In the last decades, nanotechnology has entered our daily life. One of the representatives for this is semiconductor technology in its various forms. Beside the ability to scale processes down to nanometer sizes, semiconductor technology and science is driven by the capability to form material junctions and combinations. This idea - known as heterostructure - was suggested in the late 50s, after the invention of the transistor in the late 40s. It took quasi two decades before the realization by a major technological breakthrough - the invention of molecular beam epitaxy (MBE), which developed into one of the major technologies producing the backbone devices of internet communication, mobile telephones and other advanced electronics.

In this tutorial, I would like to give an overview of MBE covering its importance for basic science providing samples for quantum mechanical studies - like the quantum hall effect, single photon sources or Kondo effect - as well as for device structures including high efficient solar cells, quantum cascade lasers or high mobility transistors. I will cover the basics of epitaxial growth, do an introduction, what a heterostructure is and its possibilities for band structure design. To illustrate these possibilities, I will take about photoluminescence from heterostructures like quantum wells and quantum dots and discuss, how a 2D electron gas emerge at heterostructure boundaries. I will provide examples from our research to explain basic growth phenomena from flat layer to pattern substrates and luminescence from semiconductor nanostructures fabricated in our labs. Finally, it will try to provide an outlook of material system beyond classical semiconductor structures.