

**Study of Workforce Development at WPI/QCC Lab for Education
and Application Prototypes (LEAP) in Central MA
-- Its Role on Silicon Photonics and Electronics Industries in New England**

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Abstract

As one of the initiatives of Manufacturing USA, American Institute of Manufacturing (AIM) Photonics aims to accelerate the technology transition of integrated photonics from research labs to industrial deployment. Funded by the MA state, the WPI/QCC Lab for Education & Application Prototypes (LEAP) was established in Worcester, MA in 2018 and is a member of AIM Photonics. LEAP aims to establish an ecosystem with academia, industry, and government to boost the adaptation of integrated photonics in industry of central Massachusetts. The LEAP will provide user facilities, training opportunities, and expertise that the whole ecosystem can use to prepare for and leverage the next technological advancements in photonics. One major role of LEAP is to enhance the workforce development in photonics. However, the needs, existing resources, and the gaps in the local ecosystem are poorly understood, making the LEAP roadmap planning difficult.

This work will investigate the existing educational resources on integrated photonics and the current needs in the ecosystem in central Massachusetts. The student team will conduct surveys and interviews in the ecosystem, particularly on the campus of Quinsigamond Community College (QCC, Worcester, MA). The survey results will be analyzed to obtain a profound knowledge of the needs, current status, and gaps that can be present between the expectations of the industry and resources in schools, including two-year community colleges and four-year universities in central MA. The outcomes of this study will guide the student investigators into understanding the roles of LEAP in order to close the gap and further provide suggestions on the roadmap of LEAP. This work is expected to help LEAP to establish a workforce development hub in central MA and to provide the most needed educational resources for the photonics industry, and eventually benefit the whole society.

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Chapter 1 Introduction

In recent years, Integrated Photonics has seen time and many hours alongside huge grants poured into this field of research. Silicon has found itself a unique niche as the preferred substrate platform for photonic integration. With its transparency at wavelengths in the range of 1550 nm, the convenient main application found has been telecommunication that spans the low loss wavelength region of 1260-1625 nm [16]. However, recently, new uses of Integrated Photonics are being researched as we begin to understand the potential utility that this new technology can provide in our new age. Programs like American Institute for Manufacturing (AIM) Photonics have taken great strides to establish experience and infrastructure in this field. One such initiative is the Lab for Education and Application Prototypes that is opening at WPI during the fall of 2019. The initiative is funded for the fabrication of prototypes and initial proof of manufacturing along with the creation of new high-tech integrated photonics manufacturing jobs. With this new industry boosting initiative, the need for a roadmap of the current industry is necessary. The work and research done by us will give the LEAP initiative the footing it needs to assess the needs of the industry and apply them to the academia that is being formed around this new field.

1.1 Silicon Photonics and AIM Photonics

Silicon photonics is a branch of study that was adopted based on transmission speed manipulation in silicon as a substrate. During experiments with this substrate, the linear optical properties evaluated in the midwave and longwave infrared spectrum, alongside the excellent thermal conductivity and high optical damage threshold is what had established silicon as the new material on everyone's scope while finding new ways to enhance transmission speeds. While silicon is a poor conductor of electricity, unlike copper wires in used today, the theory behind silicon is instead of electrons as the data transfer medium, photons are utilized. The centrosymmetric crystal structure and no useful electro-optic coefficients allows for a smooth and quick transfer of these photons. While the new form of data transfer increases data carrying capacities, silicon photonics main issue is proper light emitters and modulators due to the indirect nature of its band gap. Despite the issue, optics is the main application that has led to the steady increase in attention of photonics experiences.

A few examples of early applications are the Silicon-on-insulator (SOI) wafer structures and fibre optic gyroscopes. The SOIs' were proposed to operate in the telecom fibre-optic wavelength of 1.2-1.6 μ m [12]. In 1991, a multi-micrometer ridge waveguide in SOI with certain dimensions could be single mode since all higher-order modes will couple into the

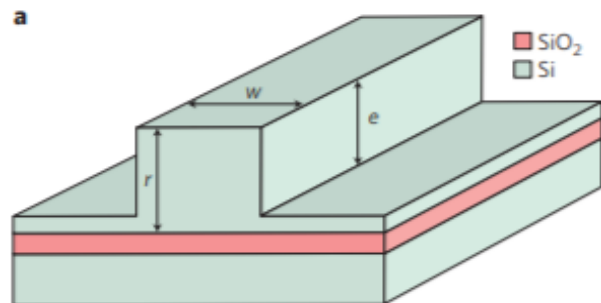


Figure 1a. SOI ridge waveguide and single-mode dimensions [13].

lowest-order mode of the surrounding slab waveguide and be lost [12]. Photons and electrons in the configuration in **Figure 1a** are much different due to 10 nm (wavelength of electron) being an order of magnitude smaller than the integrated circuit size.

Figure 1b illustrates the 1998 prototypes of fibre optic gyroscopes that were

fabricated and successfully tested for use in guided munitions.

American Institute for Manufacturing Integrated Photonics is an industry driven public-private partnership focused on developing capabilities and expertise in this technology. It is through this company's goal of accelerating the transition of integrated photonic solutions from innovation to manufacturing that we get partnerships like the Lab for Education and Application Prototypes (LEAP) for WPI and QCC. Initiatives of AIM Photonics such as LEAP will provide state of the art fabrication, packaging, and testing for small to medium enterprises. In order for their goals to come to fruition, the current central MA industry climate needs to be observed so both academia and industry can open the channels of communication and make sure to address gaps and potential problems before they come up and leave initiatives like AIM Photonics behind during this crucial stage in this technology's lifetime.

1.2 LEAP at WPI/QCC

The WPI/QCC Lab for Education and Application Prototypes (LEAP) is located at WPI's Gateway Park. The major role of LEAP in the coming years is to grow and enhance workforce development that will stand as the groundwork of AIM Photonics as they establish themselves at the forefront of Integrated Photonics manufacturing in the United States. LEAP at WPI/QCC's mission is to provide a space for prototyping, education and training, and research collaboration, specifically in the field of integrated photonics. A space for prototyping allows for an environment from academia, industry, and government sectors to create and test prototypes that incorporate photonic integrated circuits for new advancements in technology. Education and training in this industry at LEAP promotes an environment for continuing education and hands-on training. Research collaborations at LEAP will provide research opportunities and expertise in photonics related fields such as; optical and electrical device characterization, fiber optics, noninvasive optical metrology, nano/microscale prototyping development, terahertz sensing, and fiber-chip interfacing. [11]

Photonics is the next technological wave for microelectronics and data transfer. A new field of expertise and infrastructure comes along with the new wave. The goal of the inaugural years of the facility will be to secure a major footing in the photonics field in Central MA through state-of-the-art fabrication methods and high level manufacturing jobs. LEAP is available to both Quinsigamond Community College (QCC) and Worcester Polytechnic Institute (WPI) students interested in photonics but is also open to companies engaged in photonics and

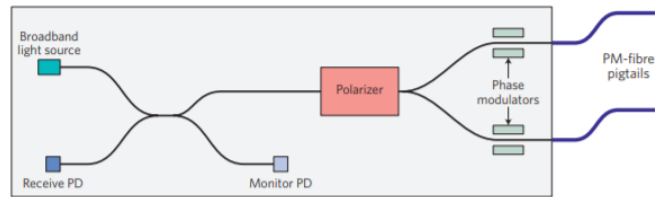


Figure 1b. Schematic of a 1998 silicon-photonic-based fibre optic gyroscope chip prototype [13].

interested in what student research projects at a state-of-the-art facility can do for them. Students from QCC and WPI with access to this facility will be engaged in research projects in the field of photonics to get the education and experience with the state-of-the-art fabrication equipment required to excel in the upcoming industrial wave photonics seems to promise. In order for our students to be well equipped for this, an understanding of where the students at QCC and WPI is necessary. For this research we will survey QCC students in order to help the overarching goal of identifying the needs, existing resources, and any gaps that present themselves in the transition from academia to the workforce that the new LEAP facility hopes to offer.

1.3 Topic and Goal of This IQP Project

1.3.1 Identifying the Needs, Resources, and Gaps

In order to identify the needs, resources, and gaps between academia and industry, there needs to be communication opened between the two. The purpose of this study is to gather research and data on the current climate of these two areas and how they are the same and different and identify possible problems LEAP will have to tackle during their inaugural years at Gateway Park. With Worcester MA economy booming, there are a slew of industry members that are attracted to this location and Integrated Photonics is no different considering the selection of schools Worcester has to offer. According to Lisa Eckelbecker's February 2019 report in the Telegram, "The Worcester Economic Index, a measure of the area's economy, grew at an annualized rate of 3.1 percent during the final three months of 2018...For the full year 2018, the index rose 3.2 percent from the previous year. According to Mr. White [Assumption college professor], the 2018 index growth was the highest since the 1990s." [21]. With Worcester being a hub for economic growth and the LEAP at WPI opening its doors to this up and coming industry, it is the perfect time for a study like this to happen on behalf of AIM Photonics.

With an increased representation of the photonics industries and life sciences in Worcester, LEAP will want to see their scopes on the advantages Integrated Photonics can have on chemical and biological sensors. With light as the medium of detection, methods of fluorescence spectroscopy such as Surface Enhanced Raman Scattering (SERS) are being researched for their uses in industrial process monitoring, water quality, leak warning/mapping, pharmaceutical drug testing, food quality, or even health diagnosis. With the almost limitless avenues that this technology can affect in the growing economy Worcester is seeing, the time to research where this field is really at is more important than ever.

1.3.2 Goals of the IQP

In the early stages of the project six goals were established to formulate an effective survey to be delivered to both academia and industry. Developing a set of goals aided us to ask the correct questions and get the most information from them. Below, **Figure 2** was designed to visually represent the goals of the study. The main goal of the study is to enhance the workforce

development through identifying the needs, existing resources, and gaps in Central MA between academia and industry.

