Semiconductor laser case study examples

[Literature](), [Novel]()

A semiconductor laser is a device that converts electrical energy into light. It consists of a semiconductor material, whose conductivity is between that of conductors and insulators. These kinds of a laser usually consist of two basic components, an optical amplifier and a resonator (“ Semiconductor Laser”, n. d.). The amplifier, referred to as the gain medium, is made of a direct-bandgap semiconductor material, such as gallium arsenide or indium phosphide. The amplifier can interact with light by absorbing and emitting photons (“ Laser”, n. d.). The amplitude of stimulated light emission is greater than that of light absorption, and the light is therefore amplified (“ Laser”, n. d.). The resonator, referred to as the optical cavity, usually consists of two plane-parallel mirrors ad a waveguide to circulate light through the amplifier and focus it. The basic design of a semiconductor laser relies on the construction of a double heterostructure, in which an amplifier layer is sandwiched between two resonator layers, so that light is confined in the amplifier layer and gets amplified (“ Semiconductor Laser”, n. d.). For example, according to Weschler (2001), the hyper silicon laser manufactured by Intel uses indium phosphide as the gain medium and the silicon as the resonator to provide the mirrors and routing for light in a low-loss, low cost way. A semiconductor laser is used for continuous wave operation (Weschler, 2001).

Semiconductor devices like diodes, transistors, and semiconductor lasers are manufactured in a similar way. First, single crystal silicon ingot is produced by slowly pulling a solid silicon seed from a silicon molten liquid. The crystal ingot is then ground and cut into thin, round slices, known as wafers. The wafer is then ground, polished and cleaned through a rigorous chemical and ultrasonic process. Second, additional epitaxial layers are grown on the surface of the wafer through a process called liquid phase epitaxy (LPE). In this process, the wafer (substrate) is passed underneath the molten of a material, and the deposition of the material crystal on the substrate occurs (" Light-Emitting Diode (LED)", n. d.). Different dopants can be added in different material melts to achieve different electronic properties in different layers. Third, a thin silicon dioxide layer is formed on the wafer surface through thermal oxidation or deposition (" Semiconductor Laser", n. d.). The wafer is further fabricated through photolithography and chemical etching (" Semiconductor Laser", n. d.). Fourth, the semiconductor wafer is metallized by heating the metal to the temperature that causes it to vaporize (" Light-Emitting Diode (LED)", n. d.). After the metal condenses and sticks to the wafer, it needs to go through an annealing process, so that the metal and the semiconductor bond firmly together (" Light-Emitting Diode (LED)", n. d.). Finally, the wafer is cut into proper sizes and mounted on the appropriate package, depending on whether it is diodes, transistors, or semiconductor lasers.

There are several principle and techniques that are important in designing and manufacturing electronic devices. First, the thin film deposition technique is very important to semiconductor manufacturing, as a fine and uniform deposition is required for tight binding between two layers in a semiconductor. According to Weschler (2001), engineers in Intel use a novel low-temperature plasma hatched process to combine an indium phosphide layer and a silicon layer together. Second, the design of the heterostructure is critical to the electronic properties of a device. For example, semiconductor lasers with novel heterostructures have been recently developed, including quantum well lasers, quantum cascade lasers, separate confinement heterostructure lasers, distributed feedback lasers, vertical-cavity surface-emitting lasers, etc. (“ Laser Diode”, n. d.) In terms of quantum well lasers, the layer holding the gain medium is made thinner than that in the traditional laser diode, rendering the quantum well lasers a higher efficiency (“ Laser Diode”, n. d.).

Reference

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