Design and Optimization of Gas Sensor Testing Chamber using COMSOL Multiphysics®

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Introduction:Metal Oxide based gas sensors are the highly promising devices which exhibit high sensitivity and selectivity characteristics. A testing setup is necessary to prove its reliability and market trust worthiness. This paper aims at the design and optimization of necessary sensing chamber which should accommodate testing of the developed gas sensor for sensitivity and selectivity. It had an aim to study the gas flow characteristics inside the chamber along with the analysis of gas mixture of two or three gases over the gas sensor. The design needs to be optimized in terms of position of vents, placement of sensor, metal oxide coated substrate etc.

Computational Methods: The gas chamber is designed using the Microfluidics module in the physics of laminar flow. Stationary and time dependent analysis of gas flow characteristics is done for the designed chamber. The mixing is done passively using baffles. The position of substrate and angle are optimized to get laminar flow of mixed gas on the substrate.

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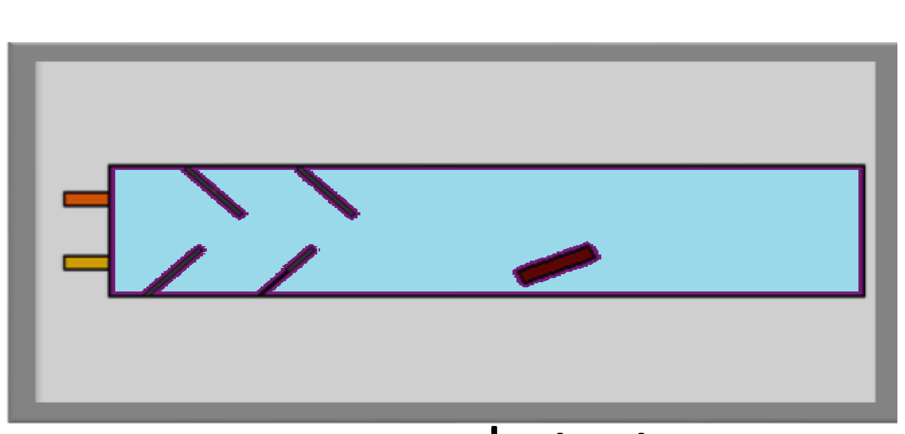
Inlet gas1

Inlet gas 2



Baffle pairs substrate Outlet

Figure 1. Gas sensing chamber

(Chamber size l=800mm,w=100mm,position of substrate = 50mm at an angle 22.5 degree)

Simulation is done based on this equation considering the density and viscosity of the gases as constant and velocity of flow is obtained.

$$\rho \frac{\partial \mathbf{u}}{\partial t} - \nabla \cdot \eta \left(\nabla \mathbf{u} + \left(\nabla \mathbf{u} \right)^T \right) + \rho \left(\mathbf{u} \cdot \nabla \right) \mathbf{u} + \nabla p = 0$$

$$\nabla \cdot \mathbf{u} = 0$$

Results: The gas flow characteristics is analyzed within the designed chamber. The turbulence resulting from baffles resulted in the required gaseous mixture .The flow of gaseous mixture over the substrate is observed to be laminar.

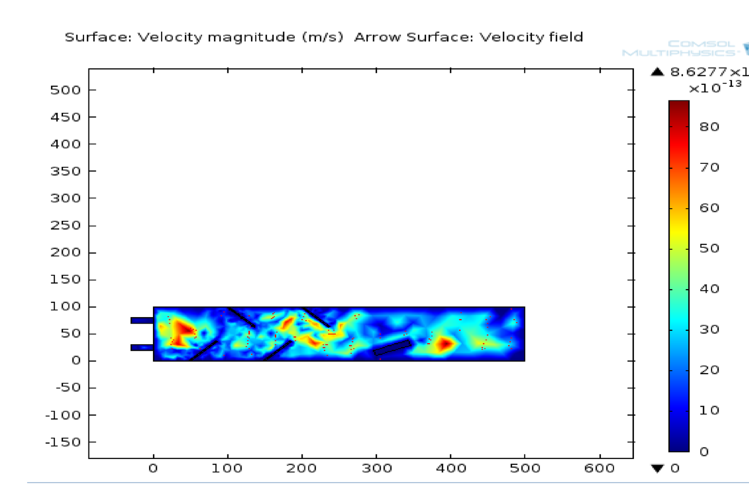


Figure 2. gas flow characteristics in static analysis

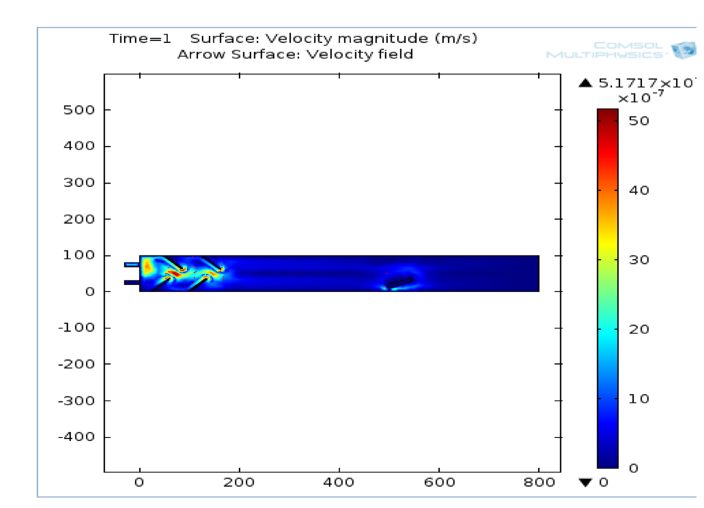


Figure 3. gas flow characteristic time domain analysis

Table 1.substrate position and velocity of flow

POSITION OF SUBSTRATE (mm)	VELOCITY OF FLOW OVER SUBSTRATE (m/s2)	OBSERVATION
200	6.35795e-14	mixing occurs on and after substrate
250	3.28729e-14	no proper mixing before substrate
300	7.25769e-14	substrate under turbulence
350	3.16309e-14	mixing before substrate is not good
400	4.83642e-14	no proper mixing before substrate
450	3.95875e-14	Mixing properly before substrate but flow over it is not uniform
500	2.04014e-14	Uniform over substrate no turbulence over it
550	2.34451e-14	More turbulence over substrate
600	2.83332e-14	Chaotic behavior over substrate
650	2.16324e-14	Chaotic behavior over substrate
700	2.01324e-14	Turbulence

Conclusions: The gas sensing chamber is designed and optimized for position of substrate and baffles. This model can be developed further by including heater and metal oxide coating and made to a complete sensing chamber.

References:

1,Mr. Satyaprakash Narayan Das and Dr.Gouranga Bose211Centurion Institute of Technology, Centurion University and Research, “Study of Fluid Dynamics and Heat Transfer in MEMS Structure”.

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