World Semiconductor Council

Best Practice Guidance of PFC Emission Reduction

In order to effectively and efficiently achieve WSC (World Semiconductor Council) post-2010 voluntary PFC (Perfluoro-compound) emission reduction program, this technical guidance is set as the best practices for WSC members' reference.

The industry expects that the implementation of best practices will result in a Normalized Emission Rate (NER) in 2020 of 0.22 $kgCO_2e/cm^2$, which is equivalent to a 30% NER reduction from the 2010 aggregated baseline. Best practices will be continuously reviewed and updated by the WSC.

1. Emission Source:
   Refer to the latest "IPCC Guideline for National Greenhouse Gas Inventories"

2. Best practices.

   The selection of the best practice for a specific situation will depend on several factors such as viability, efficiency and other considerations.

   2.1. Process recipe optimization
   Optimizing processes to consume less greenhouse gases is a fundamental practice to be done for PFC emission reduction. Note: See chapter 3.1 for details.

   2.2. Greenhouse Gas replacement
   Replacing high global warming potential (GWP) gases with lower GWP or GWP-free gases is the most effective solution to further reducing PFC emission. Note: See chapter 3.2 for details.

2.3. Point of Use (POU) abatement

An abatement system is used to reduce greenhouse gasses by destructing the PFC's. POU abatement is capable of treating PFC gases and hazardous gases simultaneously

Note: See chapter 3.3 for details.

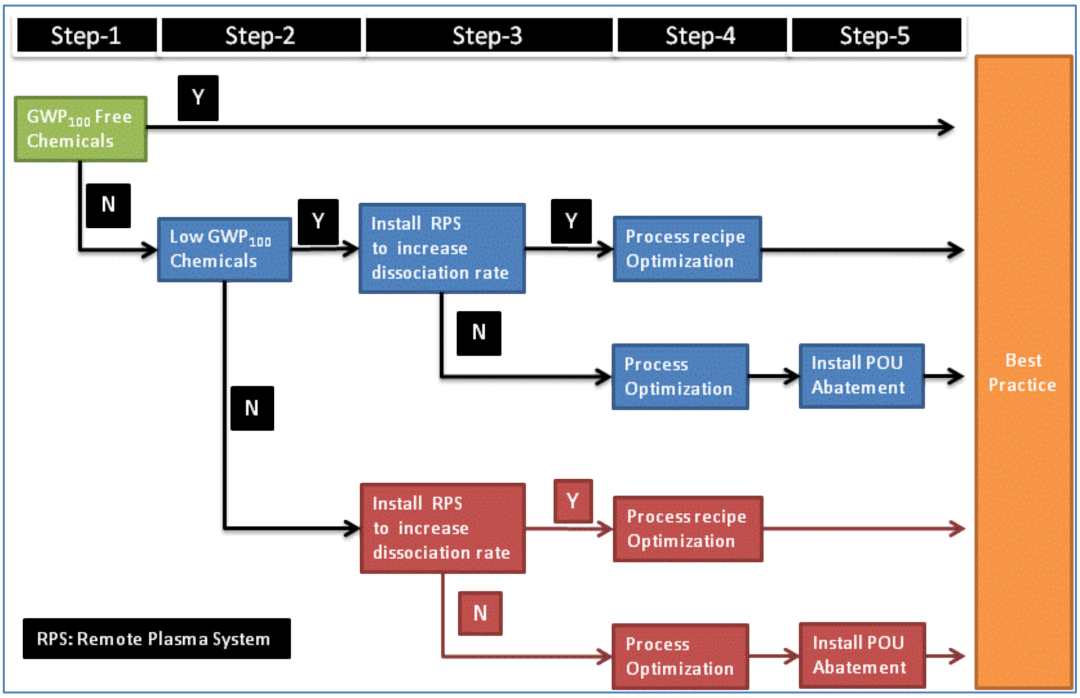
POU abatement can be applied to:

- New fabs
  - All new fab construction
- Existing fabs
  - Maintain or replace existing installed abatement capacity
  - Existing Tools relocated to different regions should include abatement
  - Upgrade of existing tool, installation of new tool in existing fabs, and major retrofits as infrastructure allows, and is feasible

2.4. Remote Plasma Cleans

This is the best way to enhance the NF3 disassociation rate in CVD chamber cleaning. It can reduce the amount of gases used and also reduce the PFC emission. Note: See chapter 3.4 for details.

