**Submission to Mr. Marcos Orellana, UN Special Rapporteur on Toxics and Human Rights**

Supporters for the Health and Rights of People in the Semiconductor Industry (SHARPS)

Via email to srtoxicshr@ohchr.org with SR Toxics/Plastics included in the subject line

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This submission to Mr. Marcos Orellana, UN Special Rapporteur on Toxics and Human Rights, is in response to a [call](https://www.ohchr.org/EN/Issues/Environment/SRToxicsandhumanrights/Pages/lifecylce-plastics.aspx) for inputs on the lifecycle of plastics and human rights. Supporters for the Health and Rights of People in the Semiconductor Industry ([SHARPS](file:///C%3A/Users/lenovo/Documents/IPEN/S%20A%20I%20C%20M/Human%20Rights/2021%20SHARPS%20Submission/cafe.daum.net/samsunglabor)) is a public interest non-governmental organization based in South Korea and has worked since 2007 to support the occupational health and safety rights of workers in the chemically-intensive electronics industry.

**Summary**

The semiconductor manufacturing process uses adhesives, chip molding resins and high molecular weight resins and polymers, along with many associated chemicals. A key polymer component of semiconductor manufacturing is [photoresist](https://www.merriam-webster.com/dictionary/photoresist) – a polymer emulsion that is used in the photolithography process to transfer a circuit pattern to a chip. Three case studies of semiconductor manufacturing relevant to human rights issues are: 1) use of reproductive toxicants, ethylene glycol ethers, with photoresist; 2) the release of toxic chemicals from photoresist; and 3) the release of toxic substances from epoxy resins.

Key human rights issues in semiconductor manufacturing include:

* Right to a safe and healthy work environment
* Right to information
* Rights of women and children
* Right to an effective remedy

**Introduction**

While public and press attention has justifiably focused on plastic pollution, the use of plastic resins, polymers and associated chemicals in manufacturing is highly relevant to occupational health and safety and to ensure “[*just and favorable conditions of work*](https://www.un.org/en/about-us/universal-declaration-of-human-rights).” This submission will focus on three case studies related to the human rights implications of plastic resins and polymers and their associated chemicals in semiconductor manufacturing.

**Plastics and resins are key to electronics manufacturing**

As noted by the [industry](https://www.craftechind.com/high-performance-plastics-in-the-semiconductor-industry/), more than 250 chemicals and a variety of plastics and resins are used in the manufacture of integrated circuits and semiconductors, including PVDF (polyvinylidene difluoride), ECTFE (ethylene chlorotrifluoroethylene), and PCTFE (polychlorotrifluoroethylene). A key polymer component of semiconductor manufacturing is [photoresist](https://www.merriam-webster.com/dictionary/photoresist) – a polymer emulsion that is used in the photolithography process to transfer a circuit pattern to a chip. A variety of toxic chemicals are used in the photolithography process. One of them, perfluorooctanoic acid (PFOA), was [listed](http://chm.pops.int/TheConvention/ConferenceoftheParties/Meetings/COP9/tabid/7521/Default.aspx) in the Stockholm Convention for global elimination at the 9th Conference of the Parties (COP9) in 2019. A five-year exemption was granted for PFOA use in PVDF and PTFE manufacturing and in photolithography or etch processes in semiconductor manufacturing. In contrast, COP9 [ended](https://ipen.org/news/un-meeting-governments-agree-global-ban-pfoa-%E2%80%93-toxic-water-pollutant) the exemption for the use of perfluorooctanesulfonate (PFOS) in photo-imaging, photoresist and anti-reflective coatings for semiconductors.

**US industry outsources reproductive harm**

Ethylene glycol ethers (EGEs) are [toxic chemicals](https://www.iloencyclopaedia.org/part-xviii-10978/guide-to-chemicals/item/1045-glycol-ethers) used with photoresist in the photolithography process for making semiconductors. EGEs were widely used in the US but phased out after industry studies [demonstrated](https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it), “…*roughly a doubling of the rate of miscarriages for thousands of potentially exposed women.*” As a [result](https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it), *“Twenty-five years ago, U.S. tech companies pledged to stop using chemicals that caused miscarriages and birth defects. They failed to ensure that their Asian suppliers did the same.”* Ironically, researchers working at IBM [warned](https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it) that harms to women from EGEs could occur from their use in other countries because EGEs are cheap, effective and widely available.