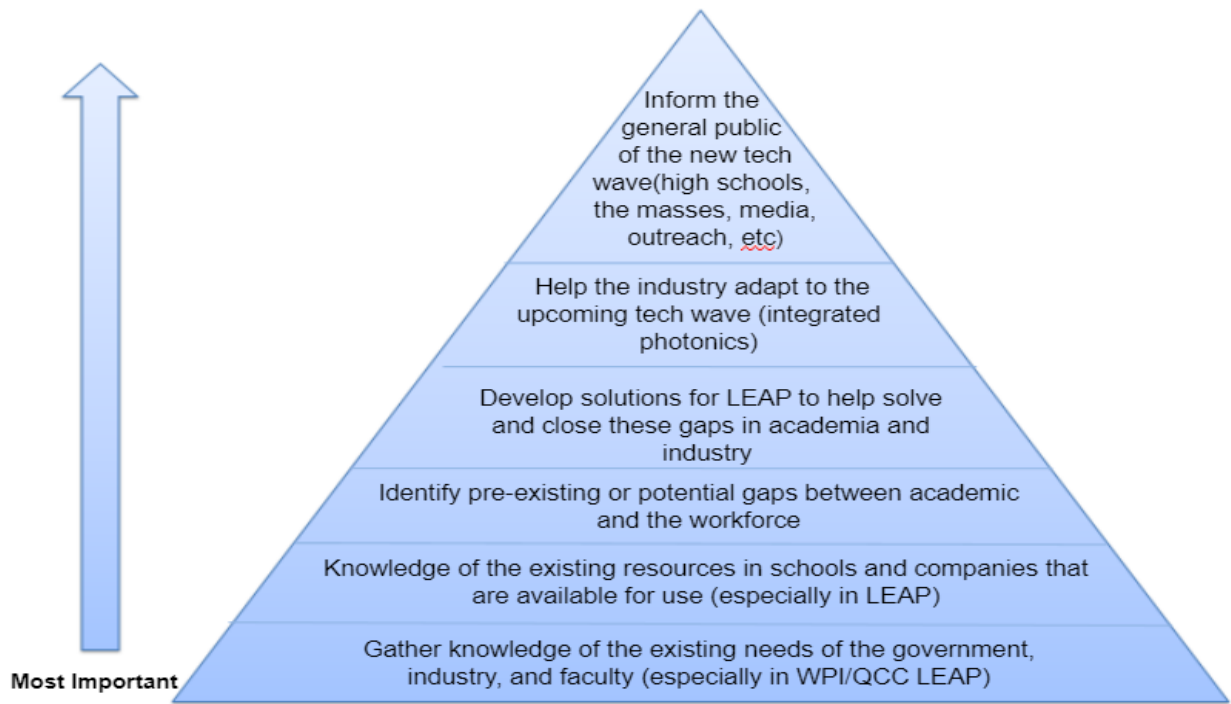


Figure 2. Goals diagram.

Chapter 2: State of the Art: Manufacturing methods used in Silicon Integrated Photonics

To better understand the needs of the workforce development for silicon photonics, we first did a literature review to get ourselves familiar with existing and potential methods used in integrated photonics industries. Such knowledge allows us to convey the right information to the subjects of our survey and enable us to provide right interpretation of the survey results. Chapter 2 is laid out to illustrate the difference between methods in the existing silicon electronics industry and the methods and facilities available or soon to be available at WPI/QCC LEAP. 2.1 lists fabrication and packaging methods broken up into group that are commonly used in the existing silicon electronics industry. Following, 2.2 lists the facilities and equipment available at WPI/QCC LEAP with subsections that go into detail of certain methods available or soon to be available at the facility. 2.3 examines a few examples of silicon photonics devices and their applications. Chapter 2 ends with a summary to recap the literature study.

2.1 Fabrication and Packaging Methods in Existing Silicon Electronics Industry

From the literature review we were able to distinguish a few categories of fabrication and packaging methods used in the silicon industry. These categories include additive methods, subtractive methods, and packaging methods. Additive methods are methods that add material to a substrate. On the other hand, subtractive methods remove material that is on top of the substrate. Packaging methods involve ways of bonding and connecting wafers and integrated circuits. Under additive methods we have photolithography, sputtering metal deposition, evaporation metal deposition. In the subtractive methods we identified wet etching, dry etching, and I-MacEtch (inverse metal-assisted chemical etching) [5]. Packaging methods include wire bonding, wafer dicing, wafer bonding [14], plastic-encapsulated microcircuit (PEM), plastic-leaded chip carrier (PLCC), and plastic ball grid array (PBGA) [2]. The next section will discuss facilities available or to be available at WPI/QCC LEAP. Additionally, a few of fabrication and packaging methods will be discussed in greater detail.

2.2 Facilities at WPI/QCC LEAP

Equipment available at the LEAP facility on WPI's campus may not be necessarily available to industry sectors yet. The equipment falls into six categories: Testing and Characterization Equipment, Wafer, Die, and Chip Prototyping, PIC (Peripheral Interface Controller) Functionalization, General Purpose Equipment, Metrology (science of measurement) and Inspection, and Nano 3D Printing Capabilities [10]. Available at LEAP under Testing and Characterization Equipment are Lightwave component analyzer, Lightwave measurement systems, Arbitrary waveform generator, PIC probe station, Visible/IR spectroscopy, and a Digital signal generator. The Wafer, Die, and Chip Prototyping category includes a Plasma system, Wire bonding, Sub-micro micro-assembly and positioning system, and a Sputter

deposition system. The PIC Functionalization category is comprised of the Comcore PFS-500i (Fiber fusion splicer), Apogee spin coating system, Deep UV aligner, a Meyer Burger Pixdro LP50 inkjet printer, and an Optical fiber prep station for cleaving. General Purpose Equipment available at the LEAP facility consists of Optical sensors, detectors, and instrumentation, Fiber-based laser systems, Optical tables with vibration isolation, Opto-mechanical hardware and components, Fume hoods, and Chemical storage. Metrology and Inspection equipment include Toolmaker/Inspection microscopy, 3D laser scanning microscopy, Thermal imaging, Atomic force microscopy, and Optical surface profilometry. The last category is the Nano 3D Printing Capabilities at LEAP which is not widely used in the industry yet. The LEAP facility has the Nanoscribe Photonic Professional GT+ that can print 3-dimensional microscale and nanoscale. The 3D printing too is optimal for replicating photonics structures as well as patterning [15].

The literature continued to understand techniques most commonly used in silicon photonics today. Below are the detailed descriptions of what we found to be the most common techniques used by industry and WPI/QCC LEAP. Each of the techniques were listed previous in section 2.1 under their respective fabrication or packaging methods category. Out of the techniques described below, dry etching is the only technique not available at the LEAP facility just yet.

2.2.1 Photolithography

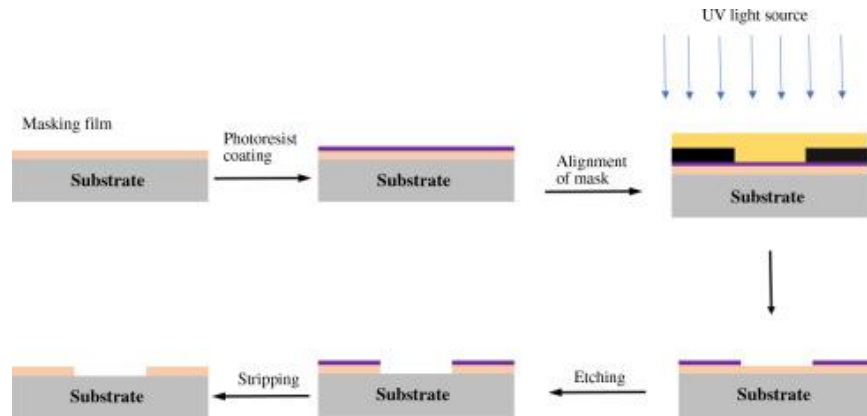


Figure 3. Photolithography process of etching a substrate.[17]

Photolithography is the method of transferring a pattern onto a substrate through optical means. **Figure 3** illustrates the process beginning with a photoresist coating being placed on the substrate. The substrate is then exposed to electromagnetic radiation adjusting the molecular structure which changes the solubility of the material all while aligning the mask of the pattern. Following exposure of the UV light source, etching takes place. Once the etching has been completed, the substrate is submerged into an aqueous solution to dissolve away the areas where photoresist was exposed to the UV light. [17]

2.2.2 Metal Deposition-Sputtering

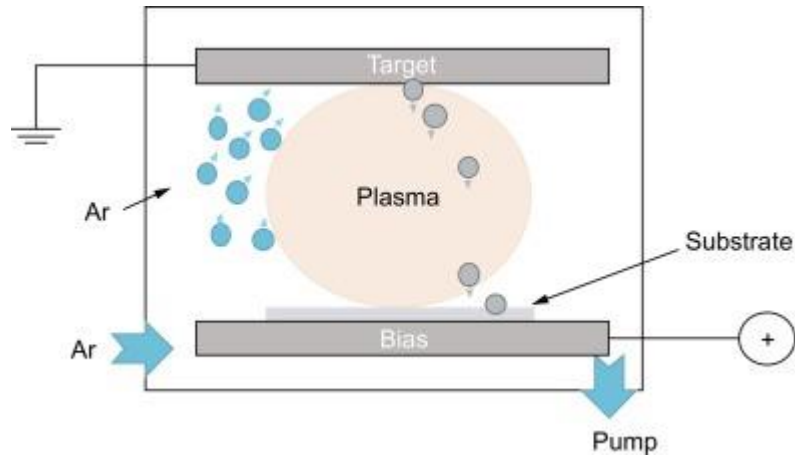


Figure 4. Sputtering deposition diagram. [1]

Sputtering deposition applies the production of a plasma through electrical discharge and the electrostatic acceleration of ions [9]. Typically, Ar^+ ions, as demonstrated in **Figure 4** are utilized during the sputtering process and accelerated towards the material to be deposited. The target location is positioned as a cathode within a vacuum chamber is usually grounded as shown in the figure above. The accelerated ions cause collisions with the substrate. The collisions cause the atoms within the substrate to be ejected and eventually become part of the thin film forming on the target.

2.2.3 Metal Deposition-Evaporation

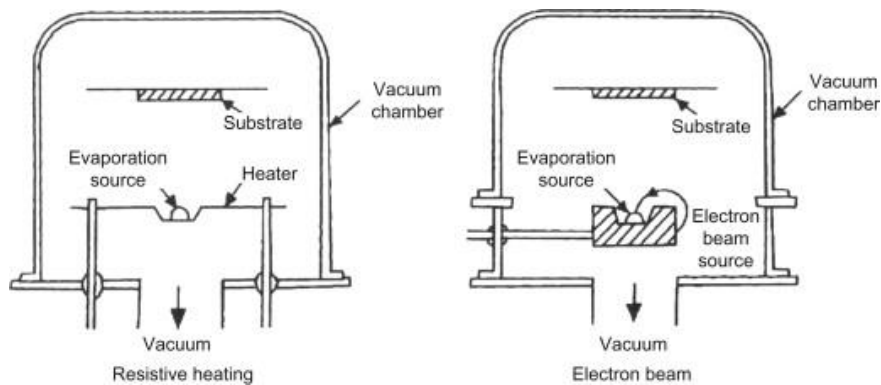


Figure 5. Evaporation deposition using resistive heating and an Electron beam. [15]

Metal deposition under the application of evaporation, also known as thermal evaporation, encompasses evaporating materials in a vacuum chamber then condensing the evaporated atoms on a substrate. Materials are evaporated by a resistively heated boat or filament

made of metals that are resistant to heat Molybdenum, Tungsten, and Tantalum.[15] The metals cannot be evaporated by resistive heating therefore, they are evaporated by electron beam deposition. Vacuum resistive heating and vacuum electron heating are both depicted in **Figure 5**.

