SAND2014-17674C

LEEM-PEEM study of surface defects, surface potential, and compositional inhomogeneities in InGaN-based heterostructures

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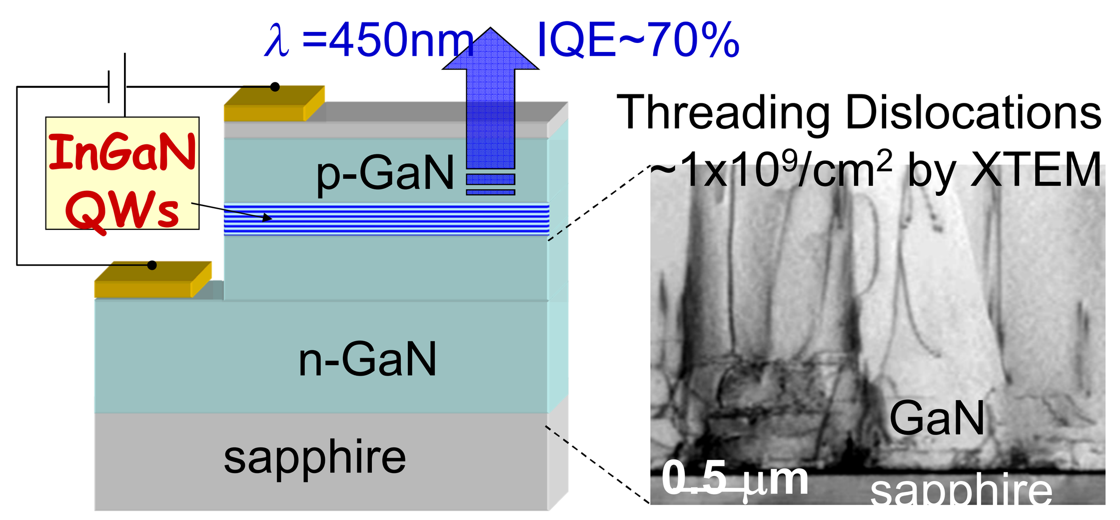
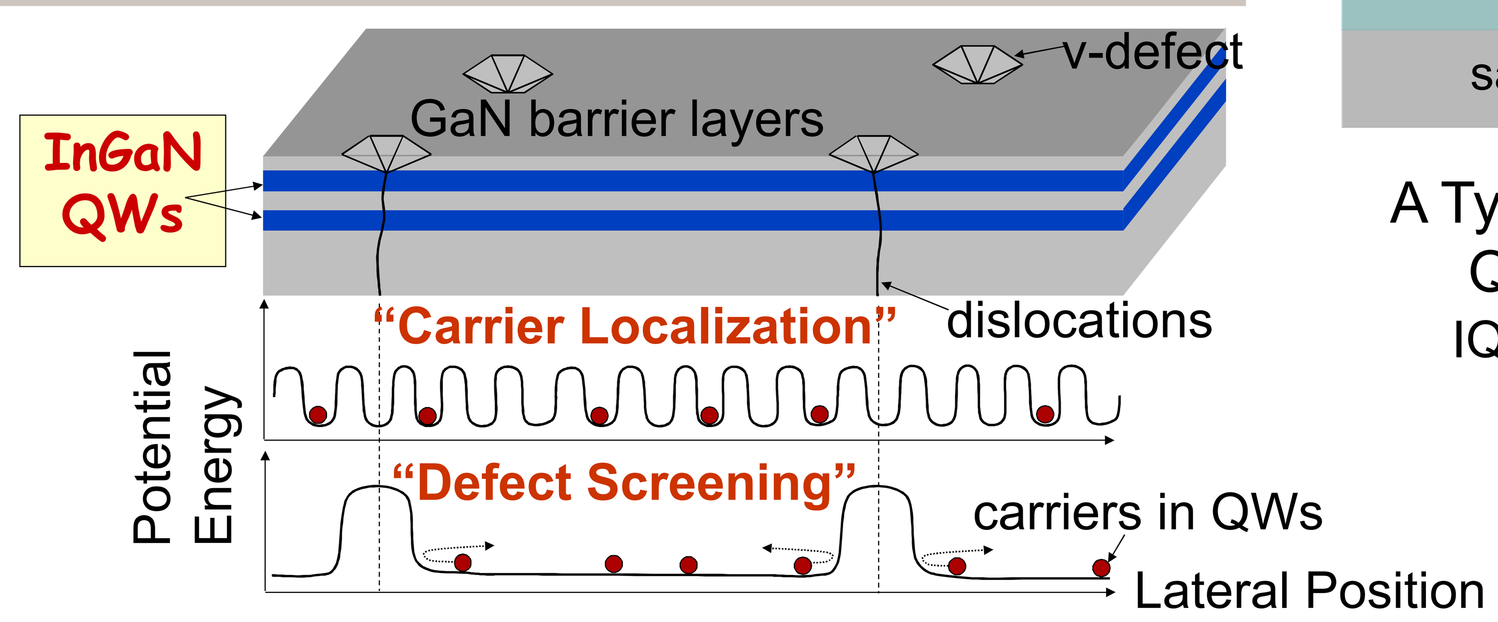
Indium-gallium-nitride-based light-emitting devices (LEDs) are the enabling technology for an ongoing global effort to replace conventional lighting with energy-efficient Solid-State Lighting. However, the remarkable optoelectronic properties of InGaN alloys remain poorly understood, with major fundamental questions still unanswered. Foremost among these is: Why do blue-emitting InGaN alloys have high radiative efficiency despite having very high threading-dislocation densities that quench light emission in traditional semiconductors? It is hypothesized that structural and compositional inhomogeneities localize carriers away from crystalline defects, but the nature and degree of localization, its correlation with defects, and its dependence on composition are controversial. Here, we present a low energy electron microscopy-photoemission electron microscopy study of InGaN multi-quantum-well samples.



