30 years of ultrafast fiber lasers

-A personal journey-

We present a review of 30 years of ultrafast fiber laser research from a personal perspective. We discuss the merits of currently prevalent systems in widely varying applications, such as telecommunications, high power amplifiers, broadband wavelength coverage, imaging and low noise fiber frequency combs. Ultrafast fiber amplifiers can now readily be operated at kW average powers and ultra-low noise fiber frequency combs have evolved into a mainstay of metrology labs around the world and are expected to soon be part of the new definition of the SI second.
We discuss some of the key milestones that have facilitated these great advancements over the years, concentrating on a variety of key components, comprising high power or low noise modelocked fiber lasers and frequency combs, efficient fiber amplifiers, electro-optic pulse generation, large mode area fibers, management of dispersion, nonlinearity, phase and coherence properties as well as relevant developments in fiber materials and nonlinear crystals, highly nonlinear and photonic crystal fibers as well as nonlinear optics in hollow core fibers. We conclude with a review of some the most prevalent applications and their societal impact.

Martin Fermann, biography, 2022

Martin Fermann studied physics at the Ruhr Universität Bochum from 1980 – 1983. After completion of a Masters Degree in 'Applied and Modern Optics' at the Universities of Brighton and Reading, U.K. in 1983/4, he joined Southampton University, U.K., from where he received his Ph.D. in 1988, working mainly on fiber-based photonics. He then joined the Technical University of Vienna as a postdoc, where he performed seminal work on ultrafast fiber lasers, and was the first to demonstrate the generation of sub 100 fs pulses from fiber lasers. In 1992 he joined Bellcore, NJ, where he continued his work on ultrafast laser technology.

He joined IMRA America Inc. in 1992 and briefly also worked as a research associate at the Ultrafast Science Center at the University of Michigan.

From 1992 – 2001 he was instrumental in developing IMRA's early laser products: femtosecond generating Er fiber lasers and Yb fiber lasers generating high energy fs pulses. After 1 year as CTO at Boston Laser he rejoined IMRA in 2002, where he is currently serving as Vice President for Research and Advanced Development.

Since 2002 his main activities have been centered around frequency comb technology and he also helped with the commercialization of IMRA's fiber laser products for ophthalmic surgery. In 2015 he also started IMRA's research lab in Longmont, CO, created for the development of nanophotonic laser technology. Since 2019 he has been heading up IMRA Scientific, dedicated to the development and dissemination of ultrafast lasers and frequency combs for scientific applications.

He has been an author or co-author of around 500 technical papers and conference presentations and around 150 US patents and applications. Many of his patents have been licensed by third parties.

He has been active in the committees of numerous technical conferences and served as General Chair for the Conference on Advanced Solid State Lasers. His main interests comprise ultrafast optics, frequency combs, precision spectroscopy and metrology, fiber and solid-state lasers as well as nano-photonics. He is a fellow of the Optical Society of America.

The role of optics/photonics in Dr. Fermann's work:

I came to the optics field from an early interest in astronomy and telescopes; the 'Bochumer Sternwarte' then led by Prof. Heinz Kaminski was an early inspiration, particularly their widely publicized detection of the first Sputnik signals. As I was finishing my physics undergraduate work at the Ruhr Universität Bochum, I had an opportunity to do a masters in advanced optical technologies with the inventor of the medical endoscope, Prof. Harald Hopkins. He inspired me to start my Ph.D. working on optical fiber technology.

Optics is central in my work. A wide knowledge base in optical technologies, including lasers, nonlinear and waveguide optics is required. The laser systems IMRA has developed are basically fully engineered versions of some (of my) early research results.
To stay competitive, IMRA's laser technology needs to be constantly improved and updated for customer demands, and new research avenues such as frequency combs and nano-photonics need to be explored. Frequency comb technology crosses over to electronics and microwaves as well as microwave and nano-photonics. Almost not a single day passes where we don't need to learn some new technology and where we don't need to find some solutions to difficult problems, be it in the optical, mechanical or microwave domain.