2.2.4 Wet Etching

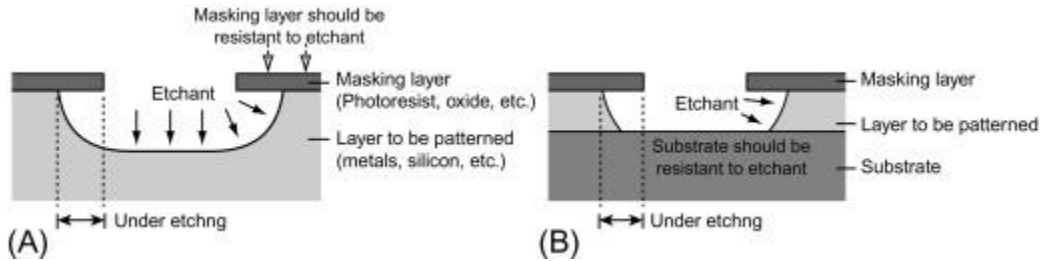


Figure 6. (A) Wet etching of a thick material. (B) Wet etching of a thin film on top a substrate.[6]

Wet etching utilizes chemical solutions to remove solid material from a wafer, commonly is specific patterns illustrated by photoresist masks on the wafer. Material exposed to the chemical solution are etched away. **Figure 6A** shows when a thick material is being etched, while **Figure 6B** shows a thin film being etched on top of a substrate that is resistant to the chemical solution. Wet etching is commonly isotropic where it proceeds in all directions at the same rate. However, any etching process that is not isotropic is anisotropic where the process proceeds in only one direction. [6]

2.2.5 Dry Etching

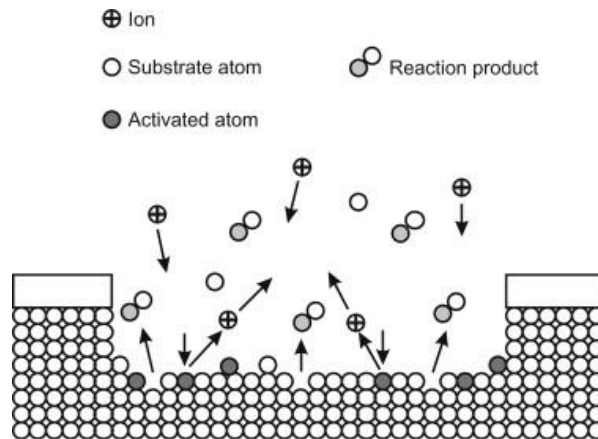


Figure 7. Reactive Ion Etching (RIE), common form of dry etching.[4]

Dry etching utilizes an etchant gas to etch small patterns with less of an undercut and higher aspect ratio than wet etching. Illustrated in the **Figure 7** is a common form of dry etching is Reactive Ion Etching (RIE) that uses gas at a high pressure known as a plasma. Applying a

magnetic field, RIE utilizes combinations of chemical reaction or physical bombardment of ions. The ions strike atoms in the material being etched. RIE results in anisotropic etching because the ions collide more on the horizontal surface rather than the sidewalls, thus the etching rate is faster in the vertical direction.

2.2.6 Wire Bonding

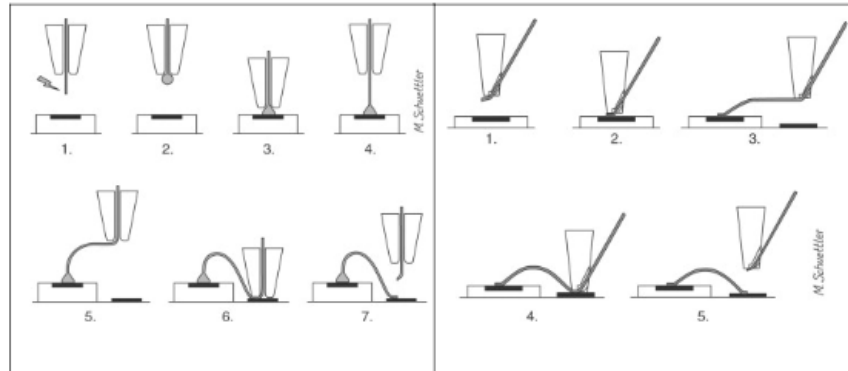


Figure 8. (a) Ball-wedge wire bonding method. (b) Wedge-wedge wire bonding method. [8]

Wire bonding technology included two processes: Ball-wedge or Wedge-wedge. The ball-wedge method presented in **Figure 8a** uses a capillary through which the bond wire (usually aluminum or gold) is threaded. A ball of material at the end of the bond wire is formed from an electrical spark then pressed to a bond pad under heat or ultrasound energy applications. The capillary is then moved to the target pad and removed while the wire is clamped then teared. The wedge-wedge method presented in **Figure 8b** utilizes a fine point capillary that includes an integrated wire feeding channel. The wire bond treads through the feeding channel and forced onto the bond pad. The first wedge is formed through the same heat or ultrasound energy applications, then the bonding capillary is carried to the target pad creating the second wedge. The wire tears the same way as the ball-wedge method [8]. In the illustration above, the difference in the wire ends of each method can be observed.

2.2.7 Wafer Dicing

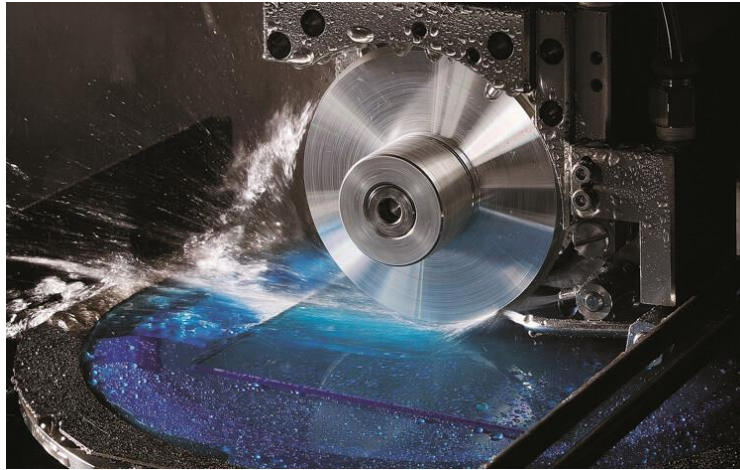


Figure 9. Blade dicing by a diamond blade.[3]

Wafer Dicing is the process of cutting thin silicon wafers into dies. It involves mechanical or laser dicing. Blade (mechanical) dicing utilizes a diamond blade as depicted in **Figure 9**. The diamond blade is used to cut through the wafers that are mounted onto a metal frame using an adhesive. The blade rotates between 15,000 to 30,000 rpm to cut through the wafers [3]. Cooling agents are lightly showered during the process within the cutting lines to prevent silicon dust particles from damaging the substrate surface. Laser or stealth dicing uses lasers with a semi-transparent light wavelength that cuts through the substrate. The wafers are cut from the inside out which produces less silicon dust particles that could damage the surface of the substrate. In contrast with blade dicing, laser dicing does not require cooling agents because it produces minimal heat transfer.

2.3 Examples of Silicon Photonic Devices and Their Applications

Along with the literature review of techniques commonly used in the photonics industry and at WPI/QCC LEAP, we dug a bit deeper into examples of silicon photonic devices and their applications. The following subsections discuss four differing devices that are among many more that are used in the photonics industry and at WPI/QCC LEAP. Detailed descriptions of the a few devices below are On-chip waveguides, On-chip couplers, On-chip light sources, and Detectors. Chapter 2 concludes after this section with a summary to recap all the literature that had taken place.

2.3.1 On-Chip Waveguide

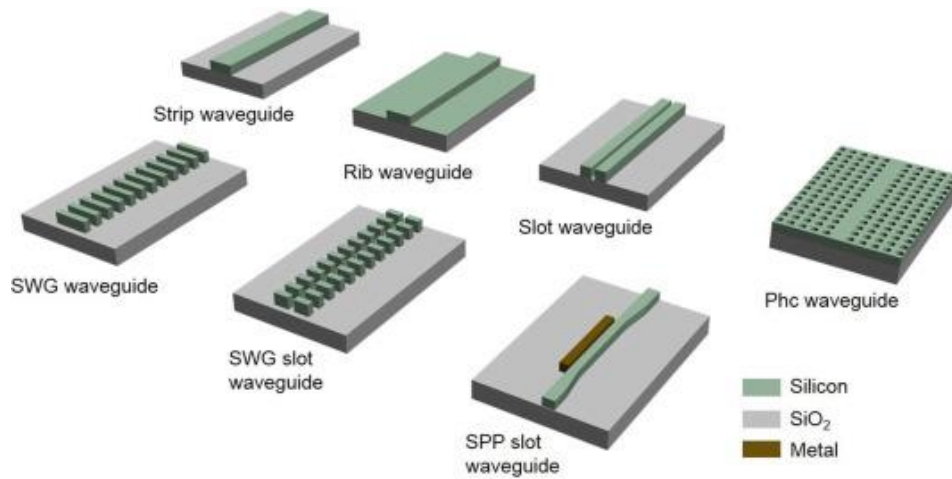


Figure 10. Various silicon waveguide structures. [13]

Silicon waveguides are used to carry signals across a chip. Different waveguide structures allow for signals to have diverse directions or routes as well as differing speeds the signals travel. Various waveguide structures are illustrated in **Figure 10**. The most commonly used waveguide structure is the strip waveguide that allows for a tight bending radius, thus is commonly used for compact signal routing. The rib waveguide allows connections to be made on either side of the waveguide and is used for electrooptic devices. The subwavelength grating (SWG) waveguide allows additional degrees of freedom compared to the strip and rib waveguides. The SWG waveguide uses a recurrent grating structure to guide the optic signal. The SWG slot waveguide adds a longitudinal slot in the SWG waveguide that can be designed to attain lower nonlinearity. To flexibly control the nonlinearity of the strip and rib waveguides, the slot waveguide was designed, adding an additional degree of freedom. The slot waveguide restricts light in the low refractive index region. Out of all the waveguides in the figure above, the photonic crystal waveguide (PhC) looks completely different. Due to the slowdown of light through the PhC waveguide, light-matter interaction is enhanced. The last waveguide depicted in Figure _ is the surface plasmon polariton (SPP) slot waveguide, which is the only one out of the seven waveguides discussed that incorporates a metal and allows for tighter light confinement. [13]

