Fabrication and Read-out of Integrated Photonic High Frequency Acoustic Wave Detectors

(Technical Paper)

Social Constraints of Implementing New Energy System

(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Acoustic microscopy for tissue imaging has been used broadly for medical and research purposes . However, many existing methods require the subject to be in the state of comma. This project builds an acoustic wave sensor with ring resonator on a membrane and when testing, the subject could maintain its mobility. The design and fabrication process follow the industry standards and could be integrated.

In Charlottesville, power outage has happened in a relatively high frequency. The city power system is outdated. New energy system is needed However, besides technological issues, there are many other social constraints needed to be considered. In the later section, these social constraints will be discussed and analyzed under the social construction of technology framework.

Technical Report

Acoustic microscopy is a method of imaging through the measurement of sound waves released in the biological tissue with certain wavelength signal applied. Many applications have been worked on this method. However, they all involve to restrain the mobility of the test subject. Most of the testing methods require the testing subject to remain stable, anthetic or electrical shot is being used to put testing object like mouse into comma. First this might cause damage to the object's health also introduce inaccuracy to the result since brain activity is different from the sober state. Therefore an imaging device that could operate when the object is in its conscious state is needed. Previously, in the biomedical engineering department in the University of Virginia, professor Song Hu has been working on optical-resolution photoacoustic microscopy (OR-PAM).This technology allows him to acquire information about the biological tissue for example mice. Currently his method involves a complicated system of piezoelectric material.

This project builds a sensor for measuring acoustic sound waves using features that built on silicon wafer. A ring resonator in this case is used. When a wide range frequency of optical signal is fed into a ring resonator, light with a certain frequency will get confined in the ring and thus signal with that frequency has a low output amplitude. This frequency is called the resonant frequency and it is related to the effective refractive index of the material and the geometry(radius) of the ring. By applying acoustic sound wave to the ring will induce a pressure and thus change the refractive index of the material and also the radius of the ring. Therefore, a shift of the resonant frequency would occur at the output. By measuring the change of the resonant frequency would give the information of acoustic wave applied to the ring.

This project will use a SONY foundry chip with the design feature of one ring resonator with 8um diameter and two photodiode connected to it. This chip is made using Silicon on

Insulator (SOI) wafer. Features are on the silicon layer. In the middle there is 2um thick silicon dioxide layer and 690um silicon substrate on the back. In order to increase the sensitivity of this device, the ring is desired to built on a membrane. Thus, it is required to etch from the back of the chip to make the ring resonator locate in the middle of this membrane. The area and the thickness of this membrane is related to the maximum pressure it could bare. Lithography mask has been designed with different pattern sizes for testing ideal feature size. The desired thickness of the membrane is in the range of tens of micrometers. This means around 650um silicon substrate needs to be etched away from the back of the chip. This requires a photoresist with high selectivity and a precision etch process. This membrane will respond to the acoustic wave with higher sensitivity. When optical wave is fed into the ring resonator, the acoustic wave will cause a larger shift in the resonant frequency that measured at the output.

A signal process system is built to control the input optical signal to the sensor and analyze the resonant frequency and its shift when acoustic wave is applied.

STS Thesis

There are 14 Grand Challenges for Engineering in the 21st century and two of them(make solar energy economical & provide energy from fusion) are directly related to energy. Energy, as the power source drives the living engine of the world. It is an essential task to generate energy efficiently and substantially. However, technology could not be separated from human activity.

From global warming to heating up frozen dinner, energy is related to everyone's life. An efficient energy system could provide safe and reliable power to fulfill our needs. An outdated and poorly designed one could cause safety issues like fire hazard and also could lead to power outages. Therefore it is important for us to implement more efficient power system. Also we need to keep in mind that new power system does not only relate to the power companies but also influence our lives significantly.

