Femtosecond future

Andreas Stingl, CEO of Austrian company Femtolasers, talks to **Nadya Anscombe** about the market for femtosecond lasers and their wide variety of applications.

■ How mature is the market for femtosecond lasers?

The first femtosecond laser was developed in the 1990s, so the market is still relatively young. Industry is understandably quite conservative when it comes to embracing new technologies. However, femtosecond lasers are no longer just a scientific or academic curiosity, but rather a powerful tool for a diverse range of applications.

Of course a femtosecond laser is more complex than a continuous-wave laser, but femtosecond lasers now come as turn-key systems that can work in difficult environments. They are not a cheap solution, but can often perform tasks that no other laser technology — or tool in general — is able to perform. People are slowly realizing this, and although many people feel that the technology still needs to prove itself, an increasing number of companies are turning to the femtosecond laser to meet their needs. This has resulted in healthy growth in all areas of the technology.

■ What markets have femtosecond lasers successfully penetrated?

The scientific market is still the biggest for femtosecond lasers, but other sectors such as diagnostics (imaging and spectroscopy) and materials manipulation are growing too. For example, in eye surgery, there are strong signs that femtosecond lasers could replace excimer sources, owing to their higher precision and lower maintenance costs. Other exciting applications include the generation of attosecond pulses, terahertz spectroscopy and optical coherence tomography (OCT). Attosecond science is a very active field and will allow us to analyse electron dynamics and work at an atomic scale. Although this market is still in its early stages, it is a very exciting one for femtosecond lasers. Terahertz spectroscopy is also an exciting application. With the increasing availability of compact femtosecond sources and semiconductor antennas and detectors, terahertz spectroscopy is finding new applications in a diverse number of markets, from explosives detection to monitoring pharmaceutical production. Femtosecond lasers have also enabled advances in OCT — a powerful medical imaging technique that can obtain subsurface images of translucent

Andreas Stingl, CEO of Femtolasers.

or opaque materials at a resolution equivalent to a low-power microscope. It provides tissue morphology imagery resolutions down to 1 μm , which is high compared with other imaging techniques such as magnetic resonance imaging or ultrasound. Another interesting application is multiphoton microscopy. This gives excellent subwavelength resolution and is able to image under the skin by setting the focal spot deep in the tissue. For current research applications, widely tunable but relatively narrow-bandwidth femtosecond lasers have been used in conjunction with a mechanical tuning mechanism that adds additional complexity. Furthermore, dispersive mirror technology allows us to tailor spectra to our requirements, and requires no moving parts.

■ What have been the most important technological advances in recent years for femtosecond lasers?

One major step forward has been the integration of the laser with the mechanics, optics, electronics and software required to make a complete system. This gives the customer a turn-key system, which is an absolute requirement for real-world applications. Integration also gives the customer a more reliable system, especially when features such as active feedback loops are built in.

Another important achievement is the development of dispersive mirrors and other ultrafast optics. These mirrors have allowed

manufacturers to replace prisms and gratings in their laser systems, which reduces the number of components and thus dramatically increases the robustness and reproducibility of the systems. However, we must find ways of reproducing these mirrors in larger quantities if we want to bring down the costs of femtosecond laser systems and open up new applications.

Pump sources have also come a long way since the development of the femtosecond laser. They are now much more compact and reliable than they used to be. This allows them to be integrated with all the other components into a single box, which protects them against the environment and makes the whole system more robust.

■ What does the future hold for femtosecond lasers?

One trend I think will become important in the future is the idea of multimodal systems; for example, using a single femtosecond laser integrated into a single system to perform both multiphoton microscopy and OCT, or terahertz spectroscopy and OCT. There is no getting past the fact that a femtosecond laser is currently an expensive piece of equipment, so using it for two techniques in one system is a clever way of maximizing on investment while also developing a very powerful diagnostic tool. The price of femtosecond lasers will come down when they can be mass-produced, but we are not yet at that stage and it will not happen overnight.

As well as cost considerations, manufacturers of femtosecond lasers face the same challenges as manufacturers of other laser types, such as temperature management, mechanical stability and portability. Customers nowadays want the next generation of technology more quickly, and they also want us to produce better-tailored lasers at reduced costs. Since its inception, the femtosecond laser market has grown at a healthy rate. However, the market is maturing and people's confidence in the technology is increasing, so I am convinced the biggest growth is yet to come.

INTERVIEW BY NADYA ANSCOMBE

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