COVID-19
High-Throughput Serologic Chip

Group 6
Dylani, Jacob, John, Paul
Outline

- Background
  - What is COVID-19
  - Current crisis
  - Current detection methods
- Individual Sensor
  - Transducer
- High-Throughput Format
  - Electrical Logic
  - Fluid Delivery
- Innovation
- Summary
Background: What is COVID-19?

- Coronavirus disease 2019 (COVID-19) is a viral respiratory illness.
- Symptoms of COVID-19:
  - Shortness of Breath
  - Fever
  - Cough
- These symptoms may be mild or severe
- No current anti-viral treatment for COVID-19
- Treatment only available for relief of symptoms
Background: Prevalence of COVID-19

Total Cases: Worldwide
2,119,333

Total Death: Worldwide
141,956

210 countries and territories affected

Total Cases: USA
653,397

Total Deaths: USA
33,405
Background: Current COVID-19 Detection Methods

- Detection During First Week of Infection
  - Nasopharyngeal swab collected
  - Virus detected using real-time reverse transcription polymerase chain reaction (RT-PCR)
  - Results within a couple hours to a few days

- Detection During Second Week of Infection
  - Virus disappears from the nose and multiplies in the lungs instead
  - Samples collected from deep airways using a suction catheter
  - Tested using RT-PCR to detect live COVID-19
  - Results within a couple hours to a few days

- Detection Methods Post-Illness
  - Detection of antibodies
  - Requires a blood sample
  - Lateral flow immunoassay that detects antibodies of immunoglobulin M and G against COVID-19
  - Results within 15 minutes
Our Device Detection Method

- This device is for mass detection of COVID-19 for those who believe they may have had this illness previously
- Antibody detection method
  - Still present in the blood post-recovery
- Allows all individuals to test for COVID-19 immunity
Antibody/Virus Binding

- Receptor-Binding Domain (RBD) present on Spike Protein (S) trimer.
- Largely hydrophobic interactions with IgG.
- $917 \, \text{Å}^2$ interaction area between antibody/antigen.
- Cell membrane (ACE2) and Antibody bind to different virus RBDs.
Aptamer Engineering

- SELEX method to find best “fit” to SARS-CoV-2 Specific Immunoglobulin-G.
- Result would share similar RBD nucleotide sequence shown below.
- Additional sequencing needed for conformation and glutaraldehyde cross-linking.
Aptamer Immobilization on Sensor

- PDMS Substrate.
- Silicon Electrode.
- APTES-GA Aptamer Immobilization.
  - Hydroxyl Surface Functionalization.
  - Silanization.
  - Glutaraldehyde Cross-Linker.
- Aptamer Bio-Recognition Element
Individual Sensor: FET Configuration

- Aptamer-antibody interaction creates a small electrostatic potential
- As more aptamers bind the gate is saturated

[7] [8]
High-Throughput Format: Electrical Output

- Allows selection of which sensor is being read at a given time
- Use of multiplexer to require 8 content points with a computer rather than 128
  - 1 Output
  - 7 Input
- Scalable
- Existing tech can be applied
High-Throughput Format: Fluid Delivery

- Tubing from collected samples attached to chip
- Flow provided by external pump
- 128 total lines
Innovation

- High-throughput technology allows testing thousands of patient samples at once
- <8 minutes per batch
Benefits

● Rapid high-throughput testing allows for mass testing.

● Allows us to determine spread and population immunity

● Minimize travel delays if immunity requirement is implemented
Summary

- We proposed a high-throughput aptamer-based antibody sensing device.
- Signal is transduced by voltage generated across an FET transistor.
- Useful for identifying who has COVID-19 immunity at a population scale.
Resources