2.3.2 On-Chip Coupler

In the sense of silicon photonics, a coupler connects multiple waveguides into one. The silicon waveguides carry optical signals across the chip. **Figure 11** depicts two silicon waveguides on a silicon oxide chip that connect in a coupling region, thus becoming one waveguide. The tapered directional coupler to the right couples light from each narrow silicon waveguide to a wider, tapered waveguide. Different signals are sent through each waveguide, then after the coupling region exit through the waveguide that was a result of the coupling. [18]

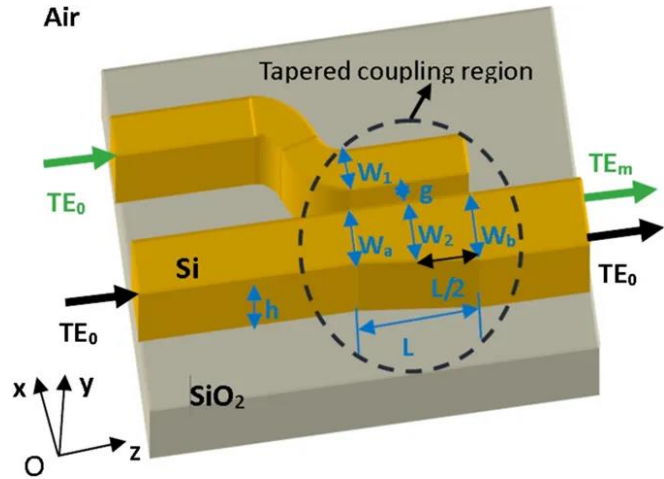


Figure 11. On-chip coupler that tapers two waveguides to be a single waveguide. [18].

2.3.3 On-Chip Light Source

On-chip light sources can obtain higher integration density with a condensed size. Additionally, they display enhanced performance in energy efficiency and proportionality. An example of an on-chip light source can be seen in **Figure 12** to the left of Germanium-on-Si laser. The unique band structure induces Germanium to perform correctly at the optical telecommunication wavelength of approximately 1550 nm and introduces the possibility of obtaining valuable light emission by engineering its band structure [19]. The Germanium-on-Si laser illustrated above is an idealized structure for generating tensile stress by etching through the Si substrate which greatly improved the light emission.

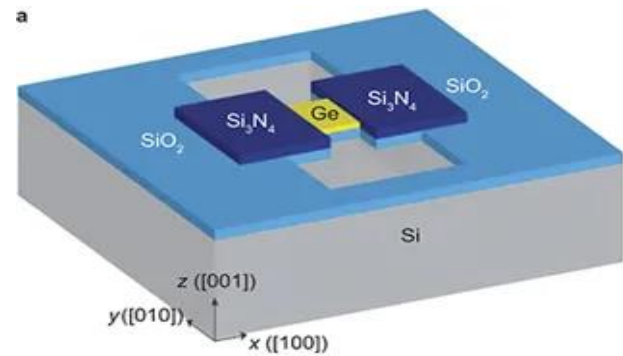


Figure 12. On-chip light source of Germanium-on-Silicon laser [19].

2.3.4 Detectors

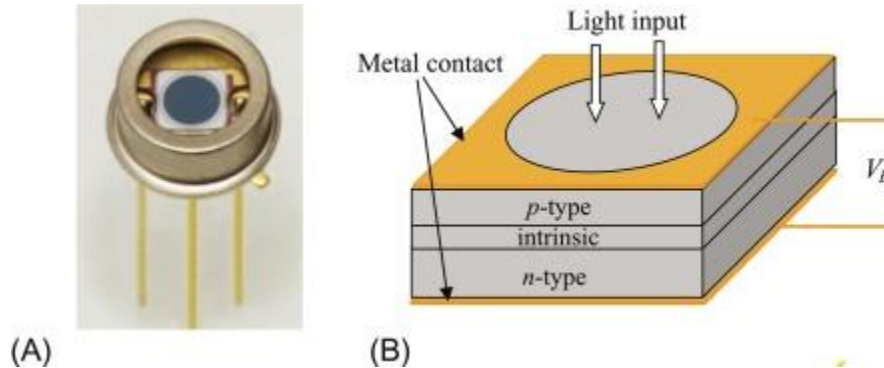


Figure 13. (A) Packaged large area photodiode. (B) Diagram of the layer structures.[7]

A photodetector converts optical signals into electrical signals. Photodiodes, also known as semiconductor photodetectors are used for optical communication systems. They are small, have fast detection speed, and high detection efficiency [7]. Each photon of the incoming optical signal is translated by the photodiode into a free electron. The translation aids the photocurrent to be linearly proportional to the power of the incoming signal. Depicted in **Figure 13** above is a packaged large area photodiode and a diagram of the layer structures, respectively. The large optical window allows for greater efficiency when accepting incoming photons. Shown in **Figure 13B**, the signal comes from the p-type layer of the wafer and since there is a large detection area and thick intrinsic layer, the photodetection response time is increased. The response time is increased due to the longer photon and electron transient time [7].

2.4 Summary

Chapter 2 discussed state of the art manufacturing methods that are used in silicon photonics. A literature study was conducted to better understand the needs of the workforce development for silicon photonics as well as existing manufacturing and packaging methods. We listed techniques used in the industry, especially those not necessarily available at the LEAP facility. However, we did list the techniques and devices available at the LEAP facility. Several techniques and devices were explained in detail following the list available at LEAP such as, wafer dicing, photolithography, wire bonding, and sputtering. Following the techniques were examples of silicon photonic devices and their applications. These included detailed descriptions of on-chip waveguides, on-chip coupler, on-chip light source, and detectors. Chapter 2 shows the difference between what is available in the industry as opposed to the LEAP facility. The techniques and devices at the LEAP facility will be available to both WPI and QCC students and faculty as well as industry sectors.

Chapter 3: Methods of this IQP Study

3.1 Statement of Research Methods

The main form of data collection for our research will be done through a survey/questionnaire. The survey will be completely voluntary and can be ended at any time for those surveyed. The students and teachers will primarily be questioned and surveyed in person, whether through a professor allowing us to take time out of their class or asked individually but could also be sent through email. The survey is split into two parts and we will keep them separated depending on who we are surveying. The second half can be sent as an attachment to industry and government officials, but during B term we plan to attend meetings and conferences to engage with people in the field and LEAP. An interview based on the survey questions shown will be implemented to see if we can get more information from these conferences and meetings. The data will be collected by the two student investigators and then collected and reformatted statistically to help us identify trends in the needs and resources of this field.

Above is the statement of Research Methods that was sent with the IRB application in order for us to continue our work into B term. The surveys changed a little after the initial IRB application approval and then was changed during our second round of surveys. Our surveying was primarily focused inside of QCC and various conferences we went to during the course of A term. The iMAPS conference in Boxborough gave us a definitive deadline to decide how our project was going to move forward in B term, as it was the first day of B term we attended this conference, and the New England chapter of the Optical Society of America conference at the LEAP facility itself gave us some insight into the industry that is accumulating in this area around Photonics. At this point in the study the Industry has not given us a good reception to utilize in our results, but this will be continued into C term. Because we focused our study in QCC, we decided to focus our efforts into the student population at QCC. To add to the survey we made a PowerPoint presentation spanning no more than five minutes, since most of our surveys were held at the beginning of a professor's class and immediately after this the students would voluntarily fill out the student/professor side of our survey and with the answers in those we would compile them into the results section and with those determine trends in the QCC side of the academics LEAP will be utilizing. PowerPoint slides are also inside the Appendix.

3.2 IRB Application process

For the majority of IQPs where surveying other students is required, due to liability concerns an Internal Review Board application must be filled out so that the focus of our project, can be reviewed for approval. This part of the project was brought to our attention from our IQP

professor but he was not completely sure of what this entailed so suggested we get in touch with someone on the IRB so we can better articulate our project's goal in our application.

The person we got in contact with was Ruth McKeogh who is the Director of Human Subjects Research. We scheduled a meeting with her where we were given guidance on how best to fit the project to the guidelines of the IRB and therefore help us transition smoothly from A term to surveys at QCC in B term. She helped us discuss the project and why the surveys needed to be done with respect to the overarching goal of the project. This meeting was very enlightening since we figured out besides the application of course, what we needed to prioritize. The concern for our project up to this point was having to rush our questionnaire since we believed the final draft of the survey needed to be approved by the IRB but Ruth McKeogh had calmed our nerves telling us our survey did not need to be its final form and the project fell under the circumstance of "exempt". This cut our application in half and turned our focus to the reason for the study. As we were told in our meeting, the survey is a nice addition but is not as necessary as a concrete reason behind the project. Because of a tight deadline for this IRB and a concern for having the project in a good state for the beginning of B term with the iMAPS conference poster presentation this application became a bottleneck for our process since our surveys could not be conducted at the time and if this was not approved we would need to change our project. On top of this, our professor told us moving into the winter months the board would not be meeting as often making an approval much harder to get approved in a timely manner. Because of this, the application was very important to us and we needed it approved if A term was to be successful. Thankfully we submitted the application on September 26th with two weeks left of A term and we were accepted on October 4th and allowed to continue our project. In the Appendix is the IRB online application that we submitted for approval.

3.3 Goal Maps

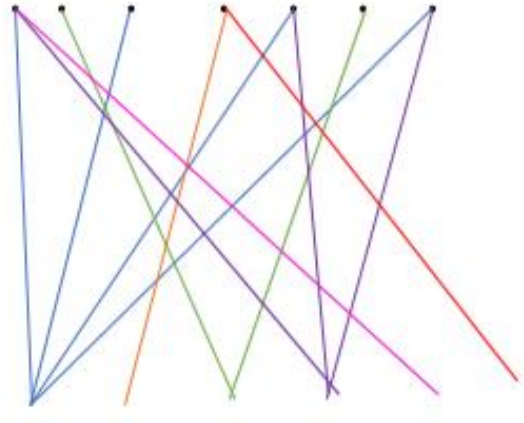
In order to form a questionnaire, goals need to be established. Setting goals of the study allows for efficient questions to be formulated in a timely manner. Since we were in a bit of a time crunch getting a survey completed, our IQP professor told us to identify the goals we wanted to achieve during this project and create a goal map that would help us better articulate the questions that will help us achieve our goals we set out to achieve at the beginning of this process. For the academia side we had our goals focused at the existing resources and needs of the school whether WPI or QCC. Another goal that we would achieve through the act of conducting this survey was informing the general public of this upcoming tech wave and how they can get involved. Below are the Goal Maps we created during A term to help us focus our project.

