January 26, 2006

Via E-mail and Express Mail
Secretariat of the Stockholm Convention
Att. Mr. John Buccini and Members of the POPs Review Committee
United Nations Environment Programme
11-13 chemin des Anemones
CH-1219, Chatelaine, Geneva, Switzerland

Re: Submission of Annex E Information on PFOS and Its Precursors

Dear Mr. Buccini:

On behalf of the Semiconductor Industry Association ("SIA"), the European Semiconductor Industry Association ("EECA-ESIA") and Semiconductor Equipment and Materials International ("SEMI"), we are pleased to provide this response to the November 18, 2005 request from the Stockholm POPs Review Committee ("POPRC") for the submission of Annex D and E information on the use of Perfluorooctane Sulphonate ("PFOS") and its precursors. PFOS-related substances play a critical role in the semiconductor manufacturing process and are largely responsible for the smaller, faster and more powerful semiconductors on the market today. Voluntary industry efforts to control emissions of PFOS have greatly reduced environmental and health concerns to de minimis levels, and the industry continues to strive for cleaner production and the application of PFOS for only critical uses.

This joint submission provides background information on the semiconductor industry, a summary of the use of PFOS in limited, critical semiconductor manufacturing operations, and a brief analysis of the environmental fate of PFOS used in this production. The submission also addresses our concerns with respect to the absence of Annex D information to support the listing of PFOS precursors as persistent organic pollutants ("POPs") under the Convention, and provides a brief summary of available information specified in Annex E of the Stockholm Convention. The completed Annex E submission form and additional resource documents that we believe will be helpful to the POPRC have also been attached.

The semiconductor industry views this submission as an initial step in what we hope will be a continued dialogue with the Secretariat and Members of the POPRC on this critical issue. In order to participate in future discussions on PFOS and contribute to the ongoing work of the

POPRC, we ask that the Secretariat grant observer status to SIA, EECA-ESIA and SEMI for the upcoming POPRC meeting on May 1-5, 2006 in Geneva.

By way of background, SIA has been the leading voice for the U.S. semiconductor industry since 1977. Today, SIA represents 95 companies responsible for more than 85 percent of semiconductor production in the United States. Collectively, the chip industry employs a U.S. domestic workforce of 225,000 people. More information about the SIA can be found at www.sia-online.org.

The ESIA, part of the European Electronic Component manufacturer's Association (EECA), represents the European-based manufacturers of semiconductor devices. The semiconductor industry provides the key enabling technologies at the forefront of the development of the digital economy. In Europe, the sector supports over 86,000 jobs in a market valued at around EUR31.7bn in 2004. More information on EECA-ESIA may be found at http://www.eeca.org/esia.htm.

SEMI is a global industry association serving companies that provide equipment, materials and services used to manufacture semiconductors, displays, nano-scaled structures, micro-electromechanical systems (MEMS) and related technologies. SEMI maintains offices in Austin, Beijing, Brussels, Hsinchu, Moscow, San Jose (Calif.), Seoul, Shanghai, Singapore, Tokyo and Washington, D.C. For more information on SEMI, visit www.semi.org.

I. Background on the Semiconductor Industry

Semiconductor technology has come a long way since the invention of the first transistor in 1947. The industry continues to drive innovation in the electronic and information technology sector. Today, personal computers have more processing power than the mainframe computers used by the U.S. National Aeronautics and Space Administration to land men on the moon in 1969. Breakthroughs in semiconductor technology have enabled organizations and individuals to store, retrieve, process and communicate information faster than ever before, driving economies and facilitating global communication and information exchange. As a recent exhibit at the Shanghai Museum for Urban Development stated, "[s]emiconductors are for the information society what grain was for the agrarian society and iron and steel were for the industrial society."