One outsourced designation for EGEs was South Korea. In 2009, [tests](https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it) of 10 samples of photoresists from Samsung and SK Hynix found an EGE in 6 of them. A subsequent study in 2015 did not find the substance in samples from these companies but did find it in a smaller company’s photoresist. The true magnitude of the problem is difficult to estimate due to the wide use of “trade secret” designations by the industry. For example, Bloomberg [notes](https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it) that a study commissioned by SK Hynix found 363 chemicals used at the plant that were not disclosed to the company due to “trade secrets.” *“Even the chip plants’ own health and safety managers have no idea what’s in many of the mixes, especially in the photoresists. That makes it difficult, if not impossible, to monitor what a given worker is being exposed to and to what degree.”*

In South Korea, the electronics industry [employs](https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it) at least 120,000 women – most of them of child bearing age. A 2014 [study](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4090871/) identified reproductive risks in semiconductor workers including spontaneous abortion, congenital malformation, and reduced fertility. Due to the lack of information, the study noted that, *“knowledge of the likely contribution(s) from specific exposures is still limited.”*

In 2016, the former UN Special Rapporteur on Toxics and Human Rights, Mr. Baskut Tuncak, noted illnesses among electronics industry worker in his [report](https://ap.ohchr.org/documents/dpage_e.aspx?si=A/HRC/33/41/Add.1) following his visit to South Korea including, “… *reproductive abnormalities and other health impacts. All former workers described to the Special Rapporteur are young females, including several in their early twenties. With many female workers of childbearing age, the alleged victims extend to the children of former workers. For example, the Special Rapporteur heard from a mother who had been pregnant during her employment and subsequently given birth to a child with birth defects.”*

**Photoresists use and release toxic chemicals**

A 2011 [study](https://www.sciencedirect.com/science/article/pii/S2093791111230026) by the Occupational Safety and Health Research Institute (established by the South Korean government) examined chemicals used and released in four photolithography processes at three different semiconductor manufacturing plants. The study noted the common use of Novolak resin which is a [phenol-formaldehyde resin](https://en.wikipedia.org/wiki/Phenol_formaldehyde_resin). Other resins with toxic chemical building blocks are also used, such as polyhydroxy styrene derivative, hydrogensiloxane polymer and cresol-formaldehyde resin.

Organic solvents used in photoresists include [ethyl benzene](https://pubchem.ncbi.nlm.nih.gov/compound/Ethylbenzene) and [propylene glycol monomethyl ether](https://pubchem.ncbi.nlm.nih.gov/compound/1-Methoxy-2-propanol) (PGME). Sometimes an adhesive such as [hexamethyldisilazane](https://pubchem.ncbi.nlm.nih.gov/compound/Hexamethyldisilazane) is used and the study notes that glycol ethers *“have been a popular solvent”* for carrying the adhesive (see above). At least tens of chemicals are used in the photolithography process and the study notes that *“employees could be exposed to all of these chemicals….”* An additional problem is that many of these substances have no occupational exposure limits.

UV light is part of the photolithography manufacturing process and the study notes that *“Workers could be exposed to the UV light-induced decomposition products of the photoresist…”* A lab decomposition experiment found that the photoresist could release [benzene](https://pubchem.ncbi.nlm.nih.gov/compound/Benzene), [toluene](https://pubchem.ncbi.nlm.nih.gov/compound/Toluene), [ethylbenzene](https://pubchem.ncbi.nlm.nih.gov/compound/Ethylbenzene), [benzofuran](https://pubchem.ncbi.nlm.nih.gov/compound/Benzofuran), [xylene](https://pubchem.ncbi.nlm.nih.gov/compound/p-xylene), [phenol](https://pubchem.ncbi.nlm.nih.gov/compound/Phenol) and [cresol](https://pubchem.ncbi.nlm.nih.gov/compound/o-Cresol) among others.

Measurements of the airborne levels of chemicals were much lower than the “tolerable limit value.” However, the “clean room” air is recirculated and the authors concluded that, *“employees working with photolithography processes could be exposed directly or indirectly to various VOCs.”*

**Polymers release toxic chemicals during manufacturing**

Plastic epoxy resins are used in many [products](https://www.plasticseurope.org/en/about-plastics/what-are-plastics/large-family/epoxy-resins) including semiconductors where they help protect the devices from moisture, heat and shock. Epoxy molding compounds (EMC) used in semiconductor manufacturing [contain](https://link.springer.com/chapter/10.1007/BFb0017963) a wide variety of chemicals including hardeners, accelerants, plasticizers, flame retardants, coupling agents and release agents. During the manufacturing process, EMC is typically heated to 180C to coat the chips. This has the potential to release chemicals into the air and expose workers.

