Description of Main Aims and Objectives

The intrinsic properties of nanocomposites depend on matrix, nanofiller, nanostructure of composite, including size distribution of nanopartisles, their dispersion and so on. Identifying the key intrinsic properties of nanocomposites are vital for both understanding of nature of nano-composite and their creation.

Dispersion of nanofiller in dielectric nanocomposites is result in interfacial polarisation at interface polymer-nanofiller. Interfacial or Maxwell–Wagner polarisation is microscopic property that associated with molecular segmental motion dielectric Maxwell–Wagner relaxation resulting from interfacial polarization at the matrix /nanofiller interface.

In nanocomposites containing magnetic phases some other effects at matrix /nanofiller interface can takes place. Now it is well know many interesting interfacial effects at interface magnetic-nonmagnetic layer in multilayer structure. Between other CMR, TMC, GMI can be mentioned. Such effects can tales place also in nanocomposites containing magnetic phases but this is not studied up to now. Moreover study of magnetic properties of nanocomposites containing magnetic phases in non-magnetic matrix give possibilities for understanding of interparticle interaction for ensemble of nano-particles.

The methods which are usually characterized dispersity of nanofiller are off-line using microscopic techniques such as TEM, X-ray, NMR and neutron scattering. These methods are very precise and can give a lot of information, but these off line experiments are labor intensive, and yet crucial in determining the influence of processing parameters on resulting microstructure. Because these time-consuming analytical methods cannot work *in flow, in real time* under influence of temperature or physical-chemical changes of nanocomposites and influence of other external factors.

Study of monodispersity based on physical effects of Maxwell–Wagner polarisation and dielectric relaxation can be carried with the use of dielectric spectroscopy in both on line and off line regime. This method can work under influence of temperature, external fields and other physical-chemical changes, in flow, that is very important for processing parameters. Study of intrinsic dielectric properties can give an important information about dispersity of nanofiller, inhomogeneities in nanocomposite, interface between nanofiller and matrix. Study of magnetic properties of nanocomposites containing magnetic phases can give important knowledge for understanding of nature interaction at interface magnetic-non-magnetic nanomaterials, interparticle interaction between nanoparticle and interaction of nanomaterials with electromagnetic field.

The main goal of proposed project is investigation of intrinsic properties and nature of interaction in nanocomposite containing magnetic phases by radio-microwave-millimeter wave dielectric spectroscopy.

Objectives of this project are basic study of dielectric and magnetic properties of different nanocomposite with various magnetic nanofiller in wide frequency range for understanding nature these properties and their correlation with intrinsic properties and macroscopic electromagnetic properties and elaboration applied method for measurement needed properties.

Object of investigation.

nanocomposite containing magnetic phases

a) **nanocrystalline nickel-zinc ferrite nanocomposite**
b) Glass-metal nanocomposite
c) **Nanowire polymeric nanocomposite**
d) oxide-coated iron nanoparticles nanocomposite
e) silver nanoparticles in glass-ceramic nanocomposite

Main objectives.

1. Preparation of host nanocomposites containing magnetic phases (India partner)
2. Study of influence of size and distribution of nanofiller in nanocomposites on mechanism of charge carriers transport and electrical properties.
3. Determination of minimal scale of inhomogeneity of nanoparticles distribution which can effect on electrical/dielectric and other properties of nanocomposites
4. Study of dielectric and magnetic properties of nanocomposite in microwave and millimetre wave frequency ranges for creation the theoretical models for interaction of electromagnetic radiation with nanocomposites containing magnetic phases.
5. Investigation of correlation of dielectric and magnetic properties of nanocomposite in microwave and millimetre wave frequency ranges with intrinsic properties (dispersity, etc) of nanocomposite
6. Elaboration the method for determination of monodispersity of nano composite with the use of microwave dielectric spectroscopy.
7. Investigation of nature of the static and dynamic response in magnetic properties of host magnetic nanomaterials.
8. Investigation of influence of technological aspect on properties of host nano-materials.

By substitution of different amount of Zn and non-magnetic elements in bulk magnetic compound magnetic dilution effect takes place. The nature of this effect is not clear up to now. By magnetic dilution it is possible to change local magnetic interaction: exchange interaction, local magnetic field, anisotropy, etc and thus change temperature of phase transition in ferrimagnetic phase, Neel temperature and static state of magnetic phase. It must be pointed out that substitution of Zn and non-magnetic elements produce frustration in exchange interaction that can lead also to formation of different glass phases in such compounds. These glass magnetic phases can be realized in different temperature ranges. So phase diagram of such compounds will be very rich.

In nano-particles of compounds mentions above, large amount of atoms are placed near the surface. Thses atoms have the other coordination number as the same atoms in bulk. They have the other exchange interaction, local magnetic field, anisotropy, etc as in the same bulk compounds. Large ratio between volume and surface fraction leads to disorder in magnetic and other subsystem of nano-materials and evident different of magnetic and other properties between bulk material and nano-structured material. This difference reveals itself in both static and dynamic properties, i.e. excitation spectra.

Because of additional disorder that is connected with great value of surface fraction host nano-particles of ferrite oxide and perovskite different magnetic phase are possible: superparamagnetic (superferromagnetic), different glass state (spin glass, cluster glass, canted glass). Different magnetic phases have different dynamic and spectra of excitation.

For properties of magnetic nano-particles interparticle interation plays an important role. Inter-particle interaction in magnetic materials in most of all cases has long-range (magnetic dipole) character. For study of influence of interparticle interaction we offer to place magnetic nanomaterials in non-magnetic matrix, in this case distance between magnetic particle will be larger and short-range interaction will be excluded.

Electromagnetic response is one of very important part of dynamic of magnetic materials. Electromagnetic response is connected with dynamic of magnetic and electric subsystems, those is very rich and interesting in materials with magnetic order. In materials with magnetic order in most of all cases most important role in electromagnetic response plays magnetic subsystem. There are many different specific effects in electromagnetic response of magnetic materials that are connected with magnetic subsytem: resonance phenomenon (FMR, ESR, NMR) and non-resonance phenomenon, that are connected with impedance and magnetic permeability (also new giant magnetic impedance (GMI) effects ect.). These phenomenon and other effects reflect excitation spectra, quasi-particles interaction and static state of these subsystems and can give important information about all this. In magnetic materials usually all properties have strong dependence on external magnetic field. In host magnetic nano-materials with many different magnetic phase all properties must also have strong temperature dependence.

Microwave and millimetre wave ranges of electromagnetic response are connected with relative low frequency excitations, those are very interesting for understanding of nature of collective mode, FMR, ac conductivity. It is supposed that relaxation time in magnetic glass states lies in this frequency ranges. That is why study of electromagnetic response in this frequency range is especially interesting in these ranges.

Method of investigation.

To reach the goal of project synergy of different methods is proposed. Static methods will be connected with the main investigation of microscopic structure and local arrangements of atoms and electromagnetic response will give information about interaction in and excitation and also additional information about static properties.