

## Research Performed

I have a strong **interdisciplinary** research experience and collaborations.

### *Optical (Opto-electronic) Materials (Renewable Energy):*

- **Development of high performance CIGS multi-junction solar cells, Inorganic-organic hybrid solar cells and Inorganic high-performance solar cells-ongoing research.**
- **Development of CdSe, CdS and CdTe photonic nanocrystals for solar cell, FET as well as detector applications.**
- **All Oxide TFT device based on high-k dielectrics and ZnO multilayer films**
- **Development of Nanomaterials based Li-ion battery**
- Optoelectronics materials: Doped and undoped ZnO films, including n- and p-type, Doped GaN films and Quantum dots.
- Photo-induced charge carriers in multilayered films, IR detectors, UV detectors.

### *Electronic, and Magnetic Materials:*

- Fabrication and characterization of Magnetic, superconducting materials and multiferroics (ceramics, thin films and single crystals using various novel techniques)
- Nanocrystalline magnetic, electronic and photonic materials, including semiconductors
- Development of spintronic materials in the form of films/nanocrystals
- Multilayers for high-k dielectrics and non-conventional oxide-based p-n junctions for LED, such as LSMO/ZnO, BTO (or STO)/p-Si, LSMO/GaN and LSMO/Si.
- Fabrication and characterization of ferroelectric and piezoelectric materials (ceramics, single crystals, and thin films) for sensor applications.
- **High-k dielectrics on III-V semiconductors (GaAs, InGaAs etc.): Current effort**

### *Nanocomposite/Nano-structured Materials: Synthesis, characterization and device fabrication*

- Nanomaterials based Nano-biosensors, environmental sensors and detectors and medical diagnostic tool including SERS.
- Growth and characterization of magnetic nanomaterials exhibiting outstanding self-assembly of nanoparticles, **coated (with silica/ODA) manganite, cobalt ferrite and CoFe alloy nanoparticles** with excellent magnetic properties for biological applications (drug delivery and detection).
- **Growth of Aligned ZnO nanorods for optoelectronic applications, gas sensors, bio sensors, hybrid inorganic-organic solar cells and window TCO for solar cells.**
- Development of Co, Au and Ag nanowires on CdSe/Si, Metamaterials.

### *Epitaxial, Nanocrystalline Films and Heterostructures (Multilayers):*

- Growth and characterization of multifunctional colossal magnetoresistive nanocrystalline epitaxial films by UHV- PLD on buffered Si (STO/Si) with high-density memory,. **Remarkable success has been achieved on this growth: Intel has shown intense interest for the technology and funded for further research.**
- Successful growth by PLD and characterization of dilute magnetic semiconductor such as **ZnMnO**, self-assembled **Co:TiO<sub>2</sub>** nanocrystalline films, and transparent Co:ITO for spintronic applications. **Pt/Co/Pt/IrMn multilayers** for memory applications.
- ZnO-based transparent semiconductors and p-n junctions: Remarkable success
- **Growth of Piezo-optic Er:ZnO films for lasers and 1.54  $\mu\text{m}$  emission used for telecommunication: Tremendous success has been achieved- International collaboration**
- Growth and characterization of ZnO and doped ZnO wide-band gap semiconductor by Magnetron RFsputtering, **GaMnN** by e-beam and Molecular Beam Epitaxy (MBE).

