# ****Opportunities in Nanoscale Lattice Dynamics with Nuclear Inelastic Scattering at the ESRF-EBS****

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Reducing the material sizes to the nanometer length scale leads to drastic modifications of the propagating lattice excitations (phonons) and their interactions with electrons and magnons. This offers the possibility for phonon engineering by tailored nanostructures, which will tremendously affect thermal management in nanoelectronics, thermoelectrics, and will accelerate the development of efficient thermal logic devices operating at THz frequencies, such as thermal diodes, rectifiers and memories. To make a breakthrough in these fields, a comprehensive understanding of both qualitative and quantitative lattice dynamics modifications in surfaces, interfaces and nanoobjects (particles, clusters and wires) as a function of layer thickness, object size and shape, epitaxial strain and chemical state is indispensable.

The complete determination of the lattice dynamics of nanoscale materials, however, is one of the grand challenges in the modern experimental and theoretical condensed matter physics. Among the available experimental methods, Nuclear Inelastic Scattering combined with first-principles theory is a particularly suitable and powerful approach to accomplish this task. The method provides access to the element- and isotope-partial phonon density of states of the Mössbauer-active atoms ensuring essentially background-free experimental results, which can be directly compared with theoretical predictions. The dependence of the detected signal upon phonon polarization allows one to perform angular-dependent lattice dynamics studies. The high penetration depth of the X-rays combined with the enormous resonant absorption cross-section of the Mössbauer effect assures the sensitivity of the method from bulk material down to a sub-monolayer coverage.

In this presentation, some ideas about lattice dynamics studies in nanoscale materials with the unprecedented energy and spatial resolution envisaged at the ESRF-EBS will be discussed.