Sulfur Emissions Detection

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**HOMELAND SECURITY CHALLENGE**
Create a hand-held device which can aid the United States Coast Guard in monitoring ship compliance to the International Maritime Organization’s (IMO) sulfur content standards by detecting sulfur dioxide (SO₂) emissions at anchor points or ports. As of January 1st, 2020, IMO standards limit sulfur content in fuel to 0.5%.

**APPROACH / METHODOLOGY**

**Zinc Oxide (ZnO) nanowire solution**
- High surface area to volume ratio
- Sufficient resolution
- Ease of interface within microelectronics
- Consistent operation
- High scalability

**Chemical Bath deposition (CBD)**
- "Dip coating" technique
- Control of bath quality and temperature
- Reinforce the nanowires’ structural build

**Plume modeling using ANSYS CFX, a computational fluid dynamics tool**
- Determine if SO₂ is measurable on vessel and the optimal measurement location
- Replicate realistic conditions, such as creating a realistic ship structure as shown

**OUTCOMES / RESULTS**
- Functionalization of alumina on ZnO nanowires provides high specificity towards SO₂ sensing
- Higher wind speeds reduce amount of SO₂ detectable. Wind direction causes pressure areas
- Prototype able to distinguish different levels of SO₂ in indoor vs outdoor testing

**CONCLUSION**
- ZnO nanowire sensors will be fast, recoverable, and provide high accuracy
- Chemical team proposed a receptor for functionalizing ZnO nanowires for lab testing
- Mechanical team found optimal locations to detect SO₂ on ships
- Hardware team produced first prototype to be used with ZnO nanowires in the future

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