A Typical $In_{0.17}Ga_{0.83}N$/GaN Multi-Quantum-Well (MQW) LED

IQE: internal quantum efficiency

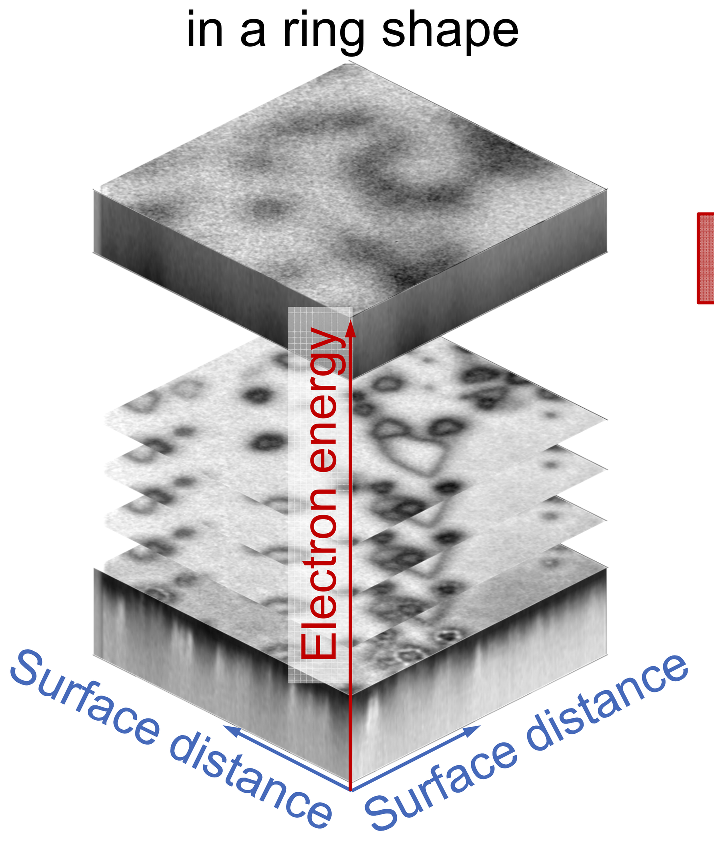


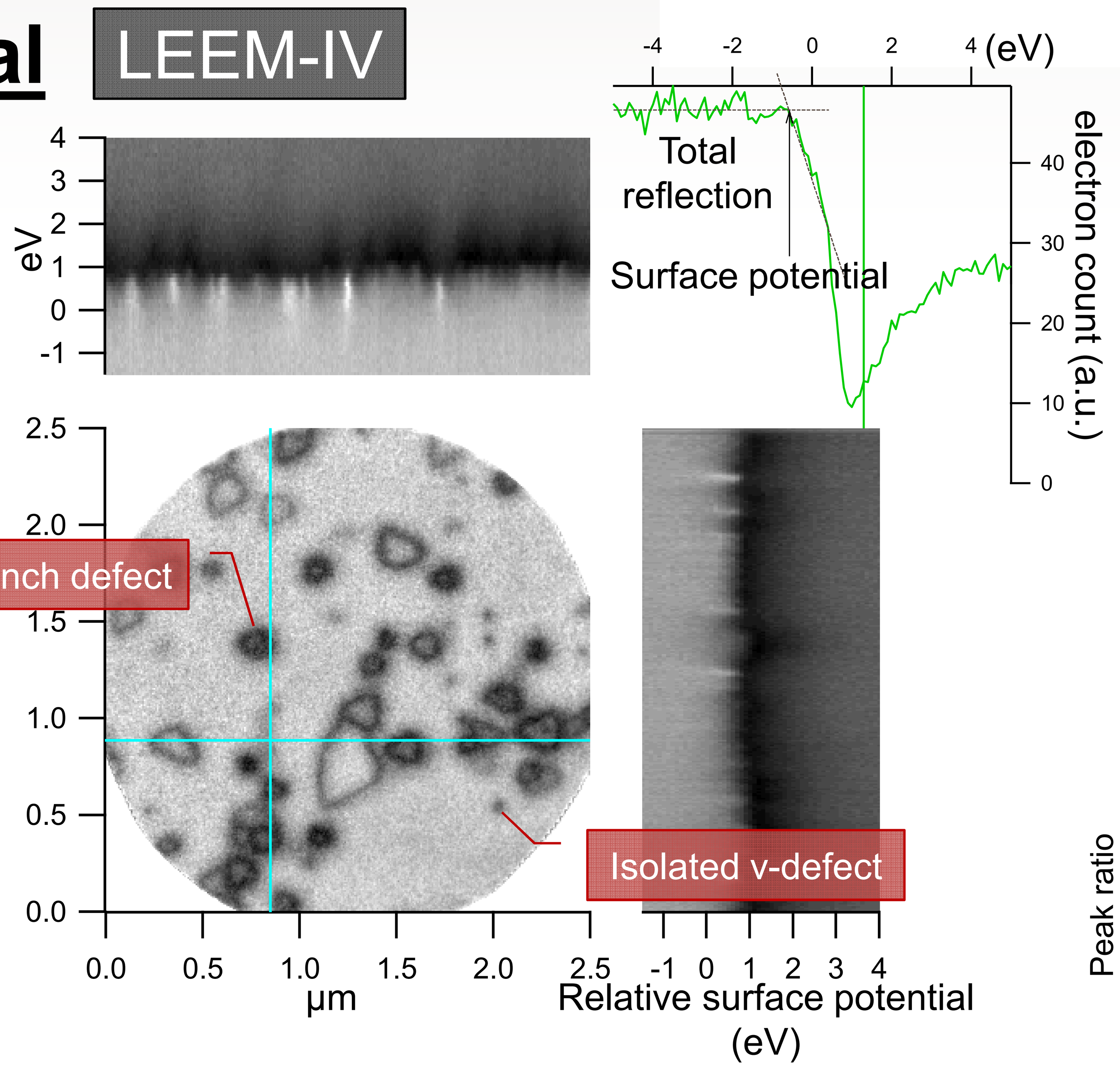