A wide and varied group of industries depend on semiconductor technology to compete in the global marketplace, achieve scientific breakthroughs, reduce environmental impacts, improve quality of life or even save lives. For example, medical professionals rely on semiconductor-powered computers to study genetic codes and model drug interactions. Scientists track animal or fish migration through the use of chip technology. In industry, semiconductors have led to productivity gains unprecedented since the development of Ford's assembly line, and at the same time have become integral components in products making them better, safer, and more environmentally friendly. Many industries feel that semiconductor technology is often the single differentiating factor in global competitiveness.

Widespread demand for, and use of, semiconductors has led to a record US$213 billion in worldwide sales in 2004. The semiconductor industry employed 225,000 people in the United States and 86,000 in Europe, with estimates of 500,000 people employed worldwide in 2003. The nature of semiconductors as an enabling technology also raises significantly their overall value to the global economy. In 2004, the electronics industry had revenues of US$1.24 trillion. Industries where electronic content is essential, such as the auto, defense, medical, space, gaming, telecom, internet provider and broadcast sectors, achieved overall revenues of US$5.0 trillion. When added together, this accounts for approximately 10 percent of the overall global economy.[1]

II. Uses of PFOS and Precursors in the Semiconductor Industry

The process used to manufacture semiconductors is highly complex; advanced manufacturing equipment requires extreme precision to accomplish high-yield, high-volume production. As circuit features get smaller, specialty chemicals like PFOS become more important, particularly during photolithography.

Photolithography is a critical step in semiconductor manufacturing where a silicon wafer is transformed into semiconductor chips. During the process, beams of light, or photons, are projected through a reticle or template onto the silicon wafer covered with a thin photosensitive film called photoresist. The light reaching the photoresist through the openings in the template solubilizes the exposed photoresist in the subsequent development step. The pattern remaining is then etched into the silicon to form the integrated circuit. Accuracy is vitally important during this photolithography patterning step because the feature size of the components and circuits is sub-microscopic.

There are three main PFOS applications that occur during photolithography, each of which is critical to achieving the accuracy and precision required to manufacture miniaturized semiconductor chips. First, Photoacid Generators ("PAGs") in the photoresist contain PFOS, which controls the photo-sensitivity and clarity of the desired image, allowing semiconductors to be manufactured with sharper, more accurately defined features and less line edge roughness. Limiting line edge roughness reduces the risk of semiconductor failure in critical applications. Secondly, surfactants containing PFOS lower the surface tension of the resist leading to reduced thickness variation and a more uniform film during the spin-on application of the resist on the wafer.

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[1] These data were derived from the SIA 2005 Annual Report entitled "2020 is Closer Than You Think," the EECA-ESIA 2005 Competitiveness Report, and readily available information provided by SIA, EECA-ESIA and SEMI on their respective websites. To access these reports and additional information, please see the following: (i) SIA at http://www.sia-online.org/home.cfm; (ii) EECA-ESIA at http://www.eeca.org/esia.htm; and (iii) SEMI at http://www.semi.org/.

The third use of PFOS is in anti-reflective coatings ("ARCs"), which prevent reflection of the radiation. This minimizes the creation of defects and roughness of the patterns. It is necessarily an exact science, where the composition of the ARCs must be matched to the resist and the light source.

There are no readily available substitutes for PFOS used in PAGs (including surfactants used as PAGs) and ARCs. When using shortened wavelengths for better resolution on miniaturized semiconductor chips (248 and 193 nm), PFOS is the only PAG chemical that can provide the necessary acidity to achieve the desired image. For ARCs, the refractive index must be as close as possible to the square root of the photoresist refractive index, and only fluorinated materials can meet this requirement.

Should overly restrictive production or use restrictions be placed on PFOS and its precursors, it would likely shut down high volume production semiconductor manufacturing. Research and development could possibly provide equally-well performing chemical substitutes for these critical processes, but if invention is required, it could take 10 to 15 years, at a minimum, to design, qualify and integrate the new technology into high volume semiconductor manufacturing. The cost would be prohibitive and divert engineers from their work on new, advanced technology development.