## **Significant contributions:**

- *High-performance CIGS/CdSe QD-based and hybrid solar cells based on nanomaterials*
- *Li-Ion battery, Thermoelectric power generation*
- *Demonstration of Nano-Biosensors using nanopatterns/ nanotechnology (nanolithography)*
- *Demonstration of ultra-thin high-k dielectrics on III-V semiconductors for innovative electronics*
- *Fabrication of all-oxide TFT device*
- *Extreme tunable TCO based metamaterials and transparent heater*
- *Magnetic and semiconductor core-shell research for biomedical applications*
- *Development of gas and bio- sensors based on Composite Semiconductor and Aligned nanomaterials*
- *Development of Nuclear detectors*
- *Fabrication and characterization of Luminescent rare-earth doped rare-earth (Eu:Y<sub>2</sub>O<sub>3</sub>, Eu:Lu<sub>2</sub>O<sub>3</sub>, Eu:ZnO) nanophosphors and ceramics for display technology, biochemical tag or pattern visualization and biomedical detection/imaging.*
- *Synthesis of ZnO based nanostructures exhibiting hierarchical growth, nanorods, nanowires for various nanoscale applications in opto-electronic (hybrid solar cells), sensors, and biomedical applications.*
- *Information technology: Novel multilayers of LBMO(LSMO)/STO/Si, LBMO/STO/MgO and LBMO/STO films and nanostructures exhibiting remarkable ferromagnetism at and above room temperature. Applications: IR imaging, magnetic-high-density memory, NVRAM (MTJ).*
- *Room temperature Ferromagnetism in ZMnO, GaMnN, nanocrystalline Co:TiO<sub>2</sub>, and Mn:GaSb DMS and Ni/Al<sub>2</sub>O<sub>3</sub>/Si films*
- *Fabrication of Magnetic Tunnel Junctions for Non-Volatile memory applications.*
- *Synthesis of nanocrystalline optical materials leading to transparent ceramics.*
- *Piezo-optic effects in nanocrystalline Er:ZnO films for acousto-optic and optoelectronic application: Record-high photo-induced phenomena (piezo-optics).*
- *Er:ZnO films for optoelectronic application: Enhanced 1.54 μm emission at RT*
- *Synthesis of FeCo, Co, Au and Ag nanowires on CdSe/Si and devices for enhanced Plasmon resonance.*
- *Magnetic and luminescent nanostructured composites for bio-medical applications*
- *Oxides on Semiconductors: For DRAM, LED, high-k applications.*
- *Remarkable enhancement of T<sub>c</sub> and magnetoresistance on nanoscale rare earth doping and melt-processing, Strain effects, surface and interface studies of manganite films.*
- *Remarkable enhancement in critical currents in melt-processed ternary superconductors and fabrication of high-T<sub>c</sub> wires/tapes*
- *Flux pinning/critical currents/angle-resolved magnetotransport/anisotropy first time observed in MgB<sub>2</sub> single crystals and dense ceramics.*
- *Artificial columnar defect (Heavy ions)/ spin-glass/cluster-glass state in superconductors/High-field magneto-transport in BSCCO/Vortex correlation by c-axis magnetotransport and many more.*

## **Current Research Interest and Plan: Brief Strategic Vision for Advancing University Research**

I will vigorously develop and continue research in various fields of National priority, including the following fields:

- *Development of novel materials for green renewable energy generation, storage and sustainability*
- *Continue the research in the field of Nanotechnology-based high-performance battery for power storage and other materials, Supercapacitors*
- *Continue research in the field of photovoltaics for renewable energy*
- *Synthesis (films and artificial nanostructures) and characterization (physical, microscopic and elemental) of metals (inter metallic and alloys), 2-D Materials (films) Ceramics (thin films), electronic materials for devices, detectors as well as Advanced Functional Materials, and work in a collaborative and interdisciplinary research. Interested to thoroughly use of clean room.*
- *Design and fabrication of Graphene-Quantum dot based efficient energy devices, Low-dimensional materials for device applications*
- *Phase change materials for IR imaging (Multilayer films approach)*
- *Studies of micromechanical properties of films used for devices*
- *MEMS and NMEMS fabrications, nanolithography and self-assembly of nanomaterials.*
- *Sensors for environment, medical diagnostics etc.*
- *Continue research on diagnostic tools (high throughput and cost effective biosensors) for preventive health care.*
- *Detectors for Gamma-ray radiation, medical imaging etc.*
- *Effects of ionizing radiation, heavy-ion irradiation on materials*
- *Establishing World-class facility for energy as well as nanotechnology research*
- *Frontier research in the direction nanotechnology (synthesis, characterization and device fabrication) for energy, biomedical and sensor applications.*
- ***Building up World-Class laboratory for ENERGY and NANOTECHNOLOGY that may include Clean room (or assist the Clean room activities) and other characterization techniques (Nano lab).***
- **A university laboratory focused on use-inspired basic and directly applied research is crucial. Many talented individuals wishing to work on renewable energy and environmental issues have little or no opportunity to train, examine and innovate with these energy systems. I would like to develop these aspects with the students and University wide faculty colleagues by encouraging faculties writing relevant proposals for funding.**
- *I am broadly focused on developing teaching (both Graduate and undergraduate) and research programs in the areas of renewable energy using nanotechnology to semiconductors, including material and device for energy & environmental sensor technologies, biotechnology, nuclear detectors, measurement/metrology, or other emerging nanoscale materials science & engineering fields related to cross-disciplinary programs which may very much complement the University faculty population. My research and teaching expertise establish a strong interdisciplinary research groups. **My goal is to apply for NSF Engineering Research Center (ERC) or MRSEC and similar Centers from DoD (MURI), DoE and NIH.***