Final Year Project Showcase Batch-2021
Year 2025

Department: Materials Engineering Programme: BE Materials Engineering	
1	**Project Idea** Gas sensors are vital for detecting harmful pollutants and ensuring public safety, yet traditional sensing materials lack efficiency, stability, and environmental compatibility. This project aims to synthesize ceria-doped silica nanoparticles, combining the high oxygen storage capacity of ceria with the large surface area of silica to enhance gas sensing performance of ammonia gas sensor. Two synthesis routes are explored; chemical sol-gel method and a sustainable green method using sugarcane bagasse, an agricultural waste. This dual-path approach not only targets functional efficiency but also addresses eco-conscious material development. The project goal is “Synthesis and Characterization of Ceria doped Silica nanoparticles through Chemical and Green Method for Gas Sensor Application”.
2	**Process** Among various synthesis methods, the sol-gel technique was selected for its simplicity, low-temperature processing, and ability to produce highly uniform and pure nanoparticles. In the chemical route, ceria-doped silica nanoparticles were synthesized using tetraethyl orthosilicate (TEOS) as the silica precursor, with cerium nitrate providing the dopant. Ammonium hydroxide acted as a catalyst in an ethanol-water medium, initiating hydrolysis and condensation reactions to form a stable sol. For the green synthesis, sugarcane bagasse ash was processed to extract silica, promoting sustainability and waste valorization. The resulting sols underwent drying, aging, and controlled calcination to yield nanoparticles with improved crystallinity and surface properties. This dual approach ensured structural control, eco-efficiency, and functionality tailored for gas sensing.
3	**Outcome** The project resulted in the successful fabrication of a chemiresistive gas sensor for ammonia (NH_3) detection at room temperature using ceria-doped silica nanoparticles. These nanoparticles were synthesized through both chemical and green routes, with sugarcane bagasse used as an eco-friendly silica source. Ceria doping introduced oxygen vacancies, enhancing gas adsorption and sensor sensitivity. Characterization confirmed uniform nanoparticle morphology, strong surface activity, and effective NH_3 response. The sensor displayed a clear resistance shift on ammonia exposure, validating its efficiency.
4	**Evidence (Theoretical Basis):** Ceria-doped silica nanostructures were synthesized through both chemical and green methods, grounded in sol-gel and precipitation principles. The sol-gel route utilized sodium silicate and cerium nitrate as precursors, while the green method employed sugarcane bagasse as a sustainable silica source. Doping with CeO_2 introduced redox-active sites and oxygen vacancies, enhancing gas interaction at the sensor surface. XRD analysis confirmed the semi-crystalline nature of the nanostructures, while SEM and EDS validated their uniform morphology and elemental composition (Si, Ce, O). The spherical nanoparticles, with sizes ranging from 20–60 nm, exhibited high surface area and porosity crucial for gas diffusion and adsorption. The fabricated sensor showed effective response toward NH_3 gas due to enhanced electron exchange and oxygen mobility enabled by ceria doping.
5	**Competitive Advantage or Unique Selling Proposition:**
a	**Attainment of any SDG; <u>SDGs-03</u>** is to Ensure healthy lives and promote well-being for all. This project is based on the development of a gas sensor detects ammonia (NH_3) a harmful gas that poses serious health risks when inhaled even at low concentrations. By enabling real-time detection, the sensor helps prevent respiratory and occupational health issues, contributing to a safer environment and better public health. **SDGs-9** This project promotes technological innovation by integrating nanomaterials and green synthesis into sensor design. The use of agricultural waste (sugarcane bagasse) and cost-effective

	materials supports scalable, low-cost sensor production for industrial gas monitoring and infrastructure safety.	
b	**Any Environmental Aspect:** Eco-friendly, minimal energy consumption, sustainable material processing, environment friendly.	
c	**Cost Reduction of Existing Product:** The project utilizes readily available low-cost precursors like sodium silicate and sugarcane bagasse which eliminates the need for expensive reagents such as TEOS; green synthesis reduces energy and resource consumption, simple fabrication process lowers manufacturing cost and overall, the sensor provides an affordable alternative to conventional commercial gas sensors without compromising performance.	
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process:** Green synthesis eliminates hazardous chemicals and energy-intensive steps, making the process environmentally safe and economically viable. Incorporating ceria into silica enhances redox activity, improving sensor sensitivity and selectivity at room temperature. The simplified sensor fabrication process using common materials like PVA and glass substrate ensures ease of production, reduced processing time, and high reproducibility, leading to a superior, low-cost, and efficient sensing device.	
e	**Expanding of Market share:** The current gas sensor market is valued at over $3 billion USD, driven by increasing environmental concerns and industrial safety demands. However, high fabrication costs, use of toxic chemicals, and lack of sustainable alternatives limit widespread adoption. This project addresses these gaps through a green, low-cost, and eco-friendly sensor developed using agricultural waste. R&D focused on sustainable nanomaterials and scalable sensor fabrication can enhance performance, reduce costs, and open new markets especially in resource-constrained and environmentally conscious sectors ultimately contributing to the expansion of eco-smart gas sensor technologies.	
f	**Capture New Market:** Environmental monitoring systems, industrial safety devices, smart agriculture, indoor air quality monitors, and low-cost IoT-enabled gas sensing platforms are emerging markets to capture.	
6	**Target Market:** The target market includes agriculture, food storage, chemical manufacturing, and industrial safety sectors, where ammonia detection is crucial for health and process control. Additionally, urban air quality monitoring systems, research institutions, smart city infrastructure, and environmental regulatory bodies represent key secondary markets.	
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10	**Pictures (If any)**