Demystifying Ultrafast Laser Systems

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Can you a tune an ultrafast laser from your iPhone? Most likely the answer is NO, but it is only a matter of time before leading laser manufacturers start offering iPhone apps for tuning lasers. Even if no one really needs this, it is a great marketing tool just to get the attention of potential customers. Unlike new laser designs, materials, and components, iPhone apps do not require many years of research and development.

Software controllable ultrafast systems are not new. There is a number of products available starting from robust Ti:sapphire oscillators to more complex amplified and even OPO systems. Development of more sophisticated products is a proven way for manufacturers to increase revenues and stay ahead of competition. It works great for the customers, at least the few who can afford such systems. The problem is that enigma of complexity, often created to justify the high cost of products, limits the range of applications of ultrafast laser systems.

Adoption of new technologies often needs a disruption to demystify complexity of legacy products. Prof. Clayton Christiansen analyzed technological disruptions in his now famous book "The Innovator's Dilemma". One of the main conclusions of this study was that new lower cost technologies are often overlooked by established companies, since their commitment to legacy products defies disruptive innovations. Ironically, Prof. Christiansen was not enthusiastic about prospects for iPhone before it was introduced: a more expensive version of a cell phone did not conform to the idea of a lower cost disruptive product. However, recent success of iPhones and iPads did follow Prof. Christiansen's theory, as these products led to major disruption in the market by merging functionality of phones and laptop computers into one device. Functionality of iPhones and iPads may never match capabilities of a good computer, but they may be good enough for majority of the customers.

Technology transitions take time and the smaller the potential market, the longer it takes. It is hard to justify investments into a new technology if target markets are small. Established vendors view innovation as a necessary part of a *long term* strategy, but they are not in a rush to replace legacy products, as long as they maintain control of the market and continue to make profits. Occasionally, benefits of a new technology or product are so clear, that it gains wide acceptance in just a few years, but even these success stories are often based on years of research, product development and a few earlier failures (like pre-iPad tablets).

In the ultrafast laser industry, wide adoption of Ti:sapphire lasers in late 1980's - early 1990's is one of such success stories. Established vendors such as Coherent and Spectra Physics rapidly adopted this new technology, as advantages of Ti:sapphire lasers over legacy products were so clear. Great performance, lower complexity and cost of ownership were among the most important factors.

Ultrafast fiber lasers, also first developed in late 1980's, have a potential for further reducing cost and complexity of ultrafast laser systems. However, this technology remains a niche market more than two

decades later, despite the great success of related fiber amplifier technology in optical communications and CW fiber lasers in material processing.

What are the factors limiting wider adoption of ultrafast fiber laser technology and expanding the range of their applications? Here are a few usual suspects:

- The ultrafast laser market is relatively small (about $300 million in annual sales).
- Influence of established vendors is high.
- Financing of start-up companies is limited.

A few other barriers are more specific:

A significant fraction of ultrafast laser sales goes into the scientific market, which cares more about laser performance than cost. Unless fiber lasers can match or exceed performance of legacy ultrafast systems, not many researchers will take a risk of purchasing one, despite a lower cost.

Many industrial customers, that employ ultrafast lasers in their products, including Microtech Instruments, Inc., have been investing into development of fiber laser based products for years, but not many of these products have been introduced so far.

At least a dozen of small and mid-size vendors are offering ultrafast fiber laser systems today and their market share is growing. Established vendors also announced long term commitments to this technology and introduced new products incorporating fiber amplifiers.

IMRA – one of the pioneers of the ultrafast laser technology has been promoting their products since the 1990's, supported by financial backing of Toyota. However, the company made a limited impact on the industry so far. It is mostly known for maintaining an extensive IP portfolio and for patent litigation battles, including the big and unsuccessful one with IPG Photonics. Industry insiders claim that it is not IMRA's intellectual property that limits adoption of fiber laser technology, but it is a lack of clear IP ownership that is a concern for established vendors. This may be good news for users of ultrafast fiber lasers, since the field is likely to be open for many competitors and therefore prices should fall fast.

Neither one of these barriers can hold adoption of ultrafast fiber laser for much longer. There is very little doubt that ultrafast fiber lasers are well positioned to impact the laser industry over the next decade by demystifying complexity of these products, reducing the price and expanding the range applications.

Microtech Instruments is proud to be among the early adopters of ultrafast fiber laser systems. Iin 2003, the company started development of new products for THz market using 10W, 10 ps fiber lasers. Microtech introduced Terahertz Parametric Oscillators TPO-1500 in 2011 and TPO-1500-HP in 2012, which delivers up to 0.3 mW of average power (>450 mW of peak power) at 1.5 THz. Operation of the TPO is based on difference frequency generation in a quasi-phase-matched Gallium Arsenide crystal placed inside a fiber laser pumped optical parametric oscillator. With spectral widths of <100 GHz, the output of these sources fits perfectly into atmospheric transmission window at 1.5 THz, making it an ideal source for terahertz imaging. Very high peak power makes TPOs suitable for imaging systems

employing nonlinear optical effects or time domain terahertz spectroscopy, while sufficiently high average power makes it suitable for thermal detector array imaging. More information on TPO systems is available at: http://www.mtinstruments.com/THz_Generators.html

Microtech has also introduced ***a near-IR picosecond, tunable OPO: FPPO-1000,*** designed for coherent Raman (CARS) and other multi-photon imaging and spectroscopy applications. The system is pumped by a 6ps, 1064 nm, 110 MHz fiber laser, which is converted to 532 nm by second harmonic generation. The 532 nm pulses act as the pump for the OPO, which is tunable from 740 – 1000 nm (signal) and 1150 - 1800 nm (idler). In a CARS experiment, the tunable signal beam is used as the pump, while the fundamental at 1064 nm provides the Stokes pulse. The user also has access to the longer wavelength idler pulses. The short duration (< 6ps) and narrow bandwidth (<10cm^{-1}) of FPPO-1000 provide the peak power and spectral selectivity critical for CARS imaging and spectroscopy. More information on FPPO-1000 ultrafast OPO system is available at: http://www.mtinstruments.com/CARS_Imaging.html

In anticipation of imminent price declines in ultrafast fiber laser market, TPO-1500-HP and FPPO-1000 are priced at a 50% discount compared to competing systems based on Ti:sapphire or YAG lasers. None of these laser systems can be controlled from an iPhone yet, but FPPO-1000 does come with a LabView software to control output wavelength. Please email sales@mtinstruments.com to request a quotation.

About Microtech Instruments, Inc.

Microtech Instruments is a manufacturer of advanced scientific instruments for Coherent Raman, Multi-photon and Terahertz imaging and spectroscopy applications. Serving the global research community for almost 20 years, Microtech collaborates with leading research organizations worldwide. For more information please visit www.mtinstruments.com