2.5. Example of the best practice selection flow



3. Reduction methodology

3.1. Process recipe optimization

- General technology Description

  Process optimization allows emission reduction by adjusting process parameters such as the chamber pressure, temperature, plasma power, cleaning gas flow rates, and ratios in the case of mixtures. Process optimization can be applicable to both chemical vapor deposition (CVD) chamber cleans and etching processes.

  Process optimization can sometimes be accomplished by using an Endpoint detection system which uses techniques such as Mass Spectrometry (MS), infrared (IR) spectroscopy, optical emission spectroscopy (OES), and radio frequency (RF) impedance monitoring to monitor changes and provide plasma process end point times. Endpoint detection has been used extensively for CVD chamber cleans, but the technology can also be applied to etch and other PFC plasma processes

- Applicability

  Process optimization is applicable to ≤150 mm, 200 mm, and 300 mm CVD reactors and to other process tools using regular PFCs. A significant amount of work has been previously published on process optimization.

3.2. Gas Replacement Chemistry

- General Technology Description

  Alternative chemistry, or chemical substitution, is the use of chemicals with lower global warming potential (GWP_{100}) or GWP_{100} free as alternatives to PFCs. Alternative chemistry also includes high GWP_{100} gases that are more efficiently used in plasma processes, resulting in an overall greenhouse gas emissions reduction.

  When considering alternative chemicals it is essential also to consider their potential safety and health impact to fab operations and employee protection, i.e. Carbonyl Fluoride (COF2), Fluorine (F2).

- Applicability

  The usage of low GWP_{100} chemicals and
  GWP free chemicals depends on specific processes (i.e. C4F6 for etching processes).

  In some cases it is appropriate to use high GWP_{100} gases that are more efficiently used in plasma processes which results in lower emissions (i.e. Nitrogen Trifluoride (NF3)).

3.3. POU Abatement and recovery

- General technology Description

  Many new PFC abatement technologies have been developed and new systems commercialized. The industry has favored POU over centralized EOP (End of Pipe) abatement for PFCs, believing that it is more effective to abate close to the source.

  Abatement manufacturers may use different methods of determining destruction/removal efficiency (DRE) because the industry has not developed a standardized method. Performance of abatement systems varies greatly depending on a variety of abatement devices and process parameters such as temperature, PFC inlet concentration, flow rate, overall inlet stream composition, etc.

- Applicability

  Technologies under development or proven to be effective in abating PFC emissions are listed as follows:

  - POU fueled combustion scrubber
  - POU absorption scrubber
  - POU plasma / plasma scrubber
  - POU electrically heated thermal scrubber
  - Collecting system (Column unit adsorption), refining and recycling system

3.4. Remote Plasma Cleans

- General technology Description

  Remote plasma clean technology was developed as an alternative to in situ CVD chamber cleans to clean the byproducts left in the chamber after wafer processing. With remote chamber clean, a plasma-generating unit is mounted on the lid of a CVD chamber. Remote cleans typically react NF3 in a plasma. The fluorine radicals and ions generated in the remote plasma unit are routed to the processing chamber where they chemically react with deposits. The deposition byproducts are then carried away in gaseous form, e.g., SiF4.

- Applicability

  Technology is commercially available for 200 mm and 300 mm CVD chamber cleans. Tool suppliers manufacture or integrate remote plasma systems for retrofits to existing process tools to replace in situ PFC cleans.

3.5. New technologies will continue to be evaluated and shared among WSC PFC WG. Best Practice document will be reviewed for updates.

4. Evaluation of new technologies

In case companies want to measure emissions or want to determine the effectiveness of new technologies, reliable measurements protocols have to be followed. Examples of such protocols are given in the references (chapter 5.).

5. References

5.1. 2006 IPCC Guideline for National Greenhouse Gas Inventories

5.2. " Reduction of Perfluorocompound (PFC) Emission: 2005 state-of-the-Technology", International SEMATECH Manufacturing Initiative (ISMI), Technology Transfer #05104693A-ENG

5.3. "Guideline for Characterization of Semiconductor Process equipment", International SEMATECH Manufacturing Initiative (ISMI), Technology Transfer # 06124825A-ENG

5.4. JEITA Guideline for F-GHG Characterization and Management, October, 2011

6. Periodical review

In order to keep updating PFC reduction technologies developed, WSC PFC WG shall review/update and make available this guidance every two years.

- February 2014
- February 2016
- February 2018
- February 2020