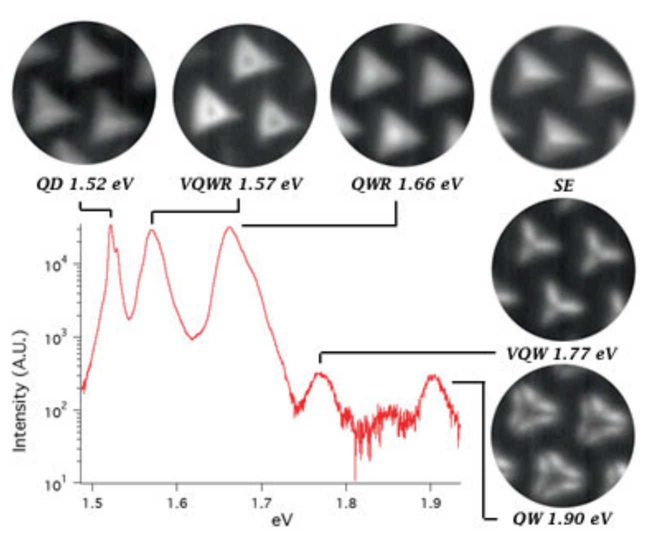
Cathodoluminescence system offers quantitative and reliable data for optoelectronics devices

The pitch

The increasing demand for new optoelectronics devices such as solar cells, laser diodes (LD), and high-brightness light-emitting diodes (HBLED) combined with the economic necessity to achieve lower consumption levels and higher yields are motivating researchers to develop new materials. Specifically many studies are being initiated to improve the understanding of the fundamental physical properties and behavior of compound semiconductor materials including quantum wells, quantum dots, and nanowire-like structures. An innovative method of cathodoluminescence (CL) is required to generate reliable, quantitative, and stable data as well as to prepare the basis for quality control during production.

Conventionally, CL is a challenging technique generally carried out using unwieldy laboratory-assembled devices. A scanning electron microscope (SEM) is required along with a CL add-on device consisting of a light-collection mirror and a detection system. Both of these must be assembled together, which can result in cumbersome and unstable alignment plus interfacing difficulties. This is particularly the case with cryogenic positioning stages. The collection mirror (parabolic or elliptic) has a very limited field of view (several micrometers), thus when the sample is moved slightly, most of the signal is lost and realignment is required. In addition, the light collection efficiency is very low because the photons collected are dispersed when they are not exactly collected at the focal point of the mirror, which results in limited sensitivity.

The company Attolight makes CL available in a simplified system that integrates CL with both light and electron microscopy. It features a hyperspectral imaging mode that reveals ultra-trace impurities and crystallographic defects not visible using other imaging modalities. At production sites, it is expected to become a major tool for detecting defective materials at an early stage of the manufacturing process thereby generating significant savings.



Cathodoluminescence characterization of a GaAs pyramid sample. The spectrum shows five main peaks corresponding to the five main structures in the pyramid. These are, from low to high energy: the quantum dot at the tip of the pyramid (QD), the vertical quantum wire (VQWR), the lateral quantum wires (QWR), the vertical quantum wells (VQW), and the quantum well along the sides of the pyramid (QW). SE is secondary electrons.

The technology

The Attolight system is an independent spectroscopy system in which a light microscope is embedded within the electron objective lens of an SEM; both fields of vision match each other. The light microscope visually positions the system so no optical alignment is required.

This innovative design is optimized to achieve superior CL performance without compromising SEM performance. For example, secondary electrons are not obstructed by the collection optics as occurs with existing systems. Integrated optics allows consistent high-efficiency collection over the entire viewing field. Owing to a numerical aperture of 0.78 (f/1.0), the average collection efficiency over the 300 μm field of view is more than 100 times larger than for a conventional CL apparatus. With this process, it has become possible to make quantitative CL measurements and compare data from one specimen to another with a system totally achromatic from UV to IR (see Figure).

A cryogenic nano-positioning stage controls the specimen temperature from 20 K to 300 K, facilitating the measurement of weak luminescent samples. A patented mechanical design with a 9-axis system ensures the absence of very low drifts and vibrations plus arbitrary sample positioning. The system also features a time-resolved option for lifetime and charge-carrier dynamics measurements in which picosecond electron pulses are generated to excite the specimen without losing the spatial resolution of 7 nm.

Opportunities

Attolight is seeking state-of-the-art research laboratories and facilities focusing on LED and LD efficiency and reliability, wafer testing, solar-cell efficiency, and defect analysis of semiconductors. The company is also interested in partnerships for the development of UV lasers having a wavelength of 266 nm and a power higher than 10 mW to drive its photoelectron sources plus it is interested in development of infrared sensors.

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