Industry

Goals

1. Knowledge of the existing needs of the government, industry, and faculty (especially in WPU/QCC/LEAP)
2. Knowledge of the existing resources in schools and companies that are available for use (especially in LEAP)
3. Solutions to closing the gap between academic and the workforce
4. What LEAP can do to help close the gap in academia and industry
- 4.1 Ideas of how to help the industry adapt to the upcoming tech wave (integrated photonics)
5. How to inform the general public of the new tech wave (high schools, the masses, media, outreach, etc)

Questions

- 
- If interested in LEAP, how are you expecting to benefit from LEAP? [1][4][4.1]
- What are you looking for from applicants coming from a 2-year or a 4-year college in the LEAP program? [3]
- In your opinion, what technology and/or knowledge is lacking in the existing curriculum to help ready them for the workforce in the photonics industry, including silicon photonics? [1][3]
- Given that the Gateway Park is going to be open to LEAP program backers, which of the following would you have an interest in attending or helping run? [2][2]
- If applicable, where do you see shortcomings in potential hires? What should academia focus on to help avoid these? [1][4]
- Do you think it is important that we try to start exposure to the field during high school years? [3]
- What challenges are you experiencing related to this field that you hope LEAP and its resources can provide a solution to? [1][4]

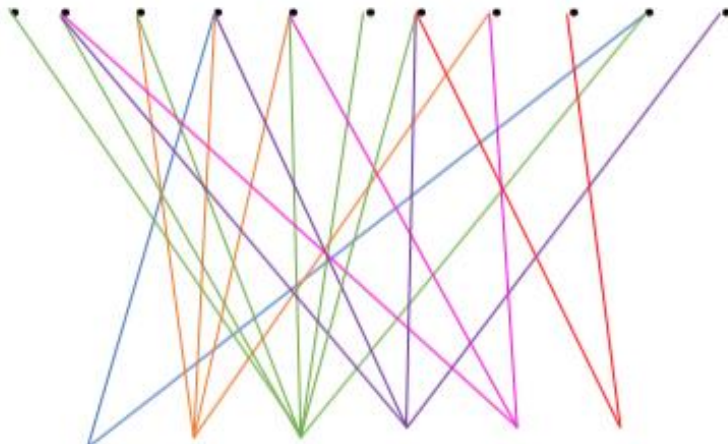
Academia

Goals

1. Knowledge of the existing needs of the government, industry, and faculty (especially in WPI/QCC LEAP)
2. Knowledge of the existing resources in schools and companies that are available for use (especially in LEAP)
3. Solutions to closing the gap between academic and the workforce
4. What LEAP can do to help close the gap in academia and industry
- 4.1 Ideas of how to help the industry adapt to the upcoming tech wave (integrated photonics)
5. How to inform the general public of the new tech wave (high schools, the masses, media, outreach, et

Questions

- Have you studied taught any topics that are relevant to Integrated Photonics? [3]
- Which of the following would you benefit from prefer to learn more about integrated photonics and the new tech wave that will be associated with it? [3][4.1][4]
- Before the presentation, did you know your school has a developed infrastructure for Integrated Photonics? [2][3]
- After the presentation, are you interested in this program offered at your school? If Yes, what interests you the most? [1][2][4]
- Are you interested in working in manufacturing and fabrication of Integrated Photonics? Which area do you think you need more training in? [2][3][4.1]
- Do you have an interest in the following related to photonics? [3]
- After the presentation and learning that LEAP is a facility open to QCC students, in which way should this facility be incorporated into the QCC student life? [3][4][5]
- Assuming you are from QCC or WPI, what interests you the most about working in conjunction with the other school in this field? [2][4.1][5]
- Do you have prior industry experience in photonics? If you choose "Yes", please explain your experience. [4.1]
- Is there a particular technology/facility/equipment/knowledge related with photonics and semiconductor industry that you are eager to get trained on or to be taught? [1][3]
- Are you considering developing your career in industry sectors related with photonics? If so, what sector? [4]



3.4 Questionnaire

The questionnaire was developed based on the goals established in section 1.3.2: Goals of the IQP. A questionnaire was made for both industry and academia to understand the needs, gaps, and existing resources of both. While the Industry questionnaire was not utilized during this work, the Academia one is reflective of the final version we used on the majority of our sample set. Both questionnaires we split up into a first part consisting of multiple choice or yes and no questions for ease of use, and a final section marked optional that was there to gain better insight from the students who are interested in the LEAP facility.

Industry

- 1.) Are you a Government Official or a Company Representative?(*Circle one*)
What is your Job Title? _____

- 2.) What category best describes your organization? (*Circle what applies*)
 - a) Part of infrastructure development
 - b) Involved in new technology and advances in the field
 - c) Potential customer or beneficiary of LEAP or other associated Integrated Photonics movements
 - i) If not LEAP what movement are you backing or a part of:

 - d) Other: _____

- 3.) If interested in LEAP, how are you expecting to benefit from LEAP? (*Circle all that apply*)
 - a) Education (retraining, curriculum development targeted at a specific industry sector, workshop, training on cutting-edge equipment)
 - b) Infrastructure (equipment, cleanroom, lab space, user facilities)
 - c) Technology (new fabrication methods, packing, testing)
 - d) Workforce development (sponsored student project; internships; career fair)
 - e) Other: _____

- 4.) What are you looking for from applicants coming from a 2-year or a 4-year college in the LEAP program? (*Circle all that apply*)
 - a) Lab experience (Understanding of equipment used in processing)
 - b) Research Background (Know what is functional and in circulation but also up to date on cutting edge)
 - c) Working Knowledge of the Infrastructure necessary
 - d) Other: _____

- 5.) Do you think it is important that we try to start exposure to the field during high school years? (*Yes / No*) If you answered yes, would you be interested in holding seminars, classes, or workshops to high school students to help develop a basis before college enrollment?(*Yes / No*)
- 6.) Given that the Gateway Park is going to be open to LEAP program backers, which of the following would you have an interest in attending or helping run? (*Check all that apply*)
- a) Company and Industry lead workshops
 - b) Individual guidance to students for research projects (IQP and MQPs)
 - c) Teaching courses of varying topics at WPI or QCC
- For those that you chose, underline the one you think would make the biggest impact.

(Optional Questionnaire)

- 7.) In your opinion, what technology and/or knowledge is lacking in the existing curriculum to help ready students for the workforce in the photonics industry, including silicon photonics?
- 8.) If applicable, where do you see shortcomings in potential hires? What should academia focus on to help avoid these?
- 9.) What challenges are you experiencing related to this field that you hope LEAP and its resources can provide a solution to?

Academia

- 1.) Which Institute are you from: _____
- 2.) Are you a Professor or a Student? (*Circle one*)
Please state your major/department: _____
- 3.) If you are a student, What best describes your circumstances:
- a.) 4 year college student
 - b.) 2 year student with plans to transfer
- State institute you plan on attending after QCC:*
- _____
- c.) Specialized Student getting their certificate
- State your field of expertise you are striving for:*
- _____

- 4.) Before the presentation, did you know your school has a developed infrastructure for Integrated Photonics? (*Yes / No*)
 If Yes are you involved? (*Yes / No*)
 If Yes how are you involved?
 a) Student Research Projects
 b) Courses
 c) Other_____
- 5.) After the presentation, are you interested in this program offered at your school?(*Yes /No*)
 If Yes, What interests you the most
 a.) Student Projects with WPI students to help Industry leading companies
 b.) Learning how to operate these state-of-the-art fabrication equipment
 c.) Learning more about the Industry as a whole.
- 6.) Have you studied/taught any topics that are relevant to Integrated Photonics?
 (*Circle all that apply*)
 a) Fibre Optics (Or other mediums of Infrastructure)
 b) Light sensors (emphasis on Technology and application)
 c) Manufacturing requirements (use of equipment)
 d) No topics taught/learned
 e) Other:_____
- 7.) Which of the following would you benefit from / prefer to learn more about Integrated Photonics and the new tech wave that will be associated with it? (*Circle all that apply*)
 a.) On campus workshops
 b.) Topic geared courses (either taught by professors or industry heads)
 c.) Seminars presented by industry
 d.) Other:_____
- 8.) Are you interested in working in Manufacturing and Fabrication of Integrated Photonics?
 (*Yes / No*)
 If you answered Yes, which area do you think you need more training in? (*Circle all that apply*)
 a) Infrastructure Development
 b) New Technologies
 c) Equipment Usage
 d) Knowledge of topics related to integrated photonics
- 9.) Do you have an interest in the following related to photonics? (*Circle all that apply*)
 a.) Involvement in research projects

- b.) Developing new equipment and infrastructure
 - c.) New targeted curriculum/courses
 - d.) Local high school visits/seminars
 - e.) Other: _____
- 10.) After the presentation and learning that LEAP is a facility open to QCC students, in which way should this facility be incorporated into the QCC student life?
(Circle all that apply)
- a.) Courses geared in Photonics allowing for a smoother transition into the facility
 - b.) Open Workshops at Gateway park for students to attend
 - c.) Other: _____
- 11.) Assuming you are from QCC or WPI, what interests you the most about working in conjunction with the other school in this field (Circle all that apply)
- a) LEAP driven seminars
 - b) IQP and MQP projects driven by both schools
 - c) Utilization of both school's expertise and resources
 - d) Other: _____
-

(Optional Questionnaire)

- 12.) Do you have prior industry experience in photonics?
- a.) Yes
 - b.) No
- If you choose "Yes", please explain your experience.
- 13.) Is there a particular technology/facility/equipment/knowledge related with photonics and semiconductor industry that you are eager to get trained on or to be taught?
- 14.) Are you considering to develop your career in industry sectors related with photonics? If so, what sector.

Chapter 4: Results

Table 1: Professors, Course Name, Course Number, Course Meeting Time, Total Students.