A 2012 government [study](https://www.kosha.or.kr/oshri/publication/researchReportSearch.do?mode=view&articleNo=63154&article.offset=0&articleLimit=10&srSearchVal=%EB%B0%98%EB%8F%84%EC%B2%B4) in South Korea by the Occupational Safety and Health Research Institute noted that the semiconductor manufacturing process included use of adhesives, chip molding resins and high molecular weight resins and polymers. During the process, the [study](https://www.kosha.or.kr/oshri/publication/researchReportSearch.do?mode=view&articleNo=63154&article.offset=0&articleLimit=10&srSearchVal=%EB%B0%98%EB%8F%84%EC%B2%B4) found that the heating process released *“various types of volatile organic compounds (VOCs), including benzene and formaldehyde…”* In the semiconductor assembly line, 10 toxic chemicals were released from EMC including acetone, benzene, [toluene](https://pubchem.ncbi.nlm.nih.gov/compound/Toluene), [2-butoxyethanol](https://pubchem.ncbi.nlm.nih.gov/compound/2-Butoxyethanol), [n-hexane](https://pubchem.ncbi.nlm.nih.gov/compound/Hexane), [cyclohexanone](https://pubchem.ncbi.nlm.nih.gov/compound/Cyclohexanone), and [tetrachloroethylene](https://pubchem.ncbi.nlm.nih.gov/compound/Tetrachloroethylene). The mold cleaning operation found releases of [formaldehyde](https://pubchem.ncbi.nlm.nih.gov/compound/Formaldehyde).

The authors noted that the concentrations of these chemicals were much lower than regulatory exposure limits. However, they emphasized that these chemicals might be released into the workplace since the doors of ovens are frequently opened for taking out the products and that the air containing those VOCs from molding processes can be diffused into the neighbor working areas due to the general ventilation system mixing the air from different production processes.

The authors also stated the importance of changing to safer alternatives, *“…considering the fact that carcinogens are created as by-products, it is desirable not to use these materials. Therefore, if possible, it is needed to substitute the substances used in these processes with ones which do not create benzene or formaldehyde.”*

Carcinogenicity is only one of the effects of the substances released by polymers during semiconductor manufacturing. The International Agency for Research on Cancer (IARC) has [classified](https://monographs.iarc.who.int/agents-classified-by-the-iarc/) [benzene](https://pubchem.ncbi.nlm.nih.gov/compound/Benzene) and [formaldehyde](https://pubchem.ncbi.nlm.nih.gov/compound/Formaldehyde#section=Evidence-for-Carcinogenicity) as known human carcinogens; [tetrachloroethylene](https://pubchem.ncbi.nlm.nih.gov/compound/Tetrachloroethylene#section=Evidence-for-Carcinogenicity) as probably carcinogenic to humans; and [benzofuran](https://pubchem.ncbi.nlm.nih.gov/compound/Benzofuran) and [cresol](https://pubchem.ncbi.nlm.nih.gov/compound/o-Cresol) as possibly carcinogenic to humans. The American Conference of Governmental Industrial Hygienists has classified [2-butoxyethanol](https://pubchem.ncbi.nlm.nih.gov/compound/2-Butoxyethanol), [cyclohexanone](https://pubchem.ncbi.nlm.nih.gov/compound/Cyclohexanone#section=Evidence-for-Carcinogenicity) and [ethyl benzene](https://pubchem.ncbi.nlm.nih.gov/compound/Ethylbenzene) as confirmed animal carcinogens with unknown relevance to humans.

In 2016, the US National Institutes of Occupational Safety and Health (NIOSH – a US government agency) published their policy on chemical carcinogens. The policy [notes](https://www.cdc.gov/niosh/topics/cancer/policy.html) that, *“Underlying this policy is the recognition that there is no safe level of exposure to a carcinogen, and therefore that reduction of worker exposure to chemical carcinogens as much as possible through elimination or substitution and engineering controls is the primary way to prevent occupational cancer.”*

**Key human rights issues**

Key human rights issues in semiconductor manufacturing include:

* Right to a safe and healthy work environment
* Right to information
* Rights of women and children
* Right to an effective remedy

**Right to a safe and healthy work environment**

While all workers have the right to a safe and healthy work environment, the former UN Special Rapporteur on Toxics and Human Rights, Mr. Baskut Tuncak, [noted](https://ap.ohchr.org/documents/dpage_e.aspx?si=A/HRC/39/48) that, *“workers around the world find themselves in the midst of a public health crisis due to their exposures to hazardous substances at work.”* The three case studies described above raise occupational health and safety concerns about the use of plastic polymers and resins in semiconductor manufacturing along with the host of toxic chemicals that accompany their use and by-product substances formed during the manufacturing process.

