

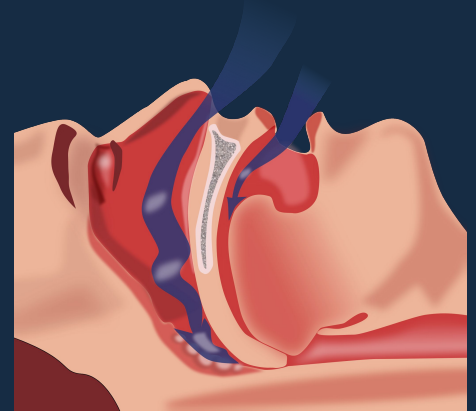
★ Sleep Apnea Detection Biochip

By: Cady, Dane, Jagar, Sam



★ Background

- Sleep Apnea is a disease in which breathing stops and start repetitively. Symptoms include:
 - Loud snoring, gasping for air, insomnia, hypersomnia, irritability, and more
- There are three main types of sleep apnea:
 - Obstructive Sleep Apnea
 - Central Sleep Apnea
 - Treatment-Emergent Central Sleep Apnea



<https://www.holisticcharlotte.com/exercise-your-throat-muscles-to-reduce-snoring/>

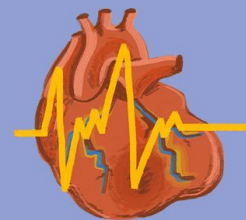
Risks of Untreated Sleep Apnea



Depression



Diabetes



Heart Failure



High Blood Pressure



Concentration and memory problems

https://www.swoknews.com/styles/health/take-back-your-life-from-sleep-apnea/article_df25af-7861-5816-a312-450dda69d80e.html

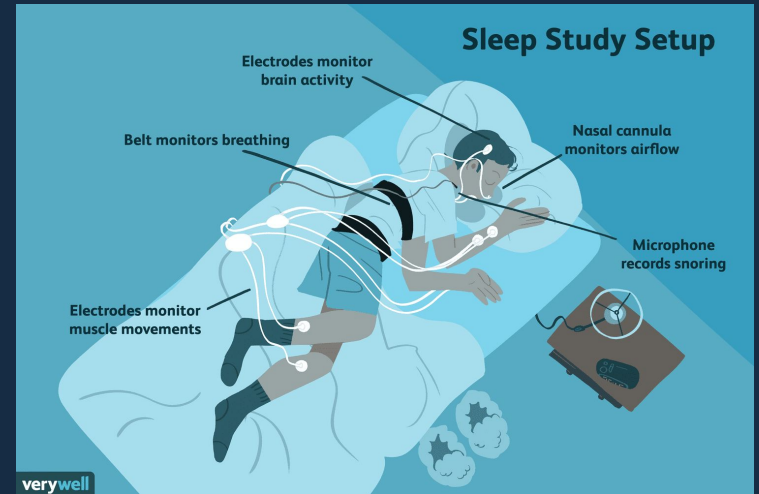
★ Current Detection Methods

- **Home Sleep Test**
 - Measure heart rate, blood oxygen level, airflow and breathing patterns
 - Inaccurate, less detailed



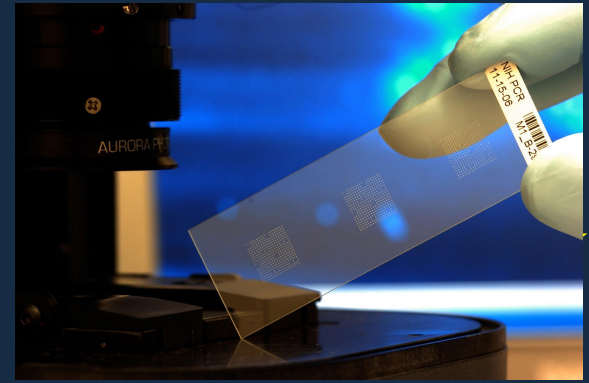
Current Detection Methods

- **Polysomnography:**
 - Records brain waves, blood oxygen level, and your heart rate, breathing during sleep
 - Measures eye and leg movements
 - Inconvenient, long wait times, unrealistic sleep environment

