Microplastic Detection using Resonance Microwave Spectrocopy

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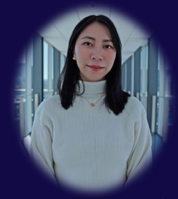

Vivian Mai[2]

1. MOTIVATION

Microplastic is any plastic fragment with diameters less than 5mm.

Negative Impact on Health and Environment:

- Microplastic ingestion causes cell damage in humans, and reduces chance of reproduction in marine lives [1].

Statistics: On average, adults consume 5g of plastics per week, and 260 million tons of plastics wastes are produced each year[2].

Need: A robust microplastic detection system is needed for microplastic tracking and analysis in many sectors.

2. PROBLEM

Existing Technologies

Fluorescent-Tagging Microscopy
Fourier Transform Infrared Spectroscopy
Raman Spectrocopy

Shortages

- **Time-consuming**
- **Expensive**
- **No batch test**

3. PROJECT OBJECTIVE

Develop a technological demonstration of a rapid, accurate, and affordable microplastic detection device.

4. SOLUTION

Employ resonance microwave spectroscopy and fluidic system microplastic detection.

5. DESIGN CONSIDERATIONS

Safety	Project-related safety concerns were mitigated. Product-related safety concerns are under evaluation.
Regulatory	Regulatory aspects dependent on application domain.
Sustainability	Reusable System Set-up Proper Filtering prior to Sample Disposal
Impacts to Society	Provides new analysis tool for different sectors: Research labs Wastewater Facilities Smart Home Sensing
Impact to Environment	Provides Real-time Data for microplastics in environment Accelerates Analysis for drinking water quality, pollution trend, etc.

6. THEORY OF DESIGN

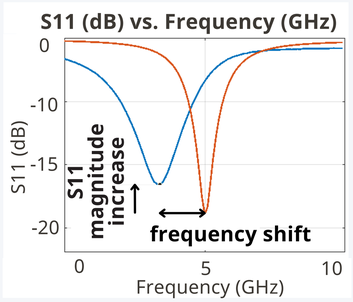
RF Resonator: a structure that naturally oscillates with greater efficiency at certain frequencies, called resonant frequency.

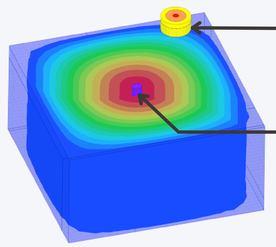
S11: Measures the ratio between the incident and reflected waves.

Working Principle: When microplastic solution is present in the microfluidic channel, the dielectric property of the channel changes, which results in 2 measurable changes:

1. **Primary Response: resonance frequency shift in S11**
2. **Secondary Response: increase in S11 magnitude**

Different microplastic concentration can be correlated with resonance frequency shift and S11 values.





Resonator with Maximum Electric Field Intensity in the Center

Port connected to VNA (Vector Network Analyzer)

- VNA injects microwave to the resonator, resulting in an electric field within the resonator.

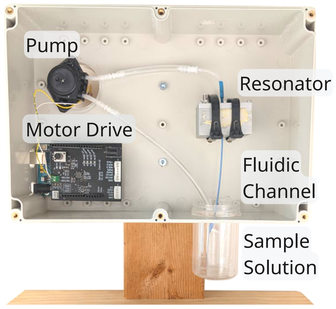
Fluidic Channel

- concentrates microplastics solution within the highest electric field region.
- small diameter:
  - prevents the resonator from overloading.

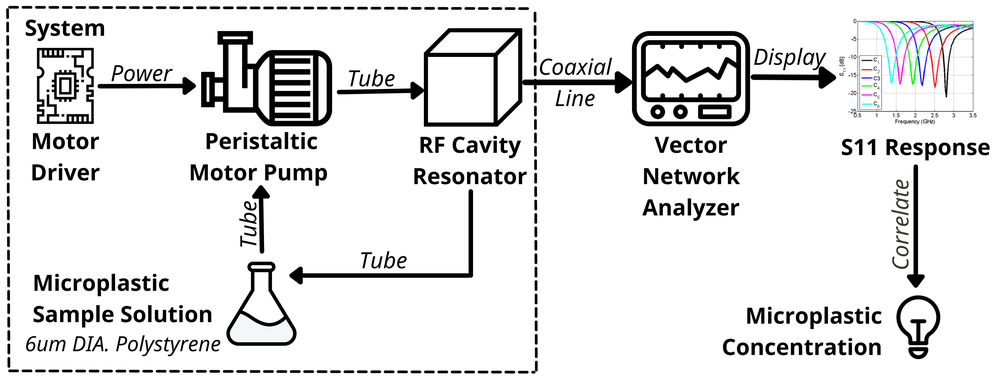
7. THE DESIGN

Critical Steps

1. Pump moves microplastic solution to the resonator.
2. Resonator resonates at different frequency depending on the sample concentration in the fluidic channel.
3. VNA measures and displays the S11 response.
4. S11 response is correlated with microplastic concentration.

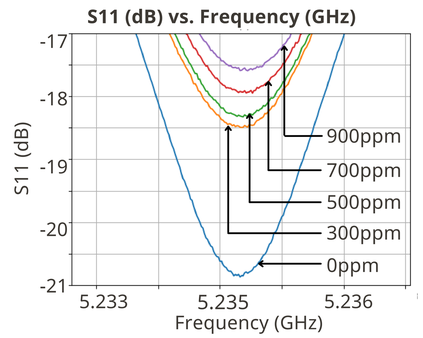


System Overview



8. RESULTS AND ANALYSIS

Process: The system is properly tested with different microplastic concentrations (0~900ppm) with multiple trials. The average S11 response is recorded for correlation.



Result Analysis	• Frequency shift was insignificant due to solution's non-ideal homogeneity and clumping. • S11 magnitude increase was consistent with concentration increase. • The observation of S11 magnitude increase is promising for correlating between S11 response and microplastic concentration.
Plan for Future Revision	• Use larger channel to prevent clumping and increase homogeneity. • Relocate port closer to the channel to prevent overloading. • Collect more data for precise approximation.

9. PROJECT MANAGEMENT

Strategy Overview

- Clear Division of Work
- Plan Ahead of Schedule
- Employ Project Management Tools
  - **Trello:** track individual tasks
  - **Gantt Chart:** visualize short- and long-term goals

Lessons Learned

More time and effort should be allocated for research of possible other applications of the project.

Contingency plan should be discussed and actively adjusted based on the project progress in weekly meetings.

Consistent use of Trello should be enforced at the start of the project instead of half-way through the project.

References

1 M. Simon, "Plastic Rain Is the New Acid Rain," 11 Junw 2020. [Online]. Available: https://www.wired.com/story/plastic-rain-is-the-new-acid-rain/

2 O. Malyuskin, "Microplastic Detection in Soil and Water Using Resonance Microwave Spectroscopy," ResearchGate, [Online]. Available: https://www.researchgate.net/publication/

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