Notably, the semiconductor industry is in the process of voluntarily phasing-out non-critical applications of PFOS where other chemicals exist with the same performance. Most fabrication plants have removed PFOS and related substances from use in developers and etchants, reducing significantly the amount of PFOS effluent released into the environment. Where possible, manufacturers are using wafers with larger surface area. As wafer area increases to 125 percent, 85 percent less resist is required per wafer. Furthermore, newer technology nodes increase the size of the wafer from 200mm to 300mm while concurrently decreasing the amount of photoresist applied to the wafer up to seven times. The concentration of PAG in the newer photoresist is decreased by more than half, leading ultimately to significantly less PFOS required during the entire semiconductor manufacturing process.

III. Environmental Fate of PFOS

The semiconductor manufacturing industry has made a significant effort to strictly manage the use of PFOS and limit emissions and exposure. Excluding wastewater, all wastes containing PFOS resulting from the use of Bottom ARCs applied directly to the wafer and photoresist are collected in solvent and disposed of via incineration. According to the latest industry mass balance data for Europe, 82 percent of all PFOS used in semiconductor manufacturing is treated in this manner. As non-lithography semiconductor uses and PFOS developer use are eliminated, only the unreacted portions or those not exposed to the reactive wavelength of light used to polymerize the resist or ARC on the wafer are released in wastewater during the subsequent rinsing step. Industry estimates that for the whole of Europe only 43.21 kg of PFOS are released in the effluent per year. Data gathered in the United States indicates that the U.S. semiconductor industry releases a similarly small amount of PFOS into wastewater effluent.[2] These volumes are extremely small compared with PFOS use in other industry sectors.

In addition, there are no air emissions due to the low vapor pressure of PFOS and the nature of the manufacturing process. Manufacturing tools are typically fully enclosed and completely automated, making atmospheric emissions and worker exposure highly unlikely. Furthermore, the final product does not carry any traces of PFOS-related substances.

All of these precautions result in negligible risk to the environment and the general public from exposure to PFOS, as confirmed recently in the EU's Scientific Committee on Health and Environmental Risks ("SCHER") report entitled "Opinion on 'RPA's report 'Perfluorooctane Sulphonates: Risk reduction strategy and analysis of advantages and drawbacks.''" Comparing emission estimates for ongoing uses in Europe in 2004 to European historical use data from 2000, the SCHER report determined that "[e]missions from ongoing uses in the photographic, semiconductor and aviation industry amount to 64 kg, i.e. less than 0.3 percent of the emissions caused by the former uses." A further examination of the 2004 data reveals that PFOS and PFOS-related substance emissions from the European semiconductor industry in 2002 represented only 0.45 percent of all PFOS emissions in Europe. This compares to metal plating, which is by far the highest emitter at 94 percent, followed by fire fighting foams at 5.4 percent.

The SCHER report also examined whether current emissions have a significant influence on the rate of reduction of PFOS concentrations in the environment. It concluded that:

> "Current emissions from ongoing uses will most likely influence the rate of reduction of the PFOS concentrations in the environment only on a local level, and will insignificantly affect the overall concentration found in the environment. Local contributions from metal platters, airports, and from the use of PFOS-containing fire fighting foam may still be significant."

Significantly, the SCHER report found that overall concentrations of PFOS may eventually diminish even if all current critical uses remain constant. Any decrease would depend entirely on textile and other larger polluting industries not resuming the use of PFOS-related substances for manufacturing purposes. The report also found that any future increases in PFOS concentrations would be attributable to the degradation of precursors already present in the environment. Given these findings, the report ultimately concluded that "[t]he contribution of the confirmed on-going industrial/professional uses to the overall risks for the environment and

[2] SIA and SEMI collected U.S. mass balance data in 1999 for a broader range of perfluorinated chemicals, which included PFOS. They found that 56 kg of perfluorinated chemical waste was released in wastewater during semiconductor manufacturing. As PFOS represents only one of the chemicals included in the U.S. mass balance study, it is likely that if only PFOS waste had been measured, it would be closer to the amount reflected in the EU mass balance study conducted in 2002.

for the general public are probably *negligible* with regard to the sectors photographic industry, semiconductor industry, and aviation industry." (emphasis added).