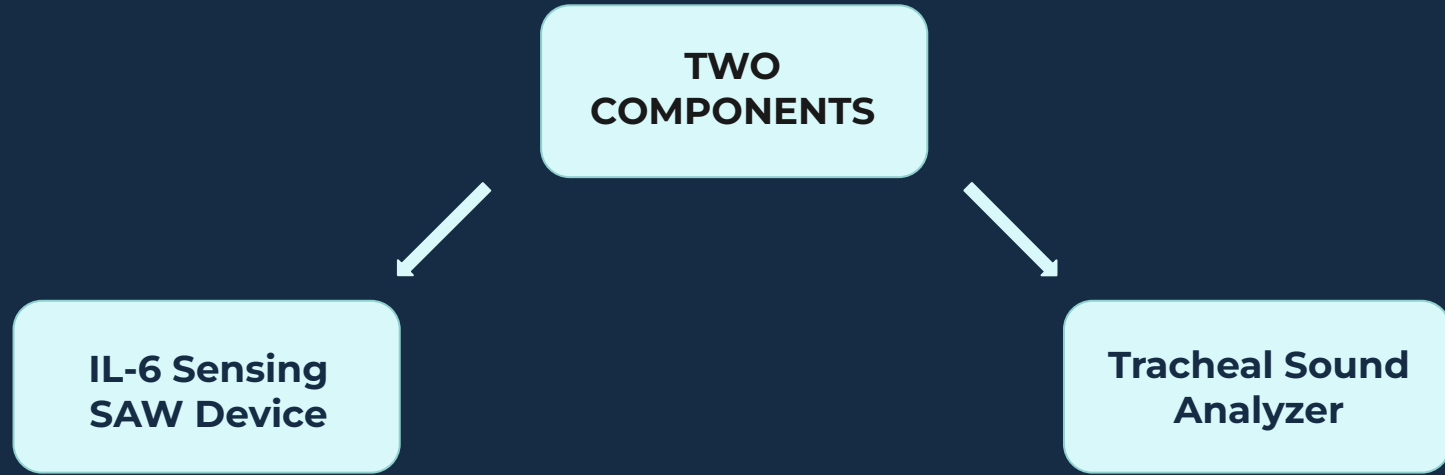


★ Principles

- Biosensing →
 - A biological sensitive recognition element that is usually immobilized on a transducer to measure analytes.
 - Sensing IL-6 in exhaled breath condensate (EBC) under the nose.
- Biochip →
 - A microchip intended to function in a biological environment.
 - Tracheal sound analysis using a mechano-acoustic sensor on a small biochip.

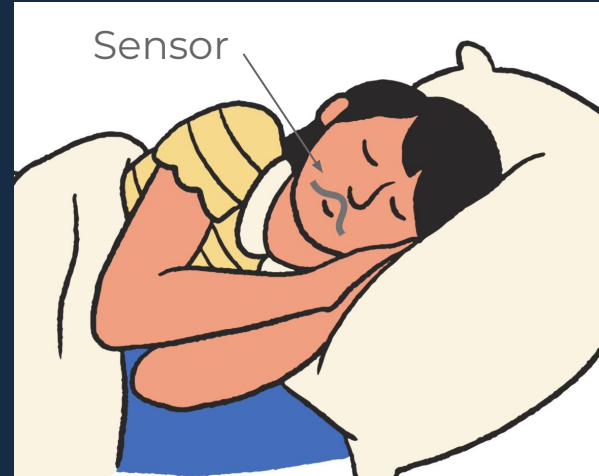


★ Device Description



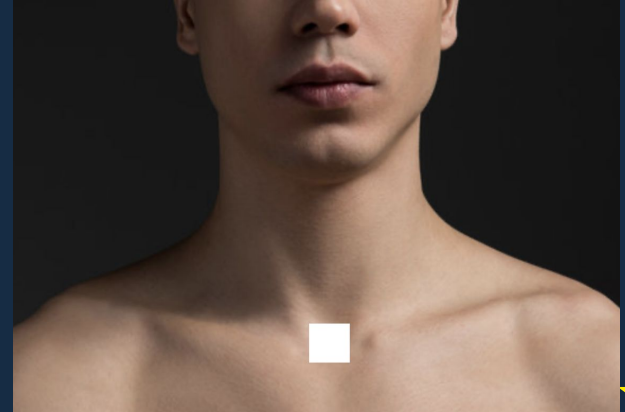
★ IL-6 Sensing

- SAW Sensor to detect IL-6 analyte
 - Bind to antibody sarilumab
- Placed under the nose
- Measures exhaled breath condensate (EBC)



