Final Year Project Showcase for Batch 2016

Department of Material Engineering		
1	**Project Idea**	Synthesizing an n-type thermoelectric semiconductor with optimized sintering temperatures
2	**Process**	The Seebeck Effect is a phenomenon through which an electrical voltage or potential difference is generated between two dissimilar electrical conductors by a temperature gradient between them. Using this phenomenon, worldwide research is being conducted to design materials and components that would reduce or eliminate the wastage of energy in the form of heat as to make the processes more efficient. The names of some famous companies that are currently researching on the application of this potent technology include the likes of Volkswagen, Ford, and BMW among others. The method that is being followed to examine the optimal sintering temperatures of our compositions is to mix the raw materials, which are Strontium Carbonate ($SrCO_3$), Titanium dioxide (TiO_2), and Bismuth Carbonate ($(BiO)_2CO_3$), are mixed in the ball milling apparatus according to set composition. The mixture is dried and calcinated to form the thermoelectric product we are aiming for, and once calcinated, pellets are made from the acquired powder that are sintered in furnaces and tested for their properties. Doping of strontium titanate (SrTiO3) either at A or B side shows an increase in conductivity and upon doping and/or formation of oxygen vacancies it transform to semiconductor and it becomes metallic in nature if enough oxygen is removed. The Seebeck coefficient, power factor and low resistivity at 750K due to carrier electron of STO doped and oxygen deficient has been notified as (|S| ~200~300 µV/K), (PF ~0.8~1.3 W/m.K2), (p<5µΩ/cm) respectively. The Seebeck Coefficient and its relationship with thermal gradient on $SrTiO_3$ with different concentrations of Bi-dopant was observed with singular pellets as well as stacking up the pellets for each composition. Stacking up the pellets produced a better thermal gradient between the two surfaces as the distance between the surfaces increased. All the surface of the stacked pellets were coated with silver adhesive to minimize the contact resistance during the flow of electric current and field.

3	**Outcome**	Thus far, the electrical properties of the resulting specimen have been investigated and it is concluded that, if dimensional corrections are considered, Bi-doped SrTiO3 can also be used as a good capacitor due to its negligible dielectric losses. Also, it was observed that capacitance can significantly vary if dielectric losses of the specimen are not stable. Further, the thermal properties of the capacitor are to be investigated to observe if the specimen will prove to be a good thermoelectric ceramic. For that, the electrical properties of the specimen with varying temperature gradients are to be observed.
4	**Evidences (Theoretical Basis)**	Through energy harvesting devices, the impending energy crisis in the third-world nations can be resolved. This is a graduation project by students of Materials Engineering Department, NED University of Engineering and Technology that studies the synthesis of thermoelectric ceramics using Strontium Titanate (SrTiO3) as the base material to be used in energy harvesting devices. The research explores the optimal sintering temperatures of the base material, as well as their doped counterparts where dopants being used are Bismuth (Bi). Moreover, their electrical properties and thermal conductivities will be measured according to the Seebeck effect
5	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over competitor. In summary, any striking aspect of the project which compels industry to invest in FYP or purchase it. Some detail description is required in terms of how, why when what. You can select one or more from following dropdown and delete rest of them)	
a	**Cost reduction of existing Product**	It has been reported in the recent study that about 66% of energy are produced from fossil fuels, a non-renewable energy source and the demand of energy in the next decades increased by 50-65%. The electricity generated by heat energy has operating efficiency of about 30-40% and it loses 66% of power to the environment in the form of waste heat. The cost reduction of the product can be decreased as the advancement in the project is higher and the probability of achieving high figure of merit is high too.
b	**Process Improvement which leads to superior product or cost reduction,**	Since the last 20 years, energy crises and serious environmental issues like global warming, limited energy resources, and high-priced sources of fuel are of major

	efficiency improvement of whole process (e.g. What is issue is current process and what improvement you suggests)	concern. Energy crises due to high priced non-renewable resources and environmental related issues like global warming, pollution, and release of greenhouse gasses have led to the development and research of clean, ecofriendly and economic devices to substitute these non-renewable resources. SUGGESTION: Proper setup required for this experiment to show best and efficient result. A setup containing Jig for the batch of samples having maximum thickness that can attain stability in handling the samples when attached with K-Type thermocouple of, different metal electrodes for high temperature along with tube furnace. By having all of these resources the probability of getting a best Seebeck coefficient can be achieved and can further implemented onto the application side for energy harvesting devices.
c	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region)	The scope of the work is to bridge gap the energy crises. The high and expensive energy gap in the remote areas where the electricity is not in sufficient reach. With the help of this project we will learn that how a synthesis of thermoelectric ceramics can be of great importance other than high temperature and corrosion resistance.
d	**Expanding of Market share** (e.g. how it expand and what is problem with current market	In recent thermoelectric ceramics plays a vital role in providing sufficient and best performances. As known for the thermoelectric generators and other energy sufficient appliances the need for such thermoelectric doped ceramics would reduce the cost and market share is expected to be higher as high efficiency at low cost would be an ideal solution for energy crisis issue.
e	**Capture new market (**e.g. Niche market or unaddressed segment**)**	As for the need of such devices that can save energy or heat sources will capture the new market with maximum market approach because it can easily be use in solar panels, walls of the furnaces, travelling busses etc.
f	**Any Environmental Aspect** (e.g. carbon reduction, energy efficient etc.)	These eco-friendly thermoelectric ceramic materials are used in both renewable energy conversion technologies and in power generation and it plays a crucial part in solving problems like energy crisis and environment degradation. The efficiency and performance of TE devices based on the material properties like its thermal and electrical conductivities, figure of merit, temperature gradient and the material's stability at elevated temperature. The advantages of oxide thermoelectric materials over other TE materials are its low toxicity, economic, and chemical stability at high temperature. Among the n-type oxides, SrTiO3 (donor

		doped) has large ZT (figure of merit) and has properties like thermoelectricity, photocatalytic activity, superconductivity, quantum para-electricity, piezoelectricity, induced ferroelectricity and correlation between ferromagnetism and superconductivity with high melting temperature 2080°C and chemically stable in air which makes it an important for TE applications at elevated temperature. It is the first superconducting ternary oxide.
g	**Any Other Aspect**	Thermoelectric ceramic materials are essential for solving the global energy crisis and environmental degradation in sustainable energy sources (such as thermoelectric power generators). Thermoelectric harvesting devices' efficiency depends on the type of material properties used, their characteristics, temperature gradient and their thermal temperature stability. This experimental approach provides fundamental knowledge and application of thermoelectric ceramic materials in power (or energy) generation.
6	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about user of the product, process or service	A potential prototype of this technology is also planned in the scheme of events of this research that would utilize the designed component in a solar panel system that would increase its efficiency. By achieving success in this study, we could land Pakistan among the pioneers of this technology and can uplift our economy by making our systems more energy efficient.
7	**Team Members (Names & Roll No.)**	Eraj Tariq (MM-16006) Fatima Mohsin (MM-16011) Baazif Karim (MM-16025)
8	**Supervisor Name**	Dr. Fayaz Hussain (fhussain@neduet.edu.pk)
9	**Pictures**