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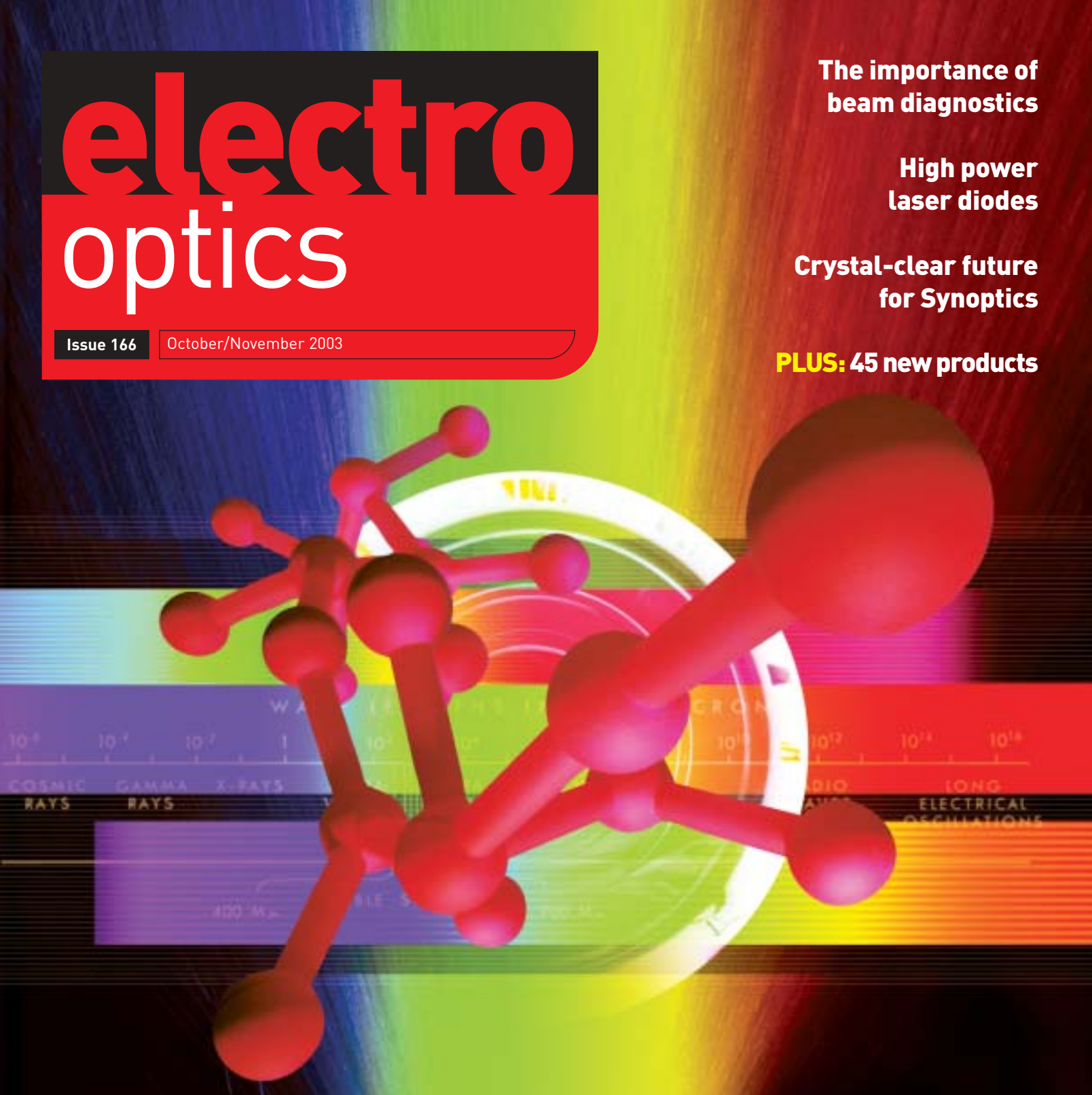

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electro optics 1968-2003 35 YEARS

Crystal-clear vision for Synoptics' future

The use of exotic crystals in laser technology has come a long way since the early days. **John Murphy** spoke to Joe Rutherford, vice president and general manager of market leader Synoptics