★ Tracheal Sound Analyzer

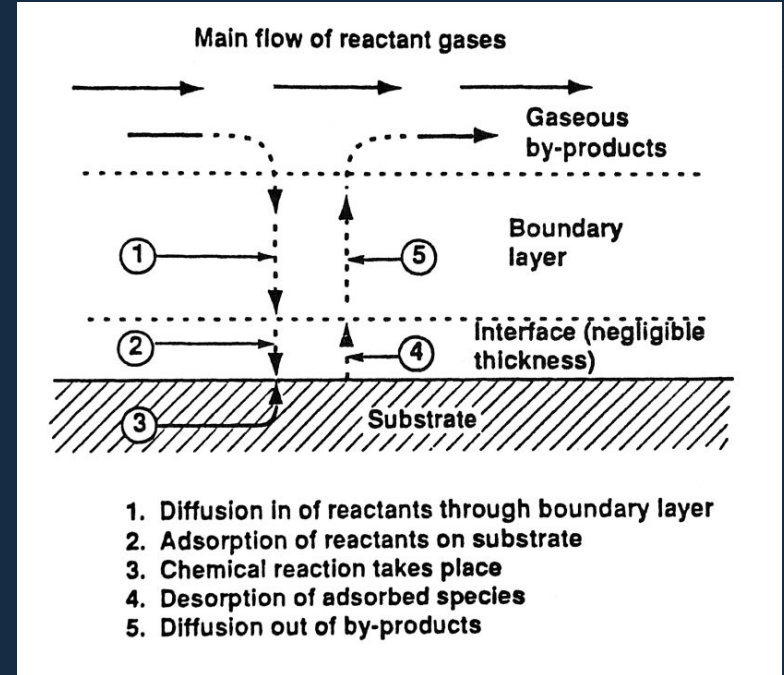
- Silicon based
- Placed on the suprasternal notch
- Measure mechano-acoustic signals
 - Breathing
 - Breathing patterns
 - Snoring
- Decode and classify signals using neural network



-Area of application.

SAW Sensor Microfabrication

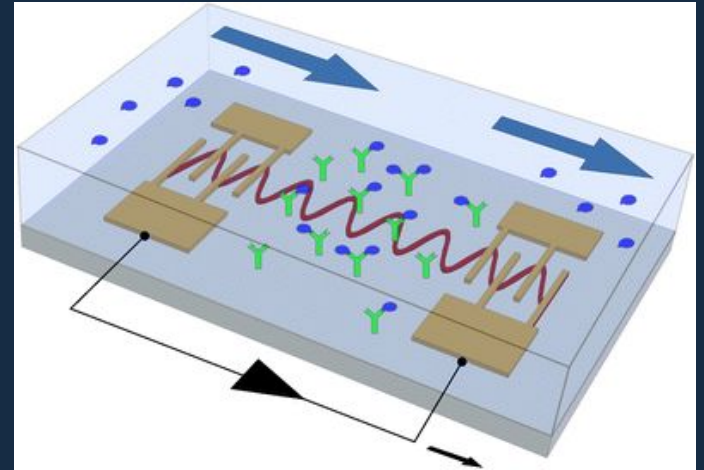
- Polyimide deposition onto silicon wafer
 - Chemical vapor deposition (CVD)
 - Reaction between pyromellitic dianhydride (PDMA) and oxydianiline (ODA)
 - Deposition of polyamic gas onto surface
 - Curing to extract polyimide from polyamic deposition



SAW Sensor

Microfabrication

- Zinc oxide (ZnO) deposition on top of previously fabricated polyimide layer
 - Physical sputtering techniques
 - Film thickness roughly three microns
- Sarilumab
 - IL-6 antibody
 - Bind antibody to SAW surface
 - Rinse unbound antibodies
- Attach off the shelf adhesive