Surface Potential

LEEM-IV

Surface potential varies around v-defects & trench defects

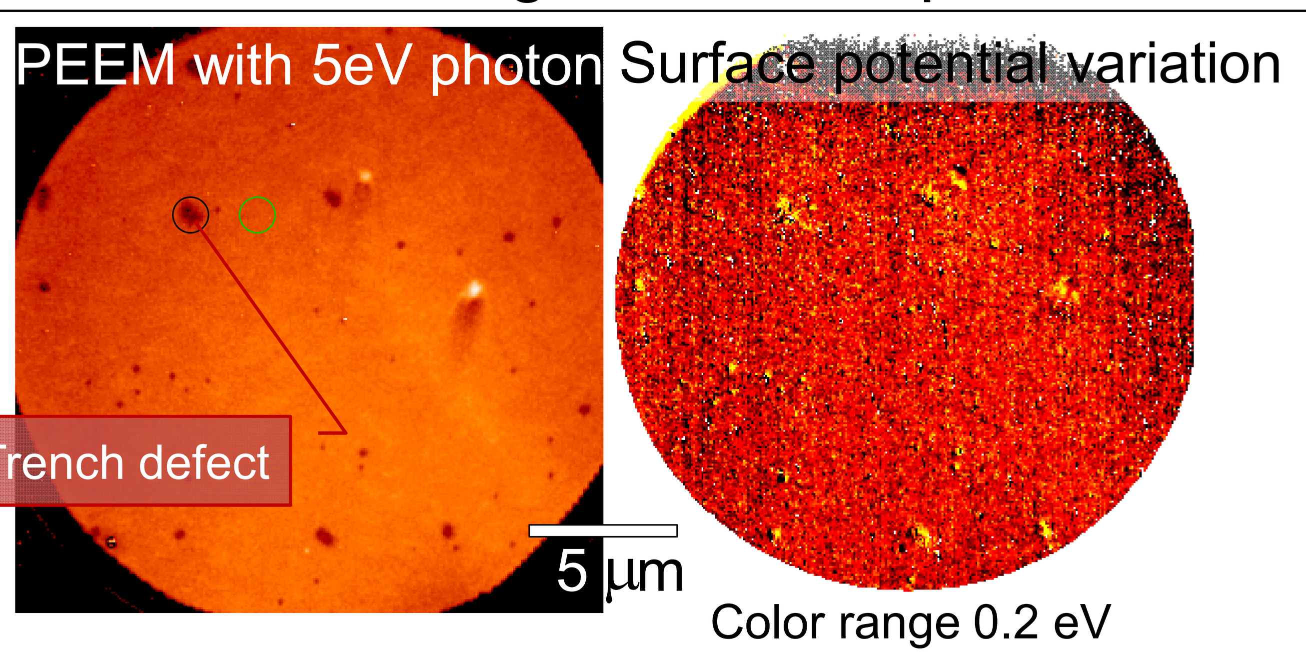
Trench defects: v-defects aligned in a ring shape