Instructors	Course Name	Course Number	Course meeting time	Total students
Dadbeh Bigonahy	Physics I (General)	Physics 101-50	Wednesday 5:00-7:30pm	7
	Physics I (Calculus based)	Physics 105-50	Monday 5:00-7:30pm	7
	Physics III (Calculus based)	Physics 205-50	Friday 5:00-9:50pm	11
	Eng. Computation and Modeling	ERG 280-01	Tuesday/Thursday 2:00-3:15pm	16
Jacob Longacre	Intro to Photonics	ELT 120-50	Wednesday 5:00pm-10:00pm	6
	Digital Electronics	ELT 121-01	Friday 9:00am-2:00pm	6
Total				56

The Study conducted at QCC composed of 6 classes as shown in the table below ranging from a General Physics class to Electrical Engineering specialized classes. The survey was conducted with the help from Professors Dadbeh Bigonahy of QCC who specializes in preparing students for their BS, MS and PhD. in Engineering and Health Services. His courses are focused in preparing QCC students after 2 years for transfer to schools such as WPI with a course study in Engineering with an Associates in Science. This group of students are primarily interested in transferring to a four-year college like WPI which will be a major recurring theme throughout the results analysis on this side of the study.

The other half of the courses are focused in the Electrical Engineering major with a focus in Photonics. Professor Jacob Longacre's mission at QCC is developing a photonics program that provides students with a solid understanding of the technology and how it is being employed locally as well as a strong base for continued education. Jacob Longacre is the primary figurehead for LEAP at QCC and it is his classes that will provide us with a sample of the QCC students that are the most prone to utilizing the resources that LEAP has to offer them.

4.1 Data Disparities

Between the two groups of QCC students surveyed we gathered enough evidence to give us a better picture of the type of QCC student LEAP will attract. The majority of students attending QCC we surveyed had an emphasis in Engineering with plans to complete an Associate in Sciences for a transfer to a four-year college. The other students, under the guidance of Jacob Longacre, were more in LEAP and its initiative at Gateway Park and as such his “Intro to Photonics” class although the smallest, showed the most interest in LEAP. The bi the two groups differ in. Engineering Trai college for opportunities in how they adv:

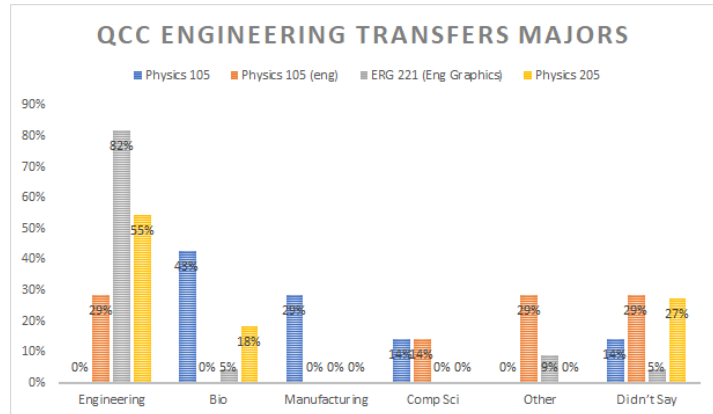


Figure 14. Majors breakdown for Professor Dadbeh’s Classes.

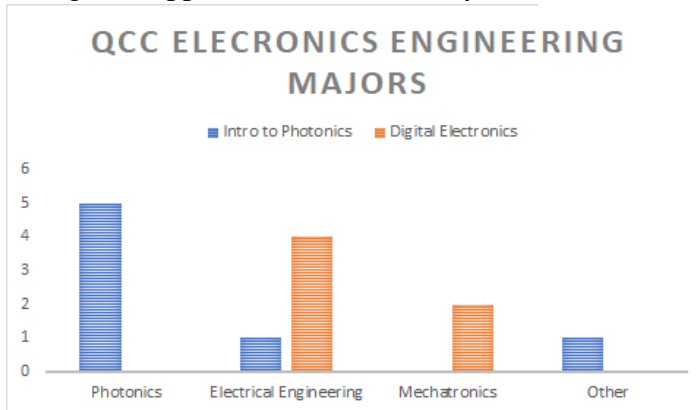


Figure 15. Majors breakdown for Professor Longacre’s Classes.

LEAP can often still scare the general population. The students from Professor Longacre have the luxury of him as their professor as he is able to expand on the ideas presented in the slideshow presented to the engineering transfers showing the students why an opportunity like this can help for a variety of career paths. Below we will show in detail how these two groups of students from QCC responded to the idea of a Facility like LEAP being available to them.

4.2 Knowledge of LEAP

Despite the school having half of the LEAP initiative under their name, and incorporating Photonics into its curriculum for Electronics Engineers, the majority of the student body surveyed still were unaware of programs like LEAP and what they can offer. Out of the 56 students that were surveyed across both Engineering Transfer students and Electronic Engineering students in more specialized classes from Professor Longacre, only 10 students were

aware of LEAP, with half of them being from Professor Longacre’s Intro to Photonics. When comparing all of the courses, Introduction to Photonics was a major outlier in this study, which can be seen in the pie chart in **Figure 16**.

Across the board, 80-100% of students were unaware of LEAP, except of course the class taught by Professor Longacre aptly

named “Intro to Photonics”. While LEAP is a new facility, if it were not for our intervention into these classes, the students most likely would not know about the exciting opportunities LEAP offers to QCC students, especially the Engineering Transfers where 44% had plans of transferring to WPI from QCC. While Photonics is not the end all be all for Engineering students, the QCC students on the Engineering transfer track are very interested in the prospect of working with WPI.

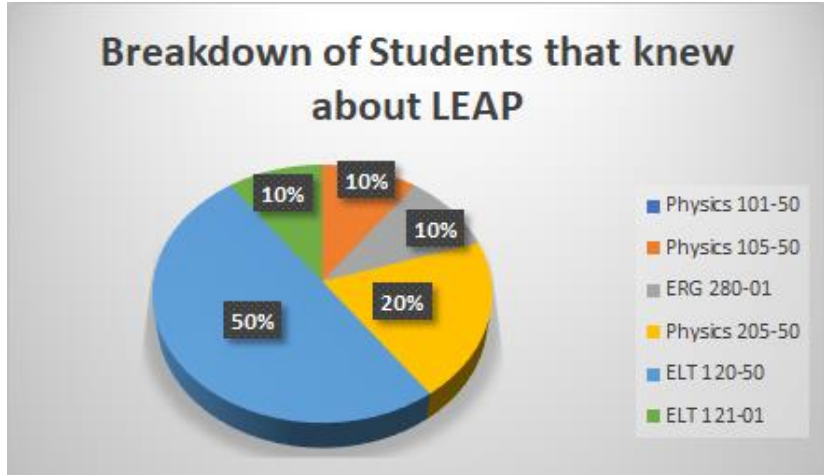


Figure 16. Breakdown of Students that knew about LEAP.

4.3 QCC Survey sample deviations

The Engineering program at QCC allows students to simultaneously receive an Associate in Science alongside preparing them to transfer into a four-year college. This group, although a larger portion of our sample set, is not the majority of students that go to QCC. The most common group at graduation are those who are there to receive their certificates in specializations. Unfortunately, due to the nature of certificates, the classes are much smaller as the certificates offered are plentiful, but they aren't well attended classes. This is true for the Electronics Engineering side of our sample set. Both classes taught by Professor Longacre fall under this theme since the *Electronics Engineering Technology - Photonics Option* can be a 2 year associate for a job right out of QCC or it could be used as a tool to move their education further at a 4 year school, preferably WPI with Jacob Longacre as their professor and the course requirements so reliant on where LEAP wants to go. Regardless it's these 2 classes that we need

to separate from the herd since these classes are filled with students eager to work with LEAP even before we surveyed them.

Keeping the Electronics Engineering Students will help us consider the two different groups of QCC students that were introduced to us during our conversation with Jacob Longacre apart. When sitting down with Professor Longacre before surveying the students he told us that QCC on the Engineering or maybe even the STEM side has two major groups that are actively present. One side convinced that their ceiling in academia specialization and want to get straight to higher volume is the through traffic that is present from students who are fulfilling requirements for their four-year BS degree in the Engineering field. These students, as the data starts to reveal to us, are more concerned with where their career will take them in their four-year college rather than where QCC can take them. This will present an interesting correlation in the data later.

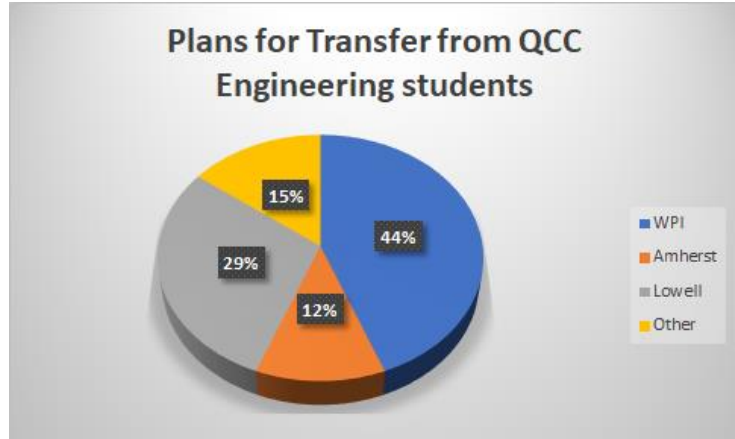


Figure 17. Plans for Transfer QCC Engineering Students.

4.3.1 Specialization at QCC

When reading what the Electronics Engineering students had to say in their surveys, the question that had the best reception was if they were interested in working in Manufacturing and Fabrication of Integrated Photonics with 92% saying they were interested. Of the two classes, the entirety of Introduction to Photonics was interested and 83% of Digital Electronics was interested. The Question was split into a second part which gives us insight into what the students still needed training in. The three areas of training we believed were the most important for students to have and that were most likely not taught to the vast majority were, Infrastructure Development since Photonics will require complex systems for fast data transfer or use for sensors in Chemical and Biological Systems or other state of the art fabrication and manufacturing equipment that we want students to be trained on, Equipment Usage since a familiarity to the equipment can help the student better adapt to the facility and expand their skills and horizons past where they thought they could at QCC, and finally, Knowledge of topics related to Integrated Photonics. The last one, Knowledge of Topics related to Integrated Photonics was a huge draw to transfer students in a program where their education is considered generalized for multiple different pathways within the umbrella of Engineering. The Graph above shows what percentage of students were interested in working in Manufacturing and Fabrication. From this data set we see Digital Electronics students were all interested in New

Technologies while the Intro to Photonics was much more diverse with New Technologies and Knowledge of Topics split for first while Equipment Usage and Infrastructure are taking up one third of the class. Since both classes had New Technologies as a top priority, we can assume that the state-of-the-art fabrication equipment will be a huge draw for QCC students already interested in the Photonics field.