Mechano-Acoustic Sensor Fabrication

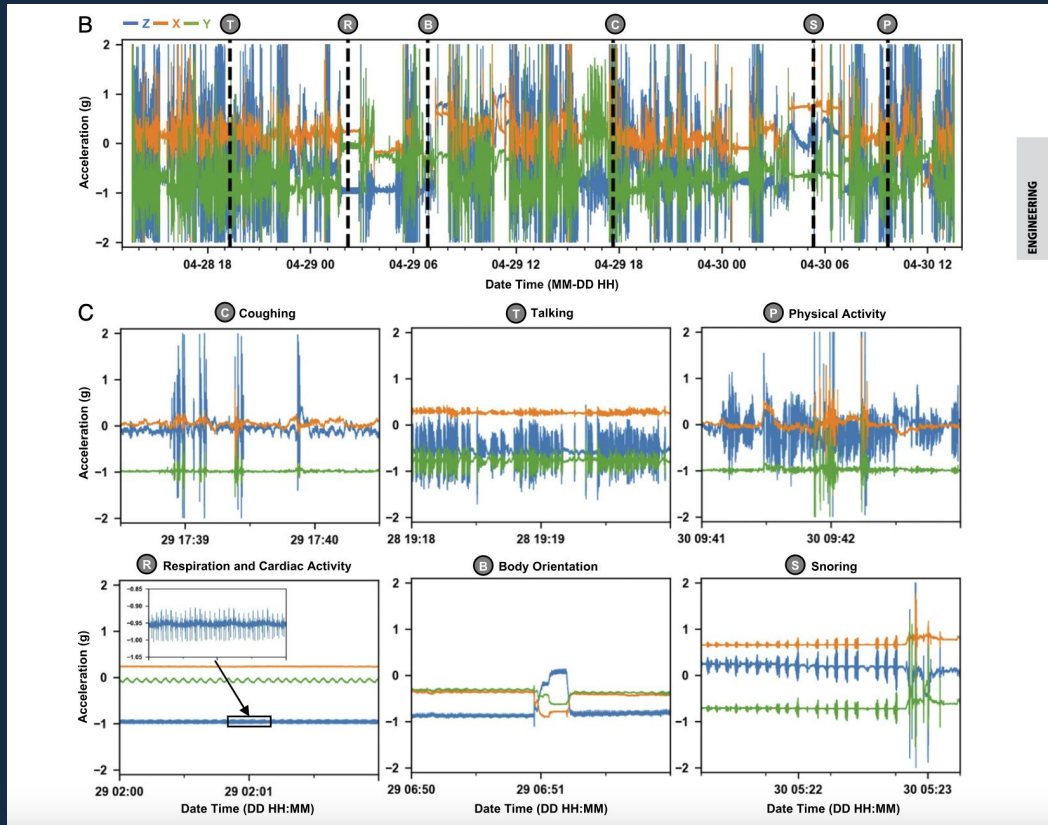
- Silicone based casing
 - Polydimethylsiloxane (PDMS)
 - Top and bottom of casing master molds fabricated using SU-8 spin casting and UV etching
 - PDMS stamp on respective molds to form top and bottom halves of casing
 - Electronic components (accelerometer, circuit board, microcontroller) placed within molded sections of bottom half of silicone casing
 - Plasma oxidation to bind top and bottom casing halves
- Attach off the shelf adhesive