Relying in part on the findings of the SCHER Report, the European Commission has proposed a directive which gives a derogation to photoresists and ARCs used in photolithography from marketing and use restrictions. In its December 5, 2005 proposed "Directive of the European Parliament and of the Council relating to restrictions on the marketing and use of perfluorooctane sulfonates" (the "Directive"), the Commission noted that "[a]ccording to SCHER, on-going critical uses in the aviation industry, the *semiconductor industry*, and the photographic industry do not appear to pose a relevant risk to the environment or human health, if releases into the environment and workplace are minimized." (emphasis added). A similar decision was made by the United States Environmental Protection Agency in 2002 to exempt PFOS used in photolithography from "significant new use" restrictions under the Toxic Substances Control Act.[3]

IV. Annex D Information

Sweden's PFOS Dossier appears to propose the listing of a group of chemicals that may not qualify as POPs under the Stockholm Convention. Specifically, the semiconductor industry is concerned with the absence of data regarding whether all proposed PFOS precursors would exhibit the required characteristics specified in the universally recognized screening criteria under Annex D for identifying POPs of global concern. After examining the most recent comprehensive lists of PFOS precursors prepared by the U.S. EPA and the U.K. Department of Environment, Food and Rural Affairs ("DEFRA"), it is clear that there is significant disagreement as to the universe of PFOS precursors. Sweden has chosen to include verbatim the DEFRA list in its PFOS Dossier submitted to the Stockholm Convention ("Convention"). This list differs considerably from the U.S. EPA list of PFOS precursors.[4] We are also concerned that there is not enough data for each of the precursors to verify their potential to degrade into PFOS. We would encourage the POPRC to seek more degradation data on individual PFOS precursors.

V. Annex E Information

The EECA-ESIA prepared a mass balance assessment of PFOS using 2002 European data that reflects the current phase-out of PFOS in developers and etchants. According to the findings, semiconductor fabrication plants use 240.9 kg of PFOS per year. When further disaggregated, the demand for various uses of PFOS appears as follows: (i) photoresist (PAG and surfactant) - 44.9 kg/yr.; (ii) edge bead remover - 85.3 kg/yr.; (iii) TARCs - 104.1 kg/yr.; and (iv) Bottom ARCs - 6.6 kg As stated previously, approximately 82 percent of all PFOS is collected in

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[3] See "Perfluoroalkyl Sulfonates: Significant New Use Rule," United States Environmental Protection Agency, 67 Fed. Reg. 72854 (December 9, 2002).

[4] See "Perfluoroalkyl Sulfonates: Significant New Use Rule," United States Environmental Protection Agency, 67 Fed. Reg. 11008 (March, 11 2002); and "Perfluoroalkyl Sulfonates: Significant New Use Rule," United States Environmental Protection Agency, 67 Fed. Reg. 72854 (December 9, 2002).

solvent and incinerated at high temperatures, and 12 percent (43.21 kg/yr.) of PFOS is released into the environment in wastewater. According to the SCHER Report, this represents 0.45 percent of all PFOS-related substance emissions in Europe annually.

As requested, industry has also provided in the attached Annex E submission form a brief summary of the status of PFOS under international conventions. The submission form also identifies key international and national studies that provide hazard assessments for end points of concern, environmental fate data, and information on exposure in local areas. In particular, industry would like to highlight the findings of the SCHER Report, which concludes that PFOS released in wastewater during the semiconductor manufacturing process has probably a *negligible* impact on human health and the environment.

Notably, the SCHER Report strongly questions the findings of an August 2004 DEFRA PFOS risk reduction strategy, stating that the DEFRA strategy "does not appear to be a sufficient basis for decision making," and "suffers from a lack of scientific detail to substantiate recommendations." In particular, the SCHER Report raises concerns over the use by DEFRA of animal exposure data to extrapolate human health risks, stating that "substantial differences exist in the elimination kinetics between animal species and man." As such, the SCHER Report recommends a full human health risk assessment of PFOS that would include indirect and occupational exposure.

