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Nanomanufacturing — Key control characteristics

Part 5-4: Energy band gap measurement of nanomaterials by electron energy loss spectroscopy (EELS)

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Part 5-4: Energy band gap measurement of nanomaterials by electron energy loss spectroscopy (EELS)

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INTRODUCTION

Electronic and electrical devices developed up to now have been fabricated by stacking a series of active and/or passive layers on a specific substrate. The current trend in developing such devices is the miniaturization of product size, whereas the basic structure of multilayers on a substrate has not changed. Accordingly geometrical scales in the inner structure of a device have been decreasing and some of the scales such as thickness of the layers have finally reached a few nanometres. One of the key control characteristics (KCCs) is the band gap of an active layer which enables the electron or hole transportation, excitation and emission of electrons, etc. to be controlled.

The band gap is referred to as an energy gap, which means a difference between an energy level in which electrons exist and an energy level in which electrons do not exist. Even though the band gap of a material is intrinsic, the band gap of a nanomaterial is an extrinsic property which represents its size-dependency. Therefore, the band gap of nanoscale materials needs to be measured locally, in situ or in vitro.

For the band gap measurement application to nanomaterials, a specific region of a nanometre-scale device or a single layer of the multi-layered structure, a transmission electron microscope (TEM), which has atomic-scale image resolution, and electron energy loss spectroscopy (EELS), which can measure energy loss of electrons, have in general been used.

In this document, a method of measuring the band gap energy at a specific location for a nanomaterial by using TEM and EELS is proposed.

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