Testing

2 Main Testing Factors:

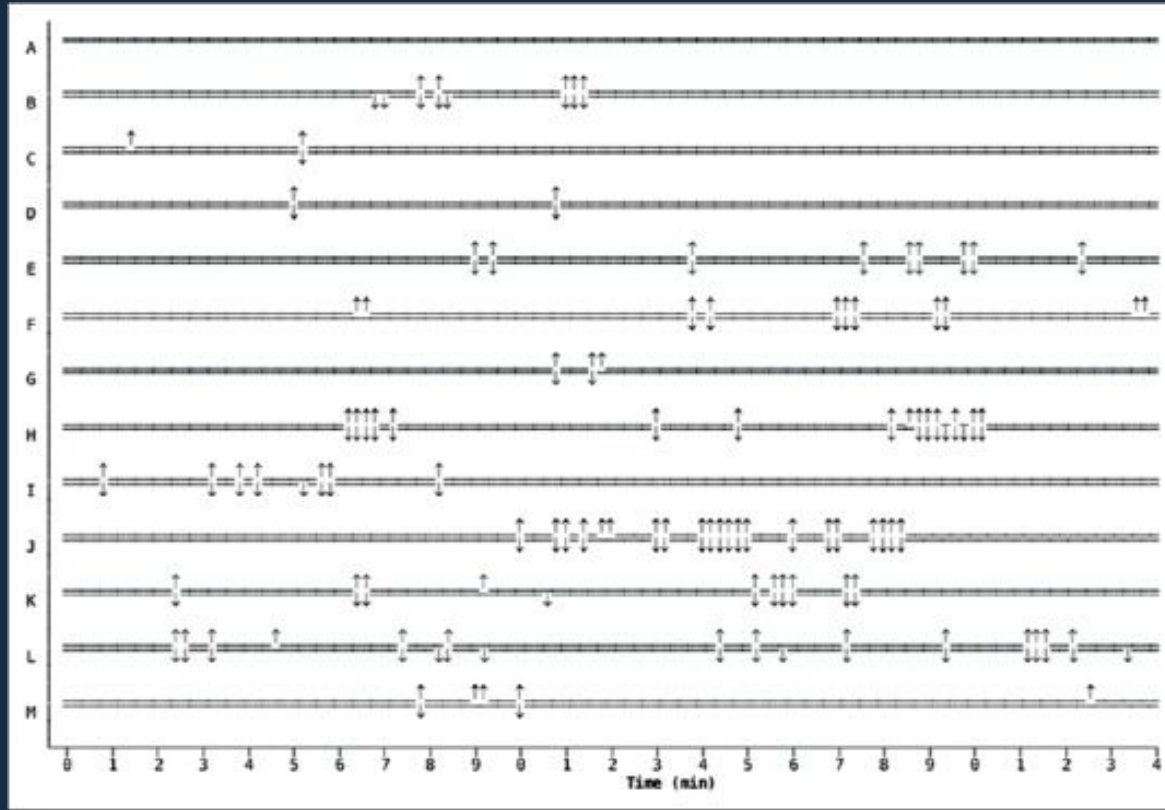
- Electrical output gained from IL-6 SAW acoustic wave which is recorded in the form of a spectrogram
- Tracheal sound audio signals converted to time-frequency spectrograms
- Spectrogram's gained are analyzed using Image analysis techniques or Deep Neural Networking

Figure: SAW spectrograms



Note: This figure was produced from "Automated, multiparametric monitoring of respiratory biomarkers and vital signs in clinical and homesettings for COVID-19 patients," Ni et al., 2021.

Figure: Spectrogram showing respiratory status



Note: This figure was produced from “Tracheal Sound Analysis for Automatic Detection of Respiratory Depression in Adult Patients during Cataract Surgery under Sedation,” Esmaeili et al., 2018.

★ Biocompatibility

- This device is external, so biocompatibility within the body is not a concern
- The materials used have been shown to not cause reactions when interacting with the skin.
 - Silicone Elastomer
 - 3M Non-irritating adhesive

★ Limitations

- Device Connection Error
 - Facial Hair, Sweat
- Human Error
 - Incorrect Placement
- Expensive



<https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.creativefabrica.com%2Fproduct%2Fpretty-cool-mustache-illustration%2F&psig=AOvVaw3Sfc27AOd53adEMwdLaAID&ust=1712944554363000&source=images&cd=vfe&opi=89978449&ved=0CBIQRxqFwoTCMDVkvbduoUDFQAAAAAdAAAAABAH>

Future Directions

- Combination of the two separate components into one.
- Enhanced sensitivity and specificity of the biosensor.
- Miniaturization.
- Possible integration of the biochip with wearable watch devices.



<https://www.nytimes.com/wirecutter/reviews/best-smartwatch-android/>

The background is a dark blue gradient with several yellow stars and dots scattered around the edges. There are two stars in the top-left, one star and one dot in the top-right, one star and one dot in the bottom-left, and one star and one dot in the bottom-right. The word "Questions?" is centered in a white, bold, sans-serif font.

Questions?

Sources

[1]<https://www.sciencedirect.com/science/article/pii/S2590137022001819#:~:text=Functionalization%20of%20electrochemical%20biosensors%20allows.media%20can%20accelerate%20future%20research.>

[2]<https://iopscience.iop.org/article/10.1088/1361-6439/aa8ae0/meta>

[3]<https://www.pnas.org/doi/epdf/10.1073/pnas.2026610118>

[4]<https://pubmed.ncbi.nlm.nih.gov/31768002/>

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[6]<https://www.nature.com/articles/s41378-023-00503-5>

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[9]<https://saliterman.umn.edu/biomems-class/syllabus-lectures-and-handouts>

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[11]https://www.3m.com/3M/en_US/p/d/v101544000/?utm_medium=redirect&utm_source=vanity-url&utm_campaign=3M.com/MedicalTape4578