Optics and Photonics as a strong and resilient field for a successful career development

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Abstract—When compared to other enabling technology fields such as Electronic Engineering or Computer Science, Optics and Photonics stands out to be by far the oldest field of research, and yet the one still standing today at the forefront of research, consumer electronics, transformation industry, communication, health, biotech and many more. From solving the mysteries of our universe to the development of the latest smart phones and the fastest internet lines, the field of Optics and Photonics has proven over and over to be at the cornerstone for everything we take for granted today. This field has been associated with many successive market booms, and sometimes also bubbles, but the underlying technology build by its exceptional engineers never gets wasted or lost, providing valuable key building blocks to fuel the "next big thing"

The International Year of Light (IYL) initiated by UNESCO back in 2015 had the remarkable effect of shedding light on the importance of optics and photonics in all aspects of our daily lives, and the International Day of Light (IDL) celebrated every May 16th is a yearly reminder of the importance of this field not only for those who chose to work in it but also for anyone else on the planet. Outreach activities from various societies invested in this field (SPIE, OPTICA, IEEE, …) have contributed to drawing more kids and especially more girls to optics and photonics as an effective career choice. We will review how optics and photonics can be a great choice to build up a strong, resilient, and exciting career.

First, we will attempt to define what a "career path" may mean to a young engineer or graduate student. There are several different kinds of career paths one might choose to take on, such as:

- Multiple unrelated jobs: Your career could be made up of multiple jobs that are unrelated to one another. For example, you could work as a car mechanic, then as a chef in a restaurant and then as a receptionist in a veterinary clinic, and perhaps eventually as an engineer at Google. Because each job is vastly different from the next, there is no way to predict what your next position will be. As they have very little in common, you may not see significant pay increases from one to the next or significant increases in responsibility.

- Advancing within the same level by changing industry/academia: This path involves advancing in the same occupation, whether you work for the same organization or at different successive companies. For example, you can be an engineer working on various projects at Apple in software, at Amazon in EE, at Microsoft in UX, at Facebook in ME and at Google in Optical Engineering. This can be fulfilling for many people who are not seeking increased responsibility or increased monetary rewards, but rather are eager to learn new things and get richer this way.

- Advancing in the same industry or academia by increasing levels: For example, after your Master in EE, you may start as a junior engineer, then senior, then principal, then director, then General Manager and eventually VP. This can be as fulfilling as changing fields, with the added benefit of advancing responsibility and monetary rewards through early stock vesting. But beware of the "rest and vest" syndrome.

Choosing Optics and Photonics as a strong career backbone is a great option and has been shown to be very resilient towards market crashes as we will review in the next sections.

Many might remember the great dot-com burst of the early 2000s, but few remember that there were actually two distinct bubbles within a few months, the second one dubbed as the "optical telecom bubble", leading to overnight market losses of over $50B for optical companies like JDSU (now split into two distinct companies Lumentum and Viavi) [1],[2]. This was the largest loss in the history of the NASDAQ at that time, with large optical companies and start-ups' valuations pushed up synthetically by the need for CWDM (Coarse Wavelength Division Multiplexing) and DWDM technology (Dense Wavelength Division Multiplexing). This technology worked well, with more than 128 wavelengths in a single fiber with over 40Gbps, and provided an amazing bandwidth potential that was not met by the actual consumer and enterprise demand at that time, leading to the crash. Nonetheless, this effort by the optics and photonics engineering community provided the technological platforms for many other markets, such as

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integrated photonics for optical computing, MEMS technologies for display and sensing, and even technologies for today's self-driving cars, IOT, AR/VR/MR, the Metaverse, quantum computing, and AI booms. Figure 1 reviews some of these past booms, which were enabled by optics and photonics.

The 1990s have seen much excitement around optical computing [4], as companies such as Intel touted that clock rates over 500Mhz might not be possible due to parasitic capacitive and inductive effects and that optical computing was the only way forward. Forbes magazine in 1999 even highlighted on its cover page that the "2010 computer will be optical" [3]. Although many of the core technologies have been fully developed, fueling both the next telecom boom and eventually the current Quantum Computing boom, the only optical technology that has been effectively implemented in computer architecture since then was optical interconnections, as backplane to backplane, chip to chip in a multichip module (MCM), or even intra-chip.

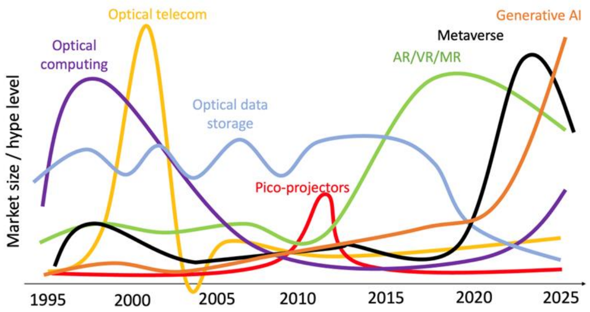

Fig. 1. The successive booms enabled by optics and photonics for the past 3 decades.

