Green GaAs Substrate Manufacturing

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Abstract. Two trends have always been apparent to substrate manufacturers. First, the diameter of the wafers generally increases. And second, prices for these wafers generally decreases. These trends force substrate manufacturers to continually seek for ways to become more efficient. In addition to the economic pressure, there has been an increasing focus, especially in Western Europe, on the ecological aspects of GaAs. So, any manufacturing efficiencies that are developed to reduce cost, must also be environmentally benign in order to fulfill the responsibility of the industry. This paper discusses several improvements we have made to our manufacturing processes that not only improve our efficiencies, but also reduce our impact on the environment.

In principle, there are three fields to influence the usage of environmental resources in semiconductor production – generation of energy and materials, recycling and disposal of waste. Recycling lies at the heart of every effort due to the effect on the costs and the environmental footprint. For the production of GaAs substrates we must recycle as much as possible at every stage of our manufacturing process. Our starting materials are pure gallium and pure arsenic and the first step is to combine these two elements chemically into GaAs. After this synthesis step, the polycrystalline material is re-melted, and a single crystal boule is grown. The boule is then sliced into wafers, which must be polished before they can be shipped to our customers for epitaxy growth. And at each step of production there is a potential to recycle some of the material.

A standard 150mm GaAs wafer weighs about 60g – half gallium and half arsenic. For each wafer, we need to start with roughly 100g of gallium and 100g of arsenic. So from this 200g initial investment of materials, only about 30% is eventually shipped to the customer. The remaining 70% is lost due to yield losses and unavoidable processing losses (e.g. kerf loss at slicing, and thickness removal at polishing). For both economic and environmental reasons, it is important to recover and recycle as much material as possible. In view of the difference in cost between pure gallium (about $650/kg) and pure arsenic (about $200/kg), most emphasis is given to recovering and/or recycling the gallium. We have developed procedures to recycle much of the material lost during the synthesis and crystal growth steps of our process. In addition, while we try to minimize the kerf loss during slicing, we recover the gallium in the slurry containing the kerf. Taken all together, we can recover roughly 50% of the starting gallium. So, with about 30% shipped to the customer, it is only the approximately 20% lost during the polishing process that we cannot recover economically.

The preceding sections have discussed how recycling can influence the manufacturing cost of a GaAs wafer. Recycling however is not limited to our main raw materials. It also includes other essential auxiliary and operating materials such as boron oxide, water and electricity and there are several further ways, in which both the costs and the environment can benefit. As an example, the initial steps of producing GaAs wafers (GaAs synthesis and crystal growth) are very energy intensive. The melting point of GaAs is 1,238 degrees Celsius, so a large amount of heat has to be generated to melt the material and must then be removed in a controlled fashion. Heat is typically obtained by using electricity-powered heaters. But the electricity is usually generated by heating something else (coal, gas, oil, etc.). To reduce both costs and our environmental impact, we have built a co-generation plant in our facility. This co-generation plant allows us to channel some of the heat used to generate the electricity for our furnaces, into other functions in our plant.

This presentation will provide details of our environment-related activities and show specific indicators which describe the environmental footprint of state-of-the-art GaAs substrate production.