In 2016, Mr. Tuncak, noted some of the consequences of semiconductor and display manufacturing in his [report](https://ap.ohchr.org/documents/dpage_e.aspx?si=A/HRC/33/41/Add.1) on his visit to South Korea: “*As of January 2015, more than 350 former workers in the electronics industry, of which approximately 130 have died, had alleged that they had developed various diseases. Victims had suffered from cancer, including lymphoma, malignant brain tumors, myelogenous leukemia and non-Hodgkin’s lymphomas, as well as aplastic anemia, reproductive abnormalities and other health impacts.”*

Due to the lack of information and the myriad of substances used in semiconductor manufacturing it is not possible to directly connect these illnesses directly to the plastics lifecycle. However, the key components of semiconductor manufacturing are polymers and resins such as photoresist and epoxy molding compounds along with their associated chemical substances and toxic chemical by-products are released during the manufacturing process. Currently available information about these substances raises concerns about their potential harm.

Finally, the health effects documented in semiconductor industry workers are not consistent with the industry’s obligations under the [UN Guiding Principles on Business and Human Rights](https://www.ohchr.org/documents/publications/guidingprinciplesbusinesshr_en.pdf). In 2018, even Samsung itself [admitted](https://apnews.com/89d1445dc7ce439baee161bc8fbb404d) for the first time that they had failed to *“sufficiently manage health threats”* at its semiconductor and liquid crystal display manufacturing plants.

**Right to information**

In 2015, the former UN Special Rapporteur on Toxics and Human Rights, Mr. Baskut Tuncak, released a [report](https://undocs.org/A/HRC/30/40) on the right to information which noted that, *“Information about hazardous substances is essential to prevent risks, mitigate harms, conduct focused research on safer alternatives, provide treatment and remedy, and ensure transparency, participation and consent in decision- and policymaking.”* The report reiterates a key chemical safety principle, that *“It is not legitimate to claim that public health and safety information on hazardous substances is confidential. There is widespread recognition that health and safety information should not be confidential, and States have legally binding obligations to this end.”* Despite these clear human rights obligations, the normal practice of the electronics industry in South Korea (and elsewhere) is to [routinely hide information](https://apnews.com/0fa26d4e3a5140239553274fddd9b983/2-words-keep-sick-samsung-workers-data-trade-secrets) on chemicals to conceal links between illnesses in workers and the company’s working environment and to prevent its workers from receiving government compensation.

**Rights of the child and women**

In a report on the human rights of workers, the former UN Special Rapporteur on Toxics and Human Rights, Mr. Baskut Tuncak, [noted](https://undocs.org/A/HRC/39/48) that, *“Safeguarding reproductive health from hazardous working conditions is a core*

*obligation of States in the elimination of discrimination against women in employment. Women workers have a right to special protection during all periods that pose reproductive risks to them as well as to their offspring, which requires protection from work that exposes them or their fetus to toxic chemicals.”* In contrast, the US electronics industry outsourced the reproductive harm from ethylene glycol ethers to Asia and other regions while fully understanding the potential for devastating impacts on women and their children. Reproductive harm in the semiconductor industry and all other occupations is also relevant to the Convention on the Elimination of All Forms of Discrimination Against Women ([CEDAW](https://www.ohchr.org/Documents/ProfessionalInterest/cedaw.pdf)) which states in Article 11 the obligation for governments to take measures on, *“The right to protection of health and to safety in working conditions, including the safeguarding of the function of reproduction.”* There are 189 [Parties](https://indicators.ohchr.org/) to CEDAW, including South Korea.

**Right to an effective remedy**

The lack of information is used by the electronics industry to deny effective remedy. As noted by the Associated Press [investigation](https://apnews.com/0fa26d4e3a5140239553274fddd9b983/2-words-keep-sick-samsung-workers-data-trade-secrets), sick workers or families of deceased workers cannot obtain full reports on chemical identity, use or facility inspections, so their cases are delayed or ignored due to lack of demonstrating connection to their work.