Optical data storage had its own multi-bumps boom, starting in the early 80s with the CD ROM boom, then the DVD boom in the 90s, and eventually the Blu-Ray boom in the early 2000, followed by lots of hope for an all-holographic page data storage technology (with companies like GE, In-Phase, …) [5]. The rapid development of flash memory technology put a halt on most next-gen optical data storage efforts, including holographic page data storage. Only optical WORM (Write Once Read Many) efforts continued somehow but at a much lower pace. This led the way to diffractive and holographic optics developments [6], which were then used later on in the AR/VR boom. In the mid-2000s, a micro-bubble appeared, pushed by companies such as MicroVision providing pico-projectors technologies based on LBS MEMS display engines (Laser Beam Scanner). Even major consumer events like CES (Consumer Electronic Show) promised that every smartphone will have a pico-projector integrated by 2010. This did not happen, but LBS MEMS display engine architectures are now widely used in smart glasses displays.

Figures 2, 3 and 4 show how a specific technology developed for a specific market boom has been used successfully for the next one, eventually serving as technological platform to the current AR/VR boom.

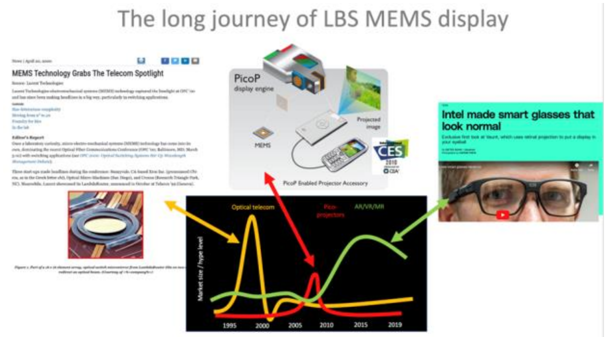

Fig. 2. How LBS MEMS have been developed over 2 successive booms to serve today the AR/VR market.

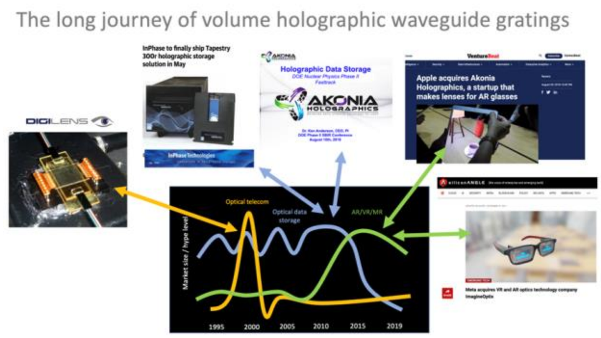

Fig. 3. How volume holographic waveguide combiners have been developed over two successive market booms to serve today the AR/VR boom.

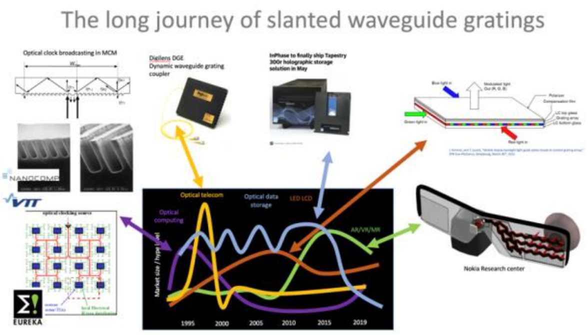

Fig. 4. Surface relief slanted grating waveguide tech developed over 4 successive market booms to serve today's AR/VR boom.

Slanted waveguide gratings are now used widely as the workhorse for smart glasses and AR display combiners (HoloLens, Magic Leap, etc.) [7]. However, this technology has not been developed for display originally, but rather for optical interconnections during the optical computing boom in the early 1990s, and specifically for optical clock broadcasting in an MCM (Multi-Chip Module), as shown in Fig.4, left. Later, during the optical telecom boom, this technology has been applied to DGE (Dynamic Waveguide Equalizers) for DWDM fiber system after EDFA amplification (Erbium Doped Fiber Amplification). Eventually, this waveguide technology has been applied to LCD backlight extraction and finally adapted to AR and smart glasses as 2D pupil expansion combiners, initially by Nokia in the 2000s, and then by Microsoft (HoloLens), Magic Leap, Vuzix, and many more.

The field of optics and photonics has proven over the years to be a great technological platform to provide basic functional building blocks for many market booms, especially in display, imaging, and sensing systems. Market booms may collapse and popular optical companies may shut down, but the technology developed through these booms are never lost, rather they are adapted to serve the next booms. This field has shown exceptional resilience over the past half century and will continue. This is especially true today in the middle of the current AR/VR and Metaverse booms which rely on many technologies that have been developed earlier for fields such as computing or telecom. Thus, for younger students and early career professionals, choosing a career in optics and photonics can be a great choice and a strong warrant for a successful and long career, no matter where markets might be moving towards.

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