to hexane, a chemical that can cause paralysis and death. Four workers died.

We found out the boss had switched from IPA to hexane because it dried faster and he could make more money. But the factory did not have the right ventilation or provide the right protective equipment for us to use this chemical. Many organizations supported us in our fight to get the factory to provide health care and compensation to the sick workers. They told us we should go to the big companies that Wintek supplied because even though they were subcontracting their work, they were also responsible. The brand said they didn't know anything about hexane. They said they told Wintek not to use it.

Testing, packing and shipping

Workers test products before packing and shipping. Much of the testing is done by machines. However, workers in the testing area are exposed to:

- **noise:** Machines open, close, tap, thump, shake, and vibrate when testing electronic products. They beep and sound alarms when electronics pass or fail tests. Workers hear these sounds over and over without earplugs. Find out if your workplace is too loud (see page 225), how to use earplugs (see page 271), and how to reduce noise in your factory (see pages 226 to 228).
- **light:** Workers who test screens are exposed to bright light as they set screens and monitors to the right colors. See chapter 14: Light for more information about eye health and lights.
- **injury:** Larger electronic products become a danger when they are moved from place to place. You can get hurt if something falls or breaks open, exposing you to sharp edges or chemicals. Sometimes you can still smell chemicals being released from the product. Knowing what chemicals were used to make it and clean it can help you be better prepared in case anyone becomes ill from exposure.

Disposing of waste

Chemicals used in the factory are recycled or just thrown away as waste. This can harm workers as well as the surrounding communities.

- **Air pollution:** The fumes from acids, plastics and solvents go through the ventilation systems. In some factories, ventilation filters out the chemicals but usually the fumes are directly released into the air without filtering.
- **Water pollution:** The chemicals in the many baths used in electronics manufacturing go through different processes designed to separate, filter, and neutralize them. Some can be reused. Some are sent to a landfill. After the water has been "cleaned," it is released into the community water system. Sometimes the water still contains a lot of chemicals. And when it combines with water from other factories, the people in the community may get very poisonous water!
- **Solid waste:** Metals, glues, and other chemicals in solid form are usually not separated. Whatever cannot be recycled or neutralized is sent to a landfill.

Worker and community groups have joined together to get factories to take responsibility for the safe disposal of factory waste. Or even better, not to generate any waste at all! (See chapter 33: Pollution from factories.)

Make electronics easy to repair

Companies design electronics to break or go out-of-date after a short time, so people will have to buy new ones. They change models every year, make them impossible to fix, and keep repair instructions and programming secret. They do this to encourage consumers to buy new products because the more often people buy, the more profit the companies will make. This is wasteful and expensive.

Sustainable design is a movement to push companies to make electronics easier to repair, and to produce products that last instead of designing for the dump. Sustainable electronics have:

- cases that are easy to open, using standard screws instead of glue.
- parts that need regular replacement, like screens, are easy to access.
- standard-sized parts that are easily interchangeable.
- free and easy-to-find repair instructions.

Designing electronics so they are easy to repair reduces the need to mine for materials, produces less waste during production and recycling, and makes electronics more affordable.

Recycling electronics

After they are thrown away, many electronics are dumped in communities in Asia and Africa. People working by themselves or in small groups open the electronics, breaking screens and shells to get to the PrCBs. They melt plastic casings and wires to get inside to the gold, silver, and other metals that they remove and then sell to make a living.

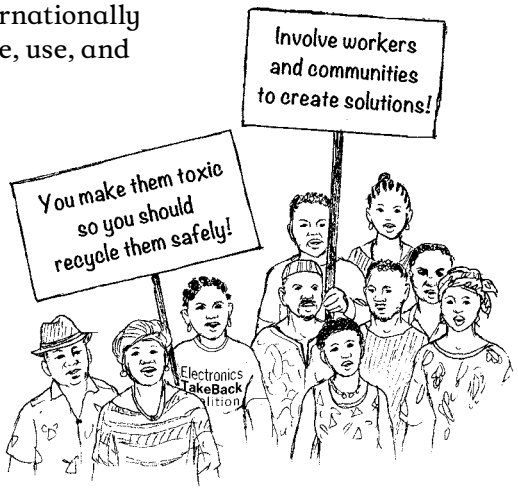
If you work recycling electronics, you are exposed to many of the chemicals used in production as well as other, even more dangerous chemicals created by burning the material.

You can reduce the amount of chemicals that get into your body by:

- Wearing gloves and clothing that covers all your skin.
- Wearing eye covers or goggles.
- Wearing a mouth and nose cover. A bandana or cloth will not protect you from chemical fumes, but it will keep some of the dust out.

Making electronics safer

From computers to cell phones, electronics have become so central to our lives that it is hard to imagine living without them. But the dangers to the health of workers and communities are often too high to live with them! A number of groups internationally have formed to change the way we make, use, and dispose of electronics. They say:



Make them safe

- Design less toxic electronics – find safer substitutes for dangerous chemicals.
- Do not use workers or customers to test whether materials are safe or dangerous.
- Design products that use less energy and have less of a bad impact on the environment.
- Design products that are durable and can be repaired and reused easily.
- Make products that can be recycled easily.
- Use as many recycled materials as possible.

Take it back

- Electronics manufacturers must create programs to take back and recycle their products for free.
- Electronics manufacturers must be responsible for their products. It is their job to ensure they are recycled safely.

Recycle responsibly

- Recycling laws should be passed to make recycling safer for people and the environment.
- Work towards zero waste – find ways of reducing and reusing materials.
- Do not dump toxic electronics waste (e-waste) in developing countries.
- Do not use prison labor to do recycling – it's toxic forced labor!