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An Approach to Evaluate Greenhouse Gas Emissions in Wafer Fabrication Processes

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Introduction

Reduction of greenhouse gas (GHG) emission is one of the greatest challenges for sustainable development. The semiconductor manufacturing process has become more complex and been involved with clean-rooms which require a large amount of energy. Moreover, their complicated processing steps use various chemicals which are increasing GHG emissions. Toward GHG reduction, it is essential to evaluate GHG emissions. This paper describes a methodology for evaluating GHG emissions of MEMS fabrication process.

Evaluation Procedure for GHG Emissions

Sources of GHG emissions of the process are categorized to three main factors; input material production, energy consumption and output treatment. Items related to GHG emissions in input/output of the process, like materials, energy, and emission, were sorted out on all process steps. Figure 1 shows the framework to investigate those inventories. Amounts of consumption/emission of these items were measured and converted to CO2 emission including its equivalent of other GHGs.

The inventory data used in this study were obtained from the advanced 8-inch MEMS line TKB812 in the National Institute of Advanced Industrial Science and Technology (AIST). TKB812 is furnished monitoring systems which collect amounts of electricity, process gas, and exhaust stream every 10 minutes. Other data that could not be obtained from these monitoring systems were measured or replaced by the value form equipments data sheet.

The process flow used for estimation is shown in Figure 2. This flow is a MEMS fabrication process with SOI wafers as input. The GHG emission was estimated for each process step.

Results and Discussions

We made the input-output lists for all process steps. In reference to all listed items, amounts of consumption or emission were retrieved.

The total GHG emission is 21.6 kg-CO2e a wafer through the entire process steps. Figure 2 shows GHG emission of each process step. Also, the estimation result provides general implication for potential major source of GHG emissions; processes with high power, for a long time, used repeatedly, of wet (using de-ionized water and liquid waste disposal), of silicone deep reactive-ion etching (through wafer), with much use of clean-room facility (purified nitrogen and compressed dry air), with use of particular chemical solution, or with use of particular waste disposal.

Since in our approach GHG emission is estimated for each process step, it can be used for eco-friendly process monitoring or equipment monitoring. Furthermore, for environmentally-correct design of each process step or equipment, one can also take advantage of our approach. For these purposes, the level of details and granularity in data acquisition should be reconsidered to assess GHG emission objectively to be widespread agreement. At least the interval of data acquisition, 10 minutes, is not sufficient if a processing time is shorter. And some of the inventories, such as detailed flow rate or pure water consumption, could not be obtained and were replaced by the value in the specification. The architecture of Equipment Engineering Systems (EES) will play very important role in data collection and pre-processing.

Summary

We calculated and analyzed GHG emission for each process step of MEMS fabrication, to obtain implication for reduction of GHG emission. The level of details and granularity in data acquisition be reconsidered for GHG reduction. At least, for GHG reduction at each process and equipment, data acquisition interval at finer level is needed. Data collection and pre-processing scheme of EES are powerful and appropriate for this purpose.

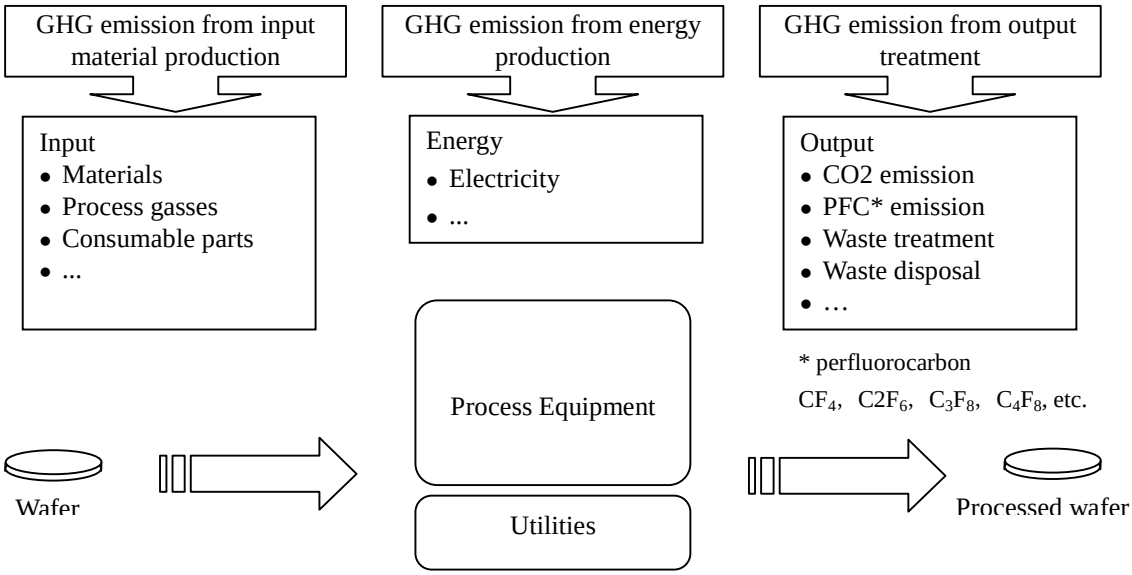

Figure 1. A framework for investigation of inventory

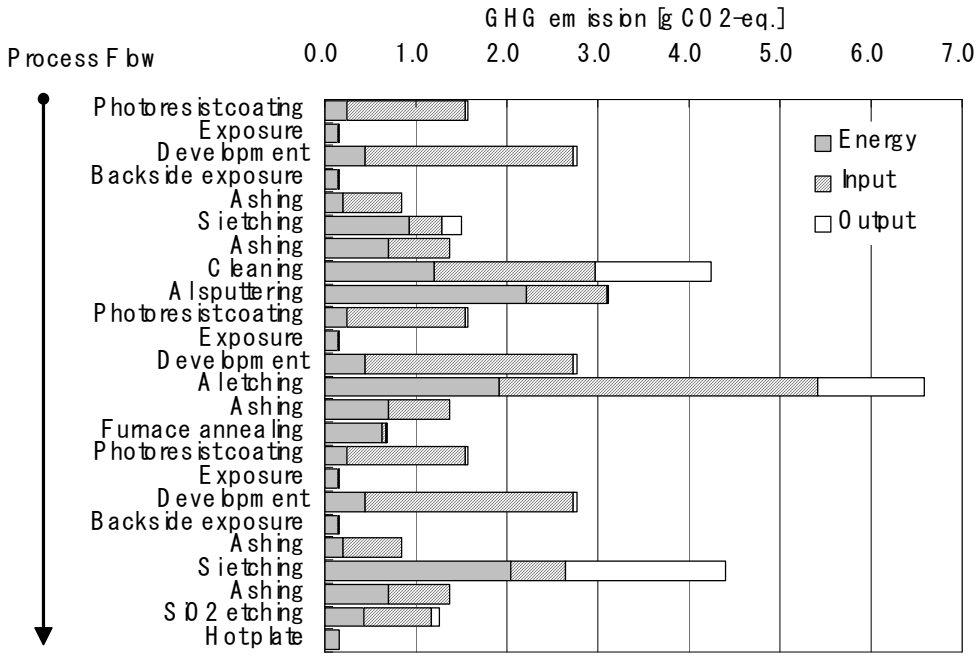

Figure 2. GHG emissions of each process steps