RBS Complex Characterization of Metamaterials Thin Layers Synthesized by Pulsed Laser Technologies

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Thermoelectrics

It is believed that the direct conversion of waste heat into electrical power in thermoelectric devices will contribute substantially to future power supply and sustainable energy management. It is well known that thermoelements, which may be used either as Seebeck electric generators or as Peltier electric coolers-heaters are characterized by a figure of merit, $ZT=S^2\sigma/k_{tot}$, where S is the Seebeck coefficient, σ is the electrical conductivity and $k_{tot}=k_{el}+k_{ph}$ is the sum of electronic and phonon thermal conductivity components in a material. The best commercially available material Bi_2Te_3 and its alloys have a ZT close to 1. In order to compete with the currently available technologies for refrigeration based on working fluids a ZT greater than 3 is necessary. However this is a challenging task because in the electrically conductive materials increasing electrical conductivity leads to an increase in the electronic component of thermal conductivity thus their ratio achieve little improvement.Today efforts in these field are directed towards reducing the phononic contribution to the electrical conductivity by engineering materials whith internal structure that is favorizing the scattering of the phonons. Values of ZT close to 2.5 were already obtained in superlattices formed by successive layers of materials with the thickness lower than the phonon mean free path. In the same time nanostructuring of materials lead also to improvements in the figure of merit by reducing the phononic contribution to the thermal conductivity due to the interface scattering in the material. The same effect was obtained in composite materials which are formed by compacting materials powder with nanostructured materials followed by annealing leading to a final product that scatters phonons in an efficient manner. We believe that the same reduction in the phononic transport can be obtained in metamaterials with low dimensionality constituents due to the phonon scattering at the interfaces improving therefore the ZT. In this respect the RBS technique can give important information about the material composition that can be used to interpret the data obtained experimentally on the thermal conductivity values measured.

Gas sensors

As a consequence of the society development today, an incredible rise in living standards of people was produced compared with one century ago. In the same time, the Industrial Revolution brought several hazards in people life, one of them being a multitude of noxious stimuli in the form of gaseous pollutants emitted from factories stacks, drained from faults in the pipes body, depositing tanks or other installations working with or transporting gases. Sensors are widely used to detect and control a variety of harmful gases, thereby protecting both the atmospheric environment and human welfare. Today there is a growing need for cheaper and more effective gas sensor solutions in order to control the quality of indoor and outdoor air.

There exists a large variety of materials used today for gas sensing(mainly depending on the target gases): SnO_2 ,ZnO , TiO_2, In_2O_3 , WO_3 , CNTs , VO_2 . Also, the study of the sensitivity, response and recovery times of these materials in form of thin films will have an invaluable impact from scientific point of view by understanding the gas sensing mechanism and from technological point of view by giving a better insight in fabricating gas sensors. An issue to be adressed consists in the requirement that the nanostructured thin films to be obtained must be porous and containing small grain size for enhanced sensor response. Metamaterials (Metaoxides) are materials engineered to have a property that is not found in nature. They are made from assemblies of multiple elements fashioned from composite materials such as metals. The materials are usually arranged in repeating patterns, at scales that are smaller than the wavelenght of the phenomena they influence. Metamaterials of interest for study are: $(In_2O_3)(WO_3)(SnO_2)$, $(ZnO)(WO_3)(SnO_2)$, $(TiO_2)(WO_3)(ZnO)$. The growth of thin films is well established, *e.g.* using Pulsed Laser Deposition (PLD) , Matrix-assisted pulsed laser evaporation (MAPLE), Combinatorial Pulsed Laser Deposition (C-PLD) and Combinatorial Matrix-assisted pulsed laser evaporation (C-MAPLE) – all of these being an expertise of the project team. The quality of the thin films depends on the deposition parameters (as laser fluence, target-substrate distance, substrate temperature) for which optimum values have to be choosen. The final structure and composition of the deposited films is dependent thus on the deposition conditions and must be known in order to understand the gas sensing mechanism.From this point of view the RBS technique can give valuable information upon the composition of the thin films under study.

The samples will be measured at the 3 MV Tandetron accelerator by RBS technique using an alpha beam. The $^{16}O(^{4}He,^{4}He)^{16}O$ elastic non-Rutherford cross setion at 3.038 MeV will be used for the profiling of O.

We need 5 days (15 shifts) at the 3 MV Tandetron accelerator.