ERROR SOURCES IN A PYROMETRIC SYSTEM FOR CONTROLLING THE PARAMETERS OF A3B5 HETEROSTRUCTURES DURING EPITAXIAL GROWTH

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Fabrication of novel optoelectronic devices (emitters and photodetectors) are vital in the fields of optical transmission systems, science, medicine, renewable energy and military. Therefore, the research in this area is considered highly relevant these days.

Metalorganic chemical vapour deposition (MOCVD) is the most significant manufacturing process for A3B5 compound semiconductors. However, the deposition processes are extremely temperature sensitive. To obtain defect-free heterostructures with reproducible parameters in mass production, the temperature repeatability of the process must be less than 0.4 °C [1]. Hence the technology is in need of precise temperature control system. From a practical standpoint, all manufacturers resort to optical methods due to the specificities of the process and reactor construction. By using a pyrometer to measure the thermal radiation emitted by the surface of a semiconductor wafer, and a reflectometer to measure the wafer's reflectivity, the emissivity-compensated pyrometry method allows to take into account changes in the optical properties of the wafer’s surface during the growth for most accurate results. The rotation of the wafer carrier allows to perform the real-time thermal mapping of all wafers in the MOCVD reactor.

Before being installed on the reactor, the pyrometric system is calibrated using a blackbody furnace. It allows to compensate the factors of the pyrometer such as wavelength, sensitivity, attenuation and geometry. However, during the process, the pyrometer is subjected to ambient heat. This leads to heating of the photodetector. The silicon photodiode is used as the sensitive element, and the current signal is converted into voltage by a high-gain transimpedance amplifier.

The magnitude of the current signal with respect to the input optical power is described using the spectral sensitivity, which has a temperature dependence. This dependence caused by changes in the width of the bandgap and absorption coefficient of silicon photodiode, which in turn affect the internal quantum efficiency. A change in ambient temperature by 20 °C can result in an error of up to 1 °C in determining the real wafer temperature, which is critical. Investigation of the temperature dependence of the spectral sensitivity of a silicon photodiode and ways to stabilize it will help improve metrological equipment for the application of novel thin-film structures in various fields; thereby extending the accessibility of the advanced devices in the future.

References:

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