MANY OF TODAY'S LASER APPLICATIONS would not be possible without an array of exotic crystals. While the first laser crystal was a natural ruby, today we have a bewildering array of letters denoting chemicals that cannot be just picked up in a riverbed. Nd:YAG, or Neodymium-Yttrium Aluminium Garnet, is perhaps the most common, but there are variations like Er,Cr:YSGG, or Erbium, Chromium-doped Yttrium Scandium Gallium Garnet, used in dental lasers, and Nd:YLF or Neodymium-doped Yttrium Lithium Fluoride, which is used in high-power, short-pulse applications.

Not only does someone have to dream up these crystals, they have to make them from an alphabet soup of chemicals, sometimes taking weeks to grow each one. It is no wonder, then, that we find that these crystals were not developed speculatively for use by doctors, dentists and production line welders. Many novel crystals only exist because of military requirements such as smart bombs and other laser-guided weapons.

The largest supplier of these crystals is Synoptics. Although it supplies about 75 per cent of the world market for laser crystals, it is just a small piece of the huge Northrop Grumman Corporation, which makes everything from satellites to fighter planes and warships. Over the history of lasers, Synoptics, under a variety of names and owners, has been developing swords and then turning them into ploughshares, only to find that the demand for its swords has started to grow again just as the market for ploughshares, particularly in telecoms, has dried up.

Joe Rutherford, vice president and general manager at Synoptics, believes some markets will 'explode' in coming years

Although the value of its products is relatively small, compared to the sort of defence programmes its parent company gets involved with, the crystals are often vital components of much larger weapon-systems. This has meant that, despite the world market for crystals being only $25million a year, there is a strong incentive for Northrop Grumman continually to invest in crystal technology, particularly since it took over TRW. The commercial laser applications that depend on this technology are effectively riding on the back of a defence requirement where cost is not the only issue.

Synoptics started life as Airtron, part of Litton Industries, a US conglomerate better known for defence electronics and building warships, which was bought by Northrop Grumman in 2000. It had started working on crystal technology in the 1960s with the Gould Group at Bell Laboratories, but was more interested in their potential use in microwave technology (Litton originally developed the microwave oven).

Joe Rutherford, vice president and general manager of Synoptics, said: 'At the time the US Government was taking a great interest in producing a usable, and reproducible solid state laser. It had initially gone after ruby, but that was not ideal, not only because of its wavelength, but also because of its efficiency – the flashlamps producing the initial light for the systems were not that powerful. Bell Labs started developing the Nd:YAG crystal as an alternative, not only because of its wavelength but also because it was much more efficient. The US government was primarily interested in rangefinders and target designators, which emerged in the 1970s.

'There was a commercial market, which was really a fall-out of the military market. Initially, the extra capacity that was built at Airtron was not meant for commercial lasers. While they were pursuing research with Bell Labs, there was an interest in what was called 'bridge jewellery', copies that people wear out while their valuable jewellery sits in the safe at home. Initially there was an interest in using pure YAG, which is transparent. That is where the initial 25 growth stations put on the floor at Airtron come from.

'Everyone was really excited because the refractive index was so good, but then within three years the Russians had brought in cubic zirconium, which was far superior as a lookalike.

'Sometimes it would be nice to say that we had this grand plan and everything just fell into place. But in reality, things do not work like that. When the US Government came along and said they needed 2000 laser rods a month, none of their existing suppliers could come up with that kind of volume – but Airtron already had the growth stations established and quickly became the leading supplier of Nd:YAG crystals. Allied Chemicals were involved but they didn't have the capacity, and Union Carbide was involved but they had put their efforts into sapphire once the ruby market had fallen out.'

Airtron had actually been purchased by Litton Industries in the 1940s, because it manufactured ejector seats for fighter planes. By accident, it also

Hydrothermally-grown KTP crystals for the medical market

ended up as the leading supplier of laser crystals to the US military. Litton did get into the business of making military laser systems through Litton Laser Systems in Florida, which was originally International Laser Systems, a spin out from Martin Marietta. But other weapons suppliers, like Hughes and RCA, also started developing specialised defence laser systems using the Airtron Crystals. Litton then purchased the Allied Chemical Synthetic Crystals group in 1989, which became Synoptics – for Synthetic Crystal and Optical Products.

consumption of laser materials dramatically decreased. Fortunately at the same time the consumption of these materials in the commercial market – industrial, scientific and medical – increased dramatically. In the latter part of the 1990s, there was only about five to 10 per cent consumption by government-related organisations.'

