1) The objective of the project

The goal of the project "In-situ modifications of novel 1D & 2D materials and their heterostructures using Raman spectroscopy and transmission electron microscopy" is twofold:

First is connected to development of precise fabrication routes for nanomaterials, in particular two dimensional materials such as graphene, boron nitride, transition metal dichalcogenides and one dimensional materials as nanowires also in atomic scale. Moreover, the fabrication routes will not only focus on the individual materials but their combination to form well-defined heterostructures with unique and as yet unexplored properties. The synthesis investigations will be conducted using both *in-situ* and *ex-situ* characterizations. The primary goal here is to understand the synthesis of these nanostructures at the atomic scale using world-leading cutting edge analytical techniques.

In the second one precise engineering route to provide defined solid-state architectures with atomically precise structure-property relationships will be understood. This will be achieved by developing nanoscale structuring also using *in-situ* techniques like electrical current and electron beam driven reactions. The primary goal is to overcome challenges involved in the use of new nanomaterials in functional devices thus making important steps to aiding nano-materials fulfill their promise.

2) Research to be carried out in the project
The proposed research can be split into four main categories:

I. Understanding the synthesis of nanostructures using chemical vapor deposition methods and Raman spectroscopy.

II. Synthesis of nanomaterials in necessary quantities for project studies.

III. In-depth characterization of nanostructures using microscopy techniques like: transmission electron microscopy, scanning electron microscopy, atomic force microscopy, optical light microscopy and spectroscopy techniques like: Raman spectroscopy & infrared spectroscopy.

IV. *In-situ* TEM electron beam driven synthesis and engineering of nanostructures with particular emphasis on 1D, 2D materials and hetero 2D materials.

3) Present reasons for choosing the research topic
In the contemporary world we live in we hear a lot of hype about nanotechnology, nanoscience and nanomaterials. What is this hype about? Well at the scale of 1 to 100 nm (a news paper sheet is 100,000 nm thick) the properties of materials start to alter. This is because at this scale we work with atoms, molecules and structures that are small enough to be considered very large molecules. Indeed, as their properties change at this small scale the changes can be gradual and vary as their size changes. This opens up the possibility to tailor the properties of nanoparticles. This on its own is tremendously exciting for scientists, engineers and industrialists. However, nanotechnology goes beyond the power of tailored properties in that in many cases new properties are discovered, as was the case for a nanomaterials named graphene which is in essence a carbon layer one atom thick. It is the propensity of tailored and new properties that excites scientists and engineers so much in all fields including basic science, medicine, engineering and way beyond. However, as already mentioned, the properties can change with size for a given material, and hence ways to fabricate and engineer them with atomic precision is required because manipulation of a few atoms can alter their properties. This is not a trivial exercise and new ways to do this as well as to understand current approaches at the atomic scale are lacking. In this proposal we aim to focus on a set of two-dimensional materials like graphene and transition metal dichalcogenides to understand their fabrication and engineering at the atomic scale. This will be crucial for the future development of these materials in many areas such as electronics, medicine and new specialized materials to name a few.