# Ammonia Gas Sensor based on Nanostructured Thin Film of PANI-DBSA

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*Abstract*- **This paper presents the fabrication of ammonia gas sensor using nanostructured thin film of PANI-DBSA. First, the interdigitated electrodes (IDEs) of platinum (Pt) were patterned on the glass substrate by depositing Pt thin film of 80 nm thickness by RF sputtering technique in 100% Ar ambient using a 3-inch diameter Pt metal (99.999% pure) target, and, subsequently IDEs were patterned using conventional photolithography technique. The DBSA doped PANI has been synthesized by direct one step emulsion polymerization using aniline as a monomer and characterization is done using XRD, UV-Visible Spectroscopy, and SEM. The synthesized PANI-DBSA nanoparticles were deposited on IDEs patterned glass substrate to realize a nanostructured film using a spin coater at 1500 rpm. Gas sensing has been done for ammonia gas at different concentration levels in the form of relative response, response time, recovery time and repeatability. The fabricated sensor detects ammonia at 1ppm level quantitatively and reversibly at room temperature operation. The fabricated PANI-DBSA thin film gas sensor exhibits good sensitivity and response time at various ppm levels of ammonia.**

## I. INTRODUCTION

Ammonia gas, irritating and corrosive in nature, is one of the most commonly produced industrially hazardous chemical gases. Therefore, it becomes imperative to detect the presence of ammonia gases in environment. In the recent past, different gas sensor technologies have been used for ammonia gas detection including semiconductor gas sensors, catalytic gas sensors, and electrochemical gas sensors. Chemiresistor, a MEMS-based gas sensors, using conducting polymers as sensing layer has been gaining popularity for ammonia gas detection due to its simple configuration, easy fabrication, cost-effectiveness, miniaturization, and most importantly room temperature operation [1].

In this present work, we report complete fabrication and characterization of MEMS-based ammonia gas sensor using nanostructured thin film of PANI-DBSA conducting polymer. Use of PANI-DBSA provides improved sensitivity as compared to other conducting polymers due it increased surface area/volume ratio of DBSA doped PANI in Nanoregime [2].

## II. MATERIAL SYNTHESIS & CHARACTERIZATION

### A. *PANI-DBSA Synthesis*

All chemicals used in this study were chemically pure. Aniline (LobaChemie) as monomer was freshly double distilled before use. Ammonium persulfate as oxidant [APS, (NH4)2S2O8], and dodecyl benzene sulfonic acid (DBSA) as a surfactant were purchased from Merck. Isopropyl alcohol (IPA), N-methyl pyrrolidone (NMP) and Chloroform (CHCl3) were also purchased from Merck and used as received. De-ionized water (resistivity >18 MΩ-cm) was used for synthesis.

DBSA and water (0.3 M aqueous DBSA solution) was stirred to form an emulsion at 0°C followed by adding monomer (0.1 mol aniline). In the emulsion, the polymerization was initiated by the dropwise addition of an aqueous solution of ammonium persulfate (0.1 mol in 100 mL de-ionized water) to maintaining reaction mixture at 0°C under continuous stirring. After completion of polymerization, the formed dark green emulsion of DBSA doped PANI was de-emulsified using propanol. The resultant mixture was filtered through sintered glass crucible and the precipitate so obtained was washed repeatedly until the pH of the filtrate became neutral. Subsequently, the filtered cake was dried and crushed to obtain PANI-DBSA nanoparticles.

### B. *Characterization Results*

The characterizations of DBSA doped PANI nanoparticles were done with various characterization techniques. The optical spectrum of the chloroform dispersion of PANI-DBSA was recorded using UV-Visible spectrophotometer (Perkin Elmer lambda 25) in the wavelength range of 250–1000 nm. X-ray diffraction (XRD) pattern was recorded using Bruker Advanced D8 system in the diffraction (2θ) range of 10-80° using CuKα (λ= 1.540598Å) as the radiation source. The scanning electron microscope (SEM, Leo-440, Carl-Zeiss, UK, accelerating potential 10.0 kV) was used to investigate the surface morphology of PANI-DBSA powder.

Fig. 1(a) represents the XRD pattern of PANI–DBSA powder. The XRD pattern display three distinguished peaks at 2 θ values of 20.5° (d=4.32Å), 25.2° (d=3.52Å) and 26.9° (3.31Å). The two peaks at 2θ of ~20° and ~25°peaks confirm the formation of PANI and represent the periodicity in parallel and perpendicular to chain axis respectively. The third one and the relative prominence of 25° peak confirm the doping in PANI.

UV-Visible absorption spectra of PANI-DBSA dispersion in chloroform is shown in Fig. 1(b). The spectrum consists of three distinguished transitions peaks at 346 nm, 431 nm and 732 nm wavelengths which correspond to $\pi \rightarrow \pi^*$ transition of the benzenoid rings, polaron$\rightarrow\pi^*$ transitions, and $\pi^* \rightarrow$polaronic transitions respectively. The prominence of peak at 732