Rutherford believes that some markets, particularly dental lasers, are set to explode in the coming years, not just in whitening teeth but in replacing the conventional drill for routine fillings.

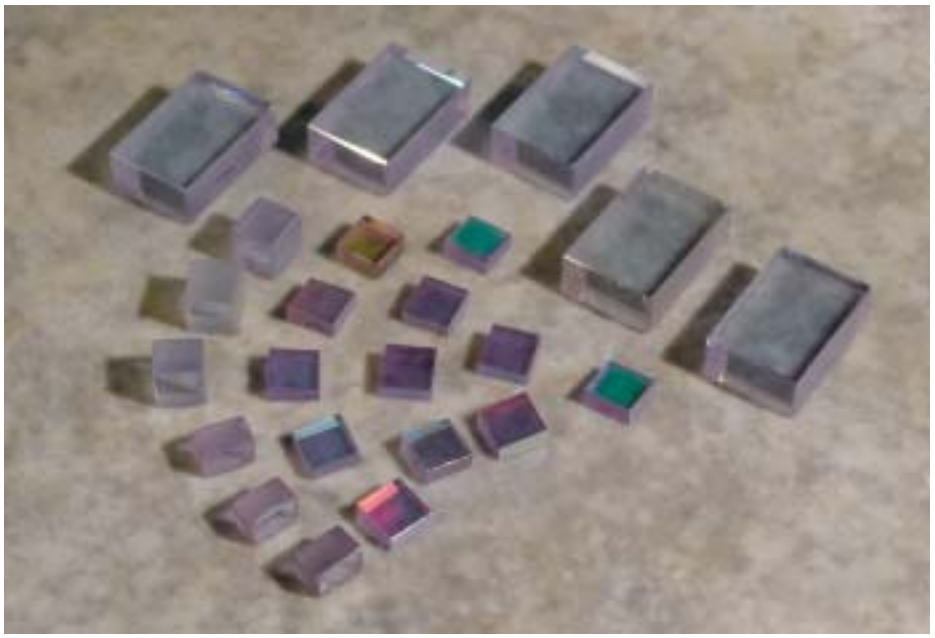
'The commercial laser market was slow to take off, mainly because the crystal technology was only one piece of the picture; most early development was confined to gas lasers'

The first forays into the commercial laser market came when the company looked for a market for crystals that had been rejected by the military manufacturers. This commercial market was slow to take off, mainly because the crystal technology was only one piece of the picture; most early commercial development was confined to gas lasers.

For about the first 20 years, Airtron concentrated mostly on Nd:YAG, but once Airtron and Allied came together as Synoptics, it was able to offer economies of scale for more exotic crystals that could exploit new markets.

Rutherford said: 'When I took this operation over in 1989, about 70 per cent of everything we produced was being consumed by the end-use military market. As we went through the dramatic cutback in the early 90s, government and military

'At the moment, we are working in four segments of the market: government, medical, scientific, and industrial. In more recent years, our military business has moved from five per cent to 15 per cent – and I think that will continue to increase. There is a new generation of smart weapons coming along, and we believe that Nd:YAG or something related to it will be the preferred technology – there is not a disruptive technology on the horizon. The medical market is going from around 532nm, and we produce the hydrothermally-grown KTP for that market; it's also at one micron, Nd:YAG; we know it's at two micron, and we produce CTH:YAG; and it's at three micron, which is Erbium:YAG. In the mid range, there is the tuneable 750nm market, which is provided by Alexandrite. There are also some filler crystals in there, addressing niches in the medical market such as Indium-YLF and some ➤



Neodymium-doped Yttrium Vanadate crystals for use in marking, spectroscopy, and research.

others. That market is very healthy and is the largest segment of our current market, but I do not expect that to remain so.