VI. Conclusion

The semiconductor industry relies on PFOS and related substances for critical uses that enable the industry to manufacture miniaturized semiconductors with extreme precision at high production and high volume. An invention or innovation would be required to achieve a total phase-out of PFOS use during fabrication. Consequently, a production ban or restriction on the use of PFOS in semiconductor manufacturing would have a drastic effect on the industry, essentially shutting down production for 10 to 15 years until such an invention could be developed, tested and integrated into the manufacturing process. The far-reaching effects of the ban would be felt in the industrial, medical, electronics, automotive, space, defense, telecommunications, education and research, entertainment, internet and many other sectors that depend on semiconductor technology to achieve better results and remain globally competitive.

The ongoing phase-out of non-critical uses of PFOS and the successful incineration of 82 percent of all PFOS used in fabrication demonstrate Industry's commitment to clean production. Current emissions of PFOS are negligible, representing, for example, only 0.45 percent of all PFOS-related substance emissions in Europe annually. International industry initiatives coordinated through the Environment, Safety, and Health Task Force of the World Semiconductor Council will further our efforts to monitor, control and reduce the use of PFOS in semiconductor fabrication around the world. Our industry remains committed to seeking better technologies that reduce the environmental impact of our products and operations.

Please contact Steve Harper if you have any questions or need additional information on this submission. His full contact details are as follows.

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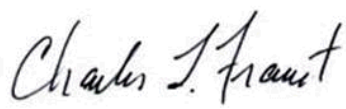
We appreciate the opportunity to respond to the Secretariat's request for information on PFOS. SIA, EECA-ESIA and SEMI look forward to participating in the POPRC's ongoing review of PFOS as observers, and we appreciate your consideration on this critical matter for our industry.

Sincerely,



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List of Attachments

1. Completed PFOS Annex E submission form.

2. "Hazard Assessment of Perfluorooctane Sulfonate (PFOS) and its Salts," the Organization of Economic Co-operation and Development (Nov. 2002).

3. "Perfluoroalkyl Sulfonates: Significant New Use Rule," United States Environmental Protection Agency, 67 Fed. Reg. 11008 (March 11, 2002).

4. "Perfluoroalkyl Sulfonates: Significant New Use Rule," United States Environmental Protection Agency, 67 Fed. Reg. 72854 (December 9, 2002).

5. "Preliminary Risk Assessment of the Developmental Toxicity Associated with Exposure to Perfluorooctanoic Acid and its Salts," United States Environmental Protection Agency (Apr. 2003).

6. "Perfluorooctane Sulphonate: Risk Reduction and Analysis of Advantages and Drawbacks," United Kingdom Department of Environment, Food and Rural Affairs (Aug. 2004).

7. "Opinion on 'RPA's report 'Perfluorooctane Sulphonates: Risk reduction strtategy and analysis of advantages and drawbacks,''" Scientific Committee on Health and Environmental Risks, European Commission (Aug. 2004).

8. "Environmental Risk Evaluation Report: Perfluorooctane Sulphonate (PFOS)," United Kingdom Environment Agency's Science Group (Sept. 2004).

9. "SEMATECH Position Statement Regarding the Business Case for the Continued Need of PFOS," International SEMATECH (Nov. 2004).

10. "Draft Risk Assessment of the Potential Human Health Effects Associated with Exposure to Perfluorooctanoic Acid and its Salts," United States Environmental Protection Agency (Jan. 2005).

11. "Results of Survey on Production and Use of PFOS, PFAS and PFOA, Related Substances and Products/Mixtures Containing These Substances," the Organization of Economic Co-operation and Development (Jan. 2005).

12. Proposal for a "Directive of the European Parliament and of the Council relating to restrictions on the marketing and use of perfluorooctane sulfonates (amendment of Council Directive 76/769/EEC)," Commission of the European Communities (May 2005).

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