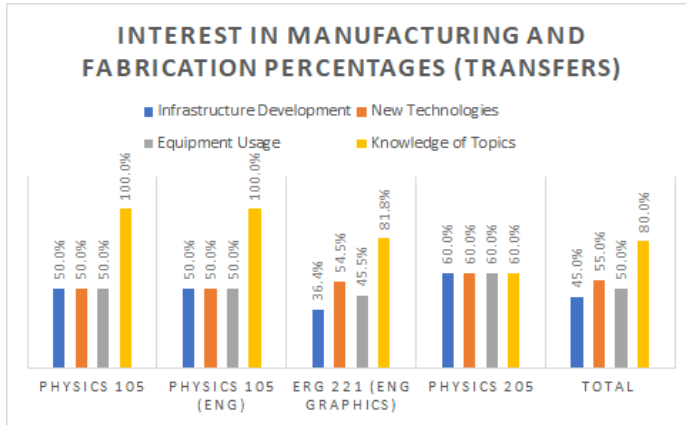


Figure 18. Interest in Manufacturing and Fabrication.

The engineering transfer students regarding this question are much less interesting. The only class that showed diversity in their answers was Engineering Graphics, although we see across the board, Knowledge of Topics was the biggest draw. Because of the nature of the data set, the only real determining set was Engineering Graphics since the rest of the classes have a constant number of answers in each set, even the Physics 205 class was 2 votes in each category meaning any distribution of is not from the three

physics classes. The majority of those interested in the 3 physics classes chose all or most of the options but because of the size of the classes, only the Engineering Modeling class gave us a better distribution and as such affected the total distribution much more than the other classes.

4.3.2 What do both groups share

While the largest divide between the two classes is in how eager they are to be working in Manufacturing and Fabrication, there are some similarities in their answers that can most likely speak to the average QCC student. Towards the end of our survey we ask them what interests them the most about working with WPI at LEAP. The three options were, LEAP driven seminars, IQP and MQP projects driven by both schools, and Utilization of both school's expertise and resources.

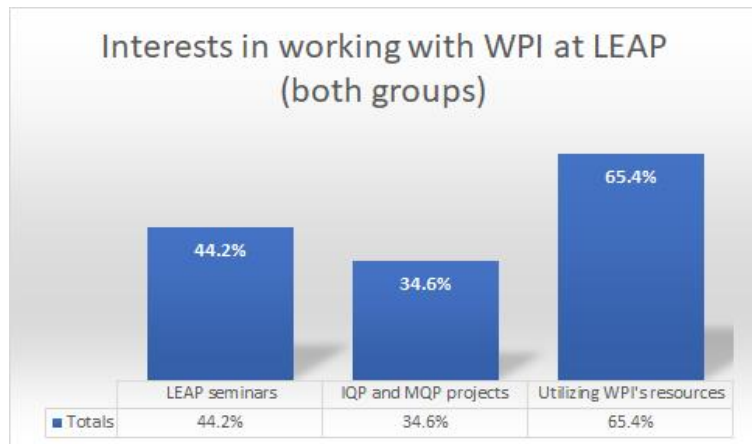


Figure 19. Interests in working with WPI at LEAP (Both groups).

From the survey sample set we see that although the more popular option changes based off of

the class and even by what year they are in, the most popular option across all QCC students is Utilizing the resources of WPI at LEAP with a 65.4% interest among all people interested. This is interesting since the divide is even more self-evident when we look at the Electronics Engineering students from Professor Longacre's classes. It's the Electronics Engineers that are the most eager to work with WPI and their resources despite them being the ones who are the closest to the Fabrication Lab and the state-of-the-art equipment that QCC has recently opened up at the Quest center. This may be due to these students being the most eager to work in Manufacturing and Fabrication and wanting to delve into this field more.

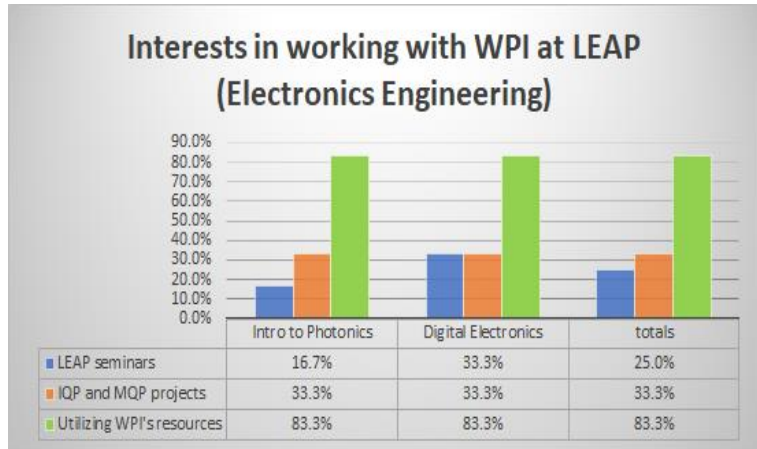


Figure 20. Interests in working with WPI at LEAP (Electronics Engineering).

General Engineering is where the data is scattered. Following from left to right we see the progression of students through their two years before transferring. In the beginning we see students much more interested in seminars where they can learn more about the topic and decide for themselves. In these classes there is no interest at all in working on projects. As the semester progresses, the students become much more inclined to utilize WPI's resources and delve deeper into topics such as Photonics.

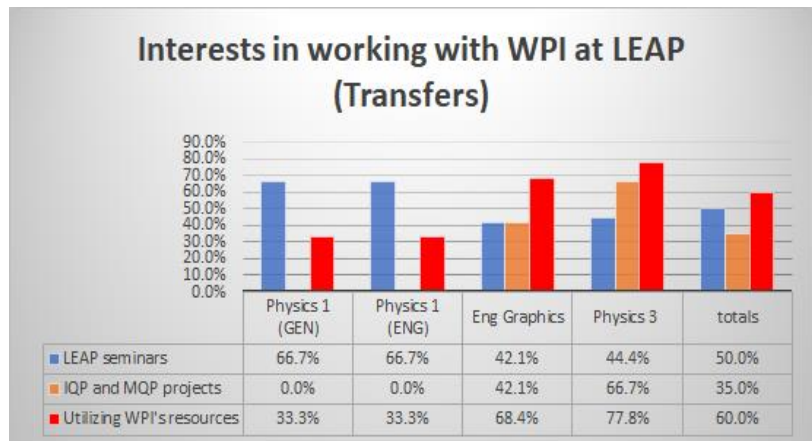


Figure 21. Interests in working with WPI at LEAP (Transfer students).

4.2 Discussion

The discussion based on the information presented from the study should be on how QCC students can fit into the mold that LEAP offers students that are looking into the Photonics field. While our project had set out to identify the needs, resources, and any gaps present between academia and the industry, the project due to time constraints found us focusing on QCC student populations and the reception a facility like LEAP can garner from those students. From the results section we were easily able to identify the characteristics of the two distinct types of students that come through QCC. The most interesting question that presents itself from this divide is which group do we focus on and do we try to reach out to the other group? For the first half of the question the students in Electrical Engineering classes from Professor Longacre are our target audience if we are concerning ourselves with students who are the most interested. Because of the role Jacob Longacre plays in the QCC/WPI partnership, his students in classes that have to do with Photonics will of course be told about the LEAP facility and how their education on the current class subject can be expanded through what LEAP can offer. The Engineering Transfers on the other hand did not show a level of interest to the point where we would look to this group to actively grab them for projects at LEAP. Instead we should look to this group for interest in WPI as the school has in the past. The most popular option for transfer among these students was WPI with Amherst and Lowell being the other front runners. More so than WPI we have students who are undecided or did not write a school as the dominant group. This could lead us to believe that some of the students are more concerned with finishing in two years but the classes that we surveyed were instead all students with a preference for transferring to continue their education. This means we can utilize LEAP seminars to get students in the door since they want to continue at WPI. Utilizing LEAP with WPI 's resources as a huge selling point to the seminars gives the students at QCC the motivation to show up to see if they can spin an opportunity like this to get a foot in the door at WPI. By utilizing the urge of many Engineering Transfer students to want to be at WPI, we can give the students the time necessary for them to fully envelope themselves into the idea of Integrated Photonics and how the facility

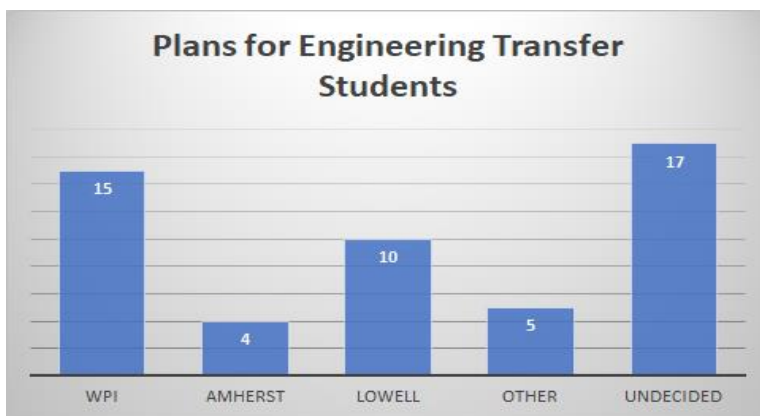


Figure 22. Plans for Engineering Transfer Students.

can help build a career for them that does not have to be limited to Electronics Engineering. Judging by the reception of earlier courses wondering how Quantum Physics and Computing differs from Integrated Photonics shows us how easily this field can confuse perspective students. Although the presentation at the beginning of surveys held in the transfer-oriented classes, questions were few

and far between and were left on the optional sections of our survey.

While Engineering Transfers are easier to get with the WPI name, Jacob Longacre's students are much easier to get in the door through the opportunities that it presents them. In the results section we found that the biggest divide between these groups was the transfers were more concerned with the Knowledge of Topics related to Photonics while the Electronics Engineering students were more interested in learning how to operate the state-of-the-art equipment. Considering that LEAP wants the students to be trained on this equipment, broadcasting to the students how they can learn on this equipment then we can get these eager students into the door. Moving forward the two main forms of outreach to QCC should be LEAP driven seminars at WPI informing the students on the various applications of Integrated Photonics in the industry and showing students how to operate the state-of-the-art manufacturing equipment at the LEAP facility.

Chapter 5: Conclusion

The purpose of this study was to gather information from industry and academia on the knowledge of the needs, current status, and gaps that can be present between the expectations of the industry and resources in two-year and four-year colleges. The study began with literature review to understand the needs of the workforce development for silicon to get ourselves familiar with existing and potential methods used in integrated photonics industries. Following the literature review we were able to establish a list of goals which aided in the development of the questionnaires for both industry and academia. However, due to time constraints, information and data was not gathered from the industry side. Only students from QCC were surveyed and analyzed. Surveying of the industry will take place in the following term by students continuing the study. The biggest outcome from the analyzation of the QCC students was there needs to be greater outreach to QCC students as not many students even knew about the LEAP facility available to them. Ways to convey the facility to the students could include LEAP driven seminars at WPI informing the students on the various applications of Integrated Photonics in the industry and teaching the students how to use state-of-the-art manufacturing equipment through workshops. This study will be continued to focus more in the industry side to identify any gaps between academia and industry.

