Chemiresistive gas sensors: Mixed gas sensing with analytical methods

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I started my journey with IITH on 25th July 2014 as an MTech student in the Electrical Engineering department. As a part of the MTech thesis, I worked in the sensors domain. It involves the development of chemical sensors at low cost using eco-friendly approaches. In this process, I motivated myself to pursue higher studies and enrolled for PhD in Jan 2016. In PhD, I joined a different group, which is working on biosensors. My PhD supervisor, Prof Shiv Govind Singh, asked me to choose a research topic related to my MTech thesis or gas (or bio) sensors. I wanted to start something new that IITH had not explored till then. So, I chose gas sensors for my research.

The global gas sensors market in 2017 was valued at over USD 800 million and it was expected to grow at a rate of 7% CAGR till 2030. But nearly 50% of the market share belongs to electrochemical gas sensors and the semiconductor gas sensors share is too low. I have done an extensive literature survey to know the reason behind this. Both electrochemical and semiconductor sensors offer significant benefits such as high accuracy, reliability, and ease of use. However, electrochemical sensors outperform semiconductor sensors in the case of specificity and power consumption. These benefits translate into cost savings over the device's useful life. The power consumption of the semiconductor sensors can be reduced by operating them at low temperatures but at the cost of sluggish response.

On the other hand, the shelf life of electrochemical gas sensors is limited compared to that of semiconductor gas sensors. Moreover, the initial cost of the electrochemical sensors is too high to use them as use and throw sensors. For example, monitoring the freshness of perishable products need gas sensors for a few hours to a few days. In this case, multiple gases should be detected accurately at low power consumption using inexpensive sensors.

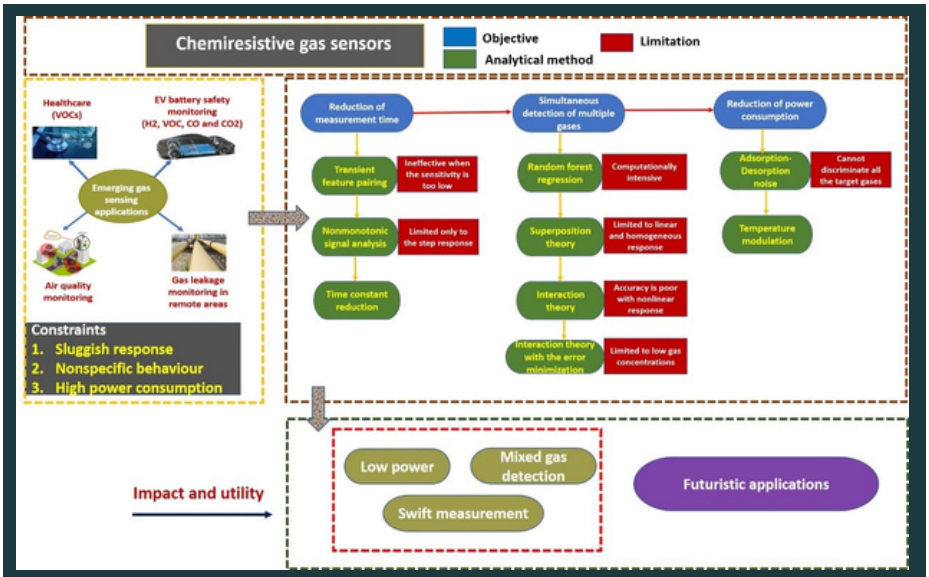

Fig. 1: (a) & (b) Schematic of the devices Ag/ BSA/TiO2/FTO (TB) & Ag/BSA/GO/TiO2/FTO (TGB) respectively. (c – d) I – V characteristics, which demonstrates that these devices are sensitive to the detection of BSA.

Based on the above analysis, I identified three grand challenges that need to be addressed to utilize resistive gas sensors in existing as well as emerging applications: (1) sluggish response, (2) non-specific behavior, and (3) high-power consumption. The research started with the design of the gas-sensing instrument.

I visited the places like IISc Bangalore and CEERI Pilani to know what type of instruments they are using for gas sensing. Surprisingly, no one had done the experiments on mixed gas sensing in India by the time we started working on it. That is the only way to address the non-specificity of the gas sensors. Then, I discussed with my supervisor and designed an advanced gas sensing system required to conduct my experiment.

After this, I experimented with the research plans with different materials and reported our results in various analytical journals like Analytical Chemistry, Sensors and Actuators B, and ACS Measurement Science. As per my knowledge, we are the first to implement strategies that track rapidly varying mixed gas concentrations.

Finally, I can say that I am satisfied with the research I have done during my PhD program. I advise new PhD students to choose their supervisor wisely. Better prefer to work with people who are interested in quality research instead of more publications. You don't need to compete with others as you can progress at your own pace.

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