'In the industrial market we are seeing one micron technology and Nd:YAG being used in the fibre delivery of laser light for welding, which can be mounted on a robot head. One of the real growth markets is the replacement of spot welders with lasers. This is particularly useful in the automotive industry. This industry is slow to change, but it's coming. Another side of the industrial market is semiconductor-related. After the collapse of the telecom industry, the electronic industry collapsed after building so much excess capacity. That industry has not yet recovered but solid-state lasers are being used in all new factory builds and upgraded systems. That could end up being 25 per cent of everything we produce in the Nd:YAG area. At the moment, that market is a fraction of what is was a few years ago, but that market will rebound. Nobody is going to stop buying PCs.

'The scientific market is always at the leading edge, with new materials being used and new applications being found. There are emerging technologies in things like cancer treatment, which could be the next boom in the medical field.'

Rutherford believes that the reason Synoptics continues to lead this area is that it has always been prepared to invest in the technology and pursue new materials. He said: 'This is not a huge market and it's not growing in leaps and bounds. There are a few smaller competitors serving particular markets. If you look at all of the laser crystals, it takes a certain amount of critical mass to pursue these things. These crystals are long growing – it may take two or more months to grow some of these crystals. If you look at barriers to entry, and the investment you would need to make to become a significant player in this marketplace, it can't be justified on paper.

'We have a list of more than 6000 part numbers. Given the size of the industry and a customer base of maybe 350 to 400 companies, it's all about niche markets. That is really why Sumitomo hasn't come out with 200 crystal pullers and attacked the market like crazy. We make 3000 laser rods a month, and the largest quantity of a particular laser rod is maybe 100 to 200. All the rest are one, two, or 10 rods.

'This is not a huge market and it is not growing in leaps and bounds. There are a few smaller competitors serving particular markets'

'Because we have been in business a long time, our investment has been made over many years. Being big is not necessarily bad. We believe growth in this market not only requires new technology, it also relies on us continually driving down costs.

'When we were part of Litton we were not a critical supplier; for the amount it consumed, it could get the material elsewhere. Since the acquisition of TRW by Northrop Grumman, we have become a critical supplier. We have been a sole source to them for many years, because of our superior quality and the investments that we have made in technology, and the investments that TRW made in developing its technology. That means they are going to continue to make the investment in the technology. Being part of an organisation that is committed to pushing forward technology, and being a critical supplier to it, is probably the best thing that could have happened to Synoptics in the past 30 years.'

Rutherford believes that crystals have a good future and it will be many years before it is replaced. He said: 'Nothing ever stays totally stable. There are a lot of crystals that we are investigating, either under contract or through our own research, where we think there is a market or will be a market. In 1987, we developed Erbium:YAG. It was very difficult to produce; it took us about six years to get right. But the market for Erbium:YAG didn't actually develop until 1998-99.

'I think the medical market is going to continue to move the wavelengths, and may need a crystal that is not grown today. There are weapons systems being developed that may need new crystals. We don't know exactly where that is going, but there is a next generation of defensive and offensive capability building in all of the 'free world'. There is a continued movement towards total elimination of any distortion, which is driving us to continually improve methods of growing crystals.

'There are new materials on the horizon. People are talking about ceramic materials, which we are also exploring. There are thoughts that this may replace Czochralski-grown crystals, because they are less expensive and more efficient. It may be possible to do some enhancement with regard to dopants. Ceramics have dramatically increased fracture resistance and in very harsh environments, such as the battlefield, this may be an advantageous feature. But ceramic technology is really in its infancy, so I don't think ceramics are going to be within 10 years, even if they throw money at it from all sources. You are talking about replacing 30 years of development in crystal technology.

'We really don't know what investment is going to be required for ceramics. They are talking about employing nanotechnology for the development of these ceramic powders. Just to create nanoparticles, you are not talking about a small expense. Then there is the whole system of temperature control, mixing and sintering pressure. At the end you get this material that still has to be cut, still has to be polished, still has to be coated – and then you are looking at a $25 million market. Yes, we are looking at the technology and participating in its development but, from my perspective, when is it going to be in the marketplace even if everything goes right? Then you are really looking at 10 years.'