Literature review

Corsini's paper is based on the theoretical background of socio-technical imaginaries of participation and engagement in the energy sector. As mentioned in the paper, in comparison to soft infrastructures, hard infrastructures like energy production, distribution and consumption play important roles in the smart city imaginary and production. A transition to a fossil fuel free future is a goal but for it to be actually achieved and there are resiliencies from the citizens and public that could not be ignored. The domain of sustainable energy system involves the resistances from the aspects of legal and political boundaries. There is a distance existed between sociotechnical imaginaries of smart city in the research domain and in local community initiatives. It is stated that a turning participation process from consultation to engagement is needed in order to achieve energy system transition. However in many researches, the commitment and engagement of citizens in the energy production, distribution and use are neglected. Thus, this paper used bibliometric mapping of multiple scientific literature to capture the "publicly performed visions of desirable futures" of the relationship between energy and the city. Bibliometric methods are driven by the demand to assess scientific production, making the

results available to a wide range of stakeholders such as scientists, policymakers, practitioners, etc. (Ellegaard and Wallin, 2015). The results are term maps that have different color, fonts and distant representing different relationships, co-occurrence and areas of studies, constructed from 74,932 publications on the topics related to energy. From analyzing these map, the authors have come up with the conclusion that most scientific researches on energy mainly focus on energy performance, efficiency and infrastructures and lack of attention on socio-political issues. More efforts are needed on taking in consideration the citizen's role in energy system.

Also as the information technology becomes more accessible, many activities related to energy consumption could be monitored (Moran, 2001) . However, Nyberg has performed case study on 'smart grid' development in Japan and came to the conclusion that extensive tailoring of in- formation is required in order to engage users to develop an active relationship with infrastructure.

Thus, when implementing a new power system to an area, social factors must be considered and reflected onto the design since human activity and the design itself is interrelated and shape each other constantly. For example, digitalization as a technology that could inform us more about any given circumstance and process however, the increase of quantitative information does not have significant qualitative change in the society because of its lack of the involvement of human behaviors.(Roy A. Nyberg, 2018) Besides technical difficulties, there are also social constraints involved in the process of implementing new power system. It is important to identify these social constraints and analyze them and then reflect them onto the design of power system in order to achieve the desired engineering goal of providing clean and substantial energy in an efficient and safe way.

Framework

Relevant social group is one of the factors in the SCOT framework. In the case of implementing new energy system, users, electricity power providers and government are the main social group that related to the change. New energy system might cause the users to worry about higher cost and other uncertainties. In Charlottesville, there are 46,487 registered residence with the poverty rate being 24.5%. This means around 11,389 residence are below the poverty line. Thus it is essential to minimize extra cost to user or provide long term benefit to users. Also, for any technology to be implemented successfully, make users to have a better understanding of how the technology works is important to remove many concerns that they might have. Another aspect is the interpretative flexibility in the SCOT framework. Different consumer and financial group might have different opinions on the same product. Families with low income might have negative opinions on extra costs or work to have a better power system since they might already minimize their power consumption. On the other hand, people with high income tend to like the idea of sustainability and environmental friendly. They might want to invest money into adopting new energy system that have a long term benefit. To the energy companies, generating benefit might be an essential goal for them. Upgrade to new system adds to the sunk cost and would not generate enough money to cover that investment in a short term. Permission from the local

government is also needed if were to change the location of power generators. Also, many states have energy plans that need to be followed.

Methods and data

As for the collection of data, many local organizations could be reached out like 350.org Charlottesville (organization uses online campaigns, grassroots organizing, and mass public actions to oppose new coal, oil and gas projects) and AHIP (home repair nonprofit organization working to ensure safe, affordable homes for our neighbors in need). Data could be collected by interviews and documents. Interviews could be conducted in the fashion of face-to-face or through designed questionnaire. All data collected from the field would be kept confidential, no participant, individual or organization, will be identified in the results. More field research could be done on the users' willingness to adapt to a new energy system and their concerns and Also, model could be built to analyze the financial situation for a company to actually upgrade their energy generating system.

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