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Appendix

Appendix A: Poster Presented by the team at the iMAPS Conference at Boxboro Regency on 10/22/2019.



Study of Workforce Development at WPI/QCC Lab for Education and Application Prototypes (LEAP) in Central MA


– Its Role on Silicon Photonics and Electronics Industries in New England

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Motivation




- Lab for Education and Application Prototypes (LEAP) facility is opening at WPI's Gateway Park under the AIM Photonics initiative
- LEAP's initiative revolves around the development of the Photonics Workforce. Whether developing state-of-the-art fabrication methods or creating high-end manufacturing jobs the focus of LEAP is becoming a leader in developing the Photonics Workforce in Central MA
- Our work aims to focus LEAP's initiatives to the areas in academia and industry that need the attention.

Research Methods

- Designed questionnaires for academia, industry, and government to identify needs and resources of each
- Questionnaires can be conducted in a classroom, over email, or during a conference.
- Interviews, especially from those in the industry, will help us close the gap between our students and professors interviewed at QCC and WPI and the expectations and needs of the industry leaders
- We expect that with this knowledge, LEAP will have a good basis of where they want


LEAP's Roadmap



- 1) Establish the needs and resources at our disposal
- 2) Find Gaps in knowledge and experience
- 3) Develop solutions that bring Industry and Academia together
- 4) Establish fabrication methods and jobs in the field

Goal: Enhance the Workforce

Goals

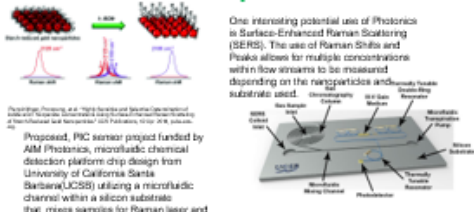


Most Important

1. Define the general goals of the area (e.g., need high schools, fill research, etc.)
2. Help the industry adjust to the upcoming tech wave (e.g., silicon photonics)
3. Develop solutions for LEAP to help solve and close these gaps in academia and industry
4. Identify (pre-existing or potential) gaps between academia and the workforce
5. Knowledge of the existing resources in academia and companies that are available for use (especially in LEAP)
6. Gather knowledge of the existing needs of the government, industry, and faculty (especially in WPI/QCC LEAP)

The main goal of the study is to enhance the workforce development through identifying the needs, finding resources, and gaps in Central MA between academia, industry, and government.

AIM Photonics affect in Photonics Development



One interesting potential use of Photonics is Surface-Enhanced Raman Scattering (SERS). The use of Raman Shifts and Peaks allows for multiple concentrations with flow streams to be measured depending on the nanoparticles and the substrate used.

Proposed, PIC sensor project funded by AIM Photonics, microfluidic chemical detection platform chip design from University of California Santa Barbara (UCSB) utilizing a microfluidic channel within a silicon substrate that mixes samples for Raman laser and spectrometer data recording on a silicon platform.

Expected Impact

- A well-developed set of goals to prepare for the new tech wave that LEAP can utilize
- Open communication channels of this developing workforce.
- Lead industry executives and their needs and resources into the doors of LEAP

Expected Outcomes

- Provide understanding of the roles of LEAP in Central MA.
- Provide suggestions on the roadmap of silicon photonics.
- Help LEAP to establish a workforce development hub in Central MA.
- Provide the most needed educational resources for the photonics industry, and eventually benefit the whole society.

Closing the Knowledge Gap

Academia	Industry/Government
Have you read/taught any topics that are relevant to integrated photonics?	If applicable, where do you see photonics in general being used? Should academia focus on this next year?
To your knowledge, does your school participate in research that is closely correlated with integrated photonics and manufacturing technology?	In your opinion, what technology and/or knowledge is lacking in the existing curriculum to help ready new for the workforce in the photonics industry, including silicon photonics?
Are you considering developing your career in industry sectors related with photonics? If so, what sector?	What are you looking for from applicants coming from a 2-year or a 4-year college in LEAP program?
To your knowledge, does your school have a developed infrastructure for integrated photonics?	Given that the Gateway Park is going to be open in LEAP program leaders, which of the following would you have an interest in standing or helping out?

Appendix B. Full IRB Application submitted by the team on 9/26/2019 to WPI IRB Committee.



Updated By: Donald Coley 26-Sep-2019
10:02:40 PM

GENERAL INFORMATION

APPLICATION TYPE

Record#: IRB-20-0062

- * What type of application are you submitting?
Exemption Application for student project involving minimal or no risk

- * There are 3 application types available

Use this application for student projects involving interviews, surveys, focus groups, observation of public behavior or benign behavioral interventions, where there is minimal risk to research subjects. "Minimal risk" means that the risks to research subjects are no greater than those ordinarily encountered in daily life. Benign behavioral interventions include testing on-line games, websites and other behavioral studies that are brief, harmless, and could not be embarrassing or offensive. (This exemption is not appropriate for studies that involve survey/interviews of children. Please select the standard application.)

- * Is this a student project?

Yes No

- * Student project type:
Undergraduate project (MQP, IQP, Suff., other)

- * (Specify):
Interview and Survey

- * Title of Study
Integrated Photonics Workplace
IQP

- * Locations of Research: *(If at WPI, please indicate where on campus. If off campus, please give details of locations.)*

WPI and QCC primarily with some government and industries in the Central Massachusetts area. The campus research will be primarily on students in the up and coming field and the faculty who are interested in this field.

Anticipated Dates of Research:

* Start Date:

Date:

22-Aug-2019

Feb-2019

* Completion

06

* **Which of the following categories best describes your study?**

Social Sciences, management and other non-biomedical disciplines

* **Purpose of Study:**

(Please provide a concise statement of the background, nature and reasons for the proposed study. Insert below using non-technical language that can be understood by non-scientist members of the IRB.)

The purpose behind our study is to identify the needs, resources and any gaps between the current academia and industry behind this new manufacturing wave of Integrated Photonics. The data collected will help our LEAP (Lab for Education and Application Prototypes) opening in Gateway Park better prepare students to meet industry demands.

* Has an IRB ever suspended or terminated a study of any investigator that will be listed on this protocol?

Yes No

Please indicate if your study involves:

* Investigational drugs or investigational medical devices

Yes No

* Hazardous Materials

Yes No

* Special diets

Yes No

* Collaborating Institutions: *(Please list all collaborating Institutions.)*

QCC

FUNDING INFORMATION

FUNDING INFORMATION

How will the study be funded?

- Grant/Contract/Subaward (Federal)
- Grant/Contract/Subaward (Non-Federal)
- Departmental funds
- Faculty start-up or incentive funds
- Investigator out-of-pocket
- No funding anticipated

STUDY PERSONNEL

All study personnel having direct contact with subjects **must** take and pass a training course on human subjects research. There are links to web-based training courses that can be accessed under the Training link on the IRB website <https://www.wpi.edu/research/support/compliance/institutional-review-board>.

Name

Coley, Donald

Involvement Start Date

14-Sep-2019

End Date

Role

Student Investigator

Please upload a copy of your relevant HS training certificate(s):

Name

Defrancesco, Ashley

Involvement Start Date

14-Sep-2019

End Date

13-Dec-2019

Role

Student Investigator

Please upload a copy of your relevant HS training certificate(s):

Name

Liu, Yuxiang

Involvement Start Date

14-Sep-2019

End Date

06-Feb-2020

Role

Principal Investigator

Please upload a copy of your relevant HS training certificate(s):

STUDY INFORMATION

* Expected Research Subjects:

(e.g. museum visitors under the age of 12)

The research subjects of our study will be WPI and QCC students and faculty within the Integrated Photonics academic ecosystem alongside government officials and people within the industry . Officials in government and the industry tied to this movement in AIM Photonics lead by LEAP will be gathered from various conventions and get together such as during iMAPSNE (International Microelectronics Assembly and Packaging Society) and a special unveiling of the LEAP chapter at Gateway Park where government officials involved in the funding and overseeing of this chapter will be there to meet with students and faculty at the school.

* Project Mission Statement and Objectives:

To identify the needs of Integrated Photonics and help our students create and grow the manufacturing wave that the field will require.

* Brief Methods Listing:

(e.g. "Survey of public to ascertain knowledge and opinions about climate change" or "Interview of professionals working on climate change regarding effective city climate change program")

Surveying students and faculty to see where academics in this area are in relation to standards set by LEAP. Survey government and industry officials associated with funding and maintenance of LEAP program to see where their focus for this chapter should be. Surveys will be done through Questionnaires either by hand distributed in classrooms or online through hyperlinks sent via email. Interviews will be carried out at the conferences and government events we will attend throughout the duration of our project

* Does the proposed research involve vulnerable research subjects?

(e.g. children, prisoners, students, persons with mental or physical disabilities)

Yes No

* Does the research involve human subjects in ways other than as participants in interviews, focus groups, or surveys?

(e.g. observation of public behavior, use of archived data or experimental procedures)

Yes No

* Will the researchers collect information that can be used to identify the subjects?

Yes No

* Could the disclosure of a human subject's identity and responses place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability or reputation?


Yes No


* Will the researchers disclose the identity or the individual responses of any human subjects?

(e.g. by quoting an individual, whether or not identified by name or title)

Yes No

Appendix 1

Attach the statement of research methods or draft methodology chapter: 

Attach a draft of surveys and/or a list of questions to be used for interviews or focus groups: 

If sample questions are included in Appendix 1, Methodology chapter, indicate the page numbers here:

ADDITIONAL DOCUMENTS

If you have any additional documents you would like to include with your application, you can upload them here.

INVESTIGATOR'S ASSURANCE

All participants in this research project are agreeing to abide by the following instructions:

- You agree to inform subjects orally or in writing that:
 - Participation in the research is voluntary .
 - Participants may end their participation at any time.
 - Participants need not answer every questions in an interview or suvey .

- If your research is **anonymous**, you also inform subjects that you are not collecting names or any identifying information from them.

- If your research is **confidential**, you inform subjects that no identifying information will be disclosed with individual responses.

- If your research is **NOT** completely anonymous and confidential, you must obtain each subject's permission to publicly disclose his or her identity and/or responses. All requests for anonymity and confidentiality must be honored. The subject must be offered the opportunity to pre-approve the publication of any quoted material.

- I certify that I have added all Study Personnel, including students, to the study personnel page