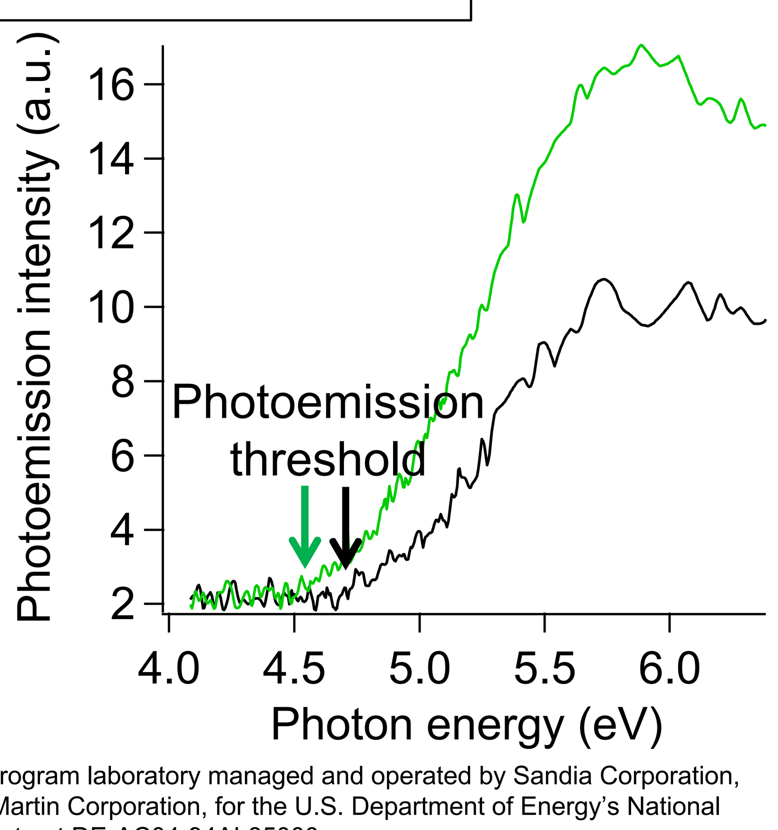




Threshold PEEM

~100-150 meV higher surface potential at trench defects

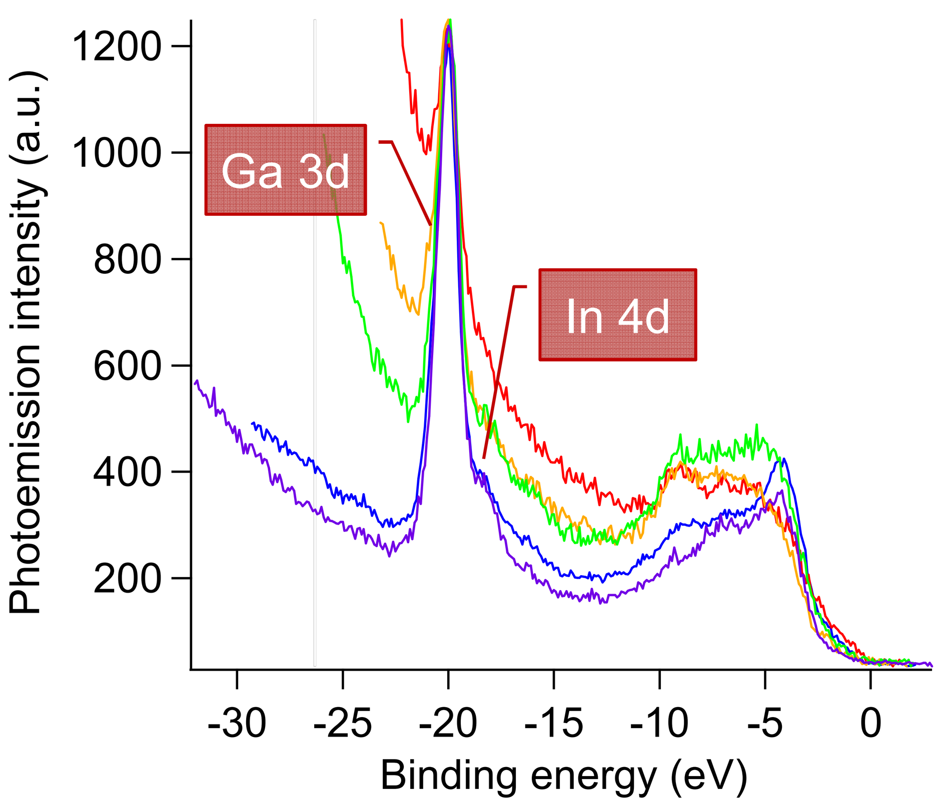




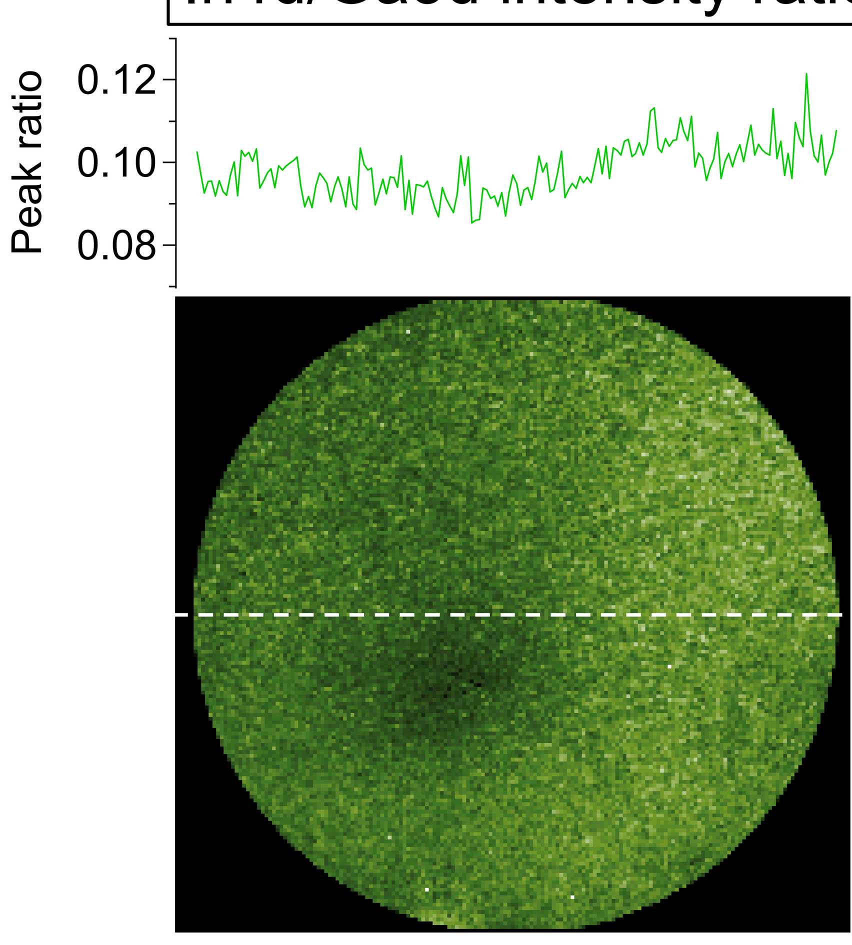
Chemical Composition Analysis

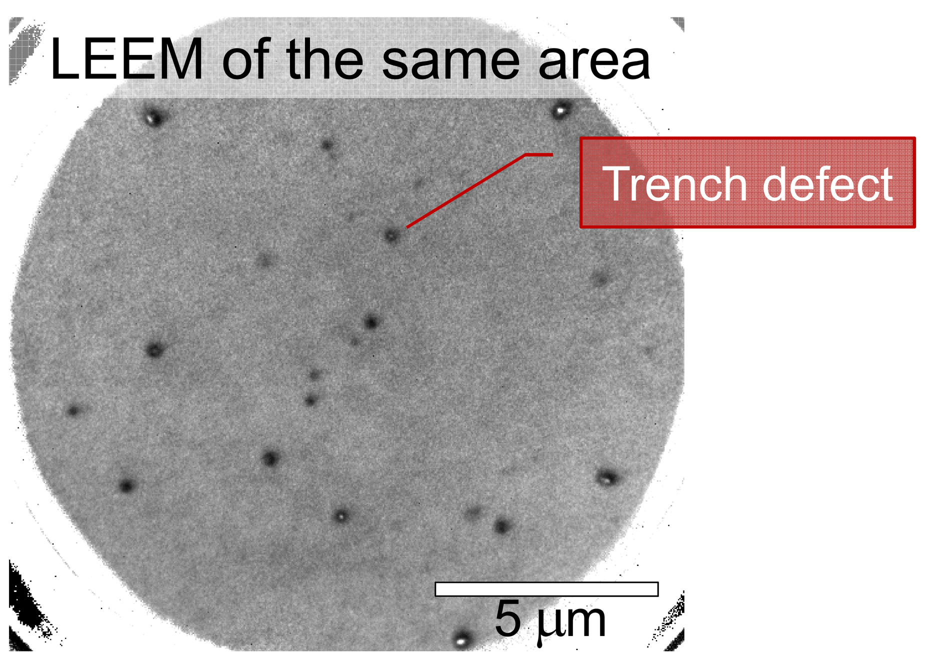
Neither chemical compositional variation nor MQW's thickness variation exists at given spatial resolution & sensitivity

Core-level PEEM



In4d/Ga3d intensity ratio





This work is supported by Sandia LDRD. A part of the work was performed at Center for Functional Nanomaterials and National Synchrotron Light Source supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-98CH10886.