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The continuous innovation in research and the elaboration of new high technology products induce rapid changes in the economy and the society. There is therefore an increasing demand from the citizens for a higher social responsibility of the researchers and political responsibles in order to ensure a sustainable development. Nanotechnology/new Materials, ICT and Bio-Engineering, belong to the research priorities to provide future solutions fulfilling these requirements. Among the different approaches within these fields, the “More than Moore” one is particularly interesting. It corresponds to semiconductor-based devices that also integrate non-electronic information such as mechanical, thermal, acoustic, chemical, optical and biomedical phenomena. New active and multifunctional nanostructures and nano-objects based on magnetic and multi-ferroic materials represent a perspective quite new branch of the More than Moore approach. It can provide advances in the field of Microsystems and Functional electronics, like for example increase of functionality and decrease of energy consumption of electronic components and microsystems, decrease of environmental impact of devices and large systems, new concepts of theragnostics.

This tutorial will provide a review of this field of activity and show some examples of present and future applications. The considered solutions are new active magneto-elastic and multiferroic nanostructures with artificially induced critical states, resulting from exchange, magneto-elastic and magnetostatic interactions between the nanolayers. This has been achieved using the structures based on “Rare Earth / Transition Metals” nanolayers and combining magnetic and ferroelectric layers. The application of the physics of critical states to nanotechnologies, which represents the main originality of the approach, has the goal to provide totally specific properties non-available in already known active materials (i.e. single-crystals, alloys, composites...). As an example, in the vicinity of the instability of Spin Reorientation Transition type, the interaction between the magnetic subsystem and the elastic one provides extraordinary dynamic properties of the coupled magneto-elastic system: increase of one to several order of values of the magneto-elastic coupling and of the sensitivity relatively to the magnetic field (with possible new generations of micro-sensors and micro-actuators), giant amplification of dynamic non-linearities (x 10,000) allowing the elaboration of totally new driving techniques of micro-actuators (subharmonic driving, low frequency excitations by nonlinear interaction of high frequency driving fields, demodulation effects, bi-stable response to harmonic driving...), high controlability of elasticity (up to 100%) by magnetic field or stresses (usable for micro-sensors or tunability of resonators in wide ranges or quasi-phonics crystals), high increase of the magneto-electric sensitivity (x100) in multiferroic (RE/TM / Piezo-electric) nanostructures. Presented applications will consider magneto-electric sensors and actuators, MELRAM memories memristive devices with ultra-low power consumption, tunable RF components, smart communicative objects distributed in ad hoc wireless networks, tactile computer interfaces based on arrays of micro-actuators, micro-fluidic devices for lab on chips biosensors & micropumps, MEMS for active flow control etc.