

Happy birthday CD-R! 2

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The recordable CD is ten years old this summer. In a mere decade it has moved on from an interesting variation of the CD-MO promoted by Philips/Sony into the largest growth area for CD.

BY TIM FROST

The invention of CD-R - dated rather precisely on 13 June 1988 - is credited to Taiyo Yuden, a company that specialises in a variety of electronic components.

Then, as now, Taiyo Yuden was so far on the periphery of this industry that few had ever heard of them. This writer's first contact with Taiyo Yuden was a dozen or more years ago when I was product manager for Harman in the UK, which had taken on distribution of Taiyo's first step in to the blank media business - That's tape cassettes. Taiyo had developed its own highly original manufacturing techniques and metal coating, and the team that came over from Japan was just as original as their product. Having not met Dr Tad Ishiguro when we were doing business back then, it was a pleasure to meet up with the man himself at the last European REPLtech and follow up the history of CD-R with some views on the future of record-once media.

Dr Ishiguro, now general manager of product planning for Taiyo Yuden, is acknowledged as the 'father' of CD-R. He headed the development team that has produced a recordable product which has succeeded where better funded and more heavily promoted recording formats have failed.

The obvious starter question was how did a company established in the 1950s producing ceramic capacitors, ferrite cores, inductors and hybrid circuits, end up developing CD-R?

The seed of Taiyo Yuden's CD-R development was the cassette tape that first saw the light of day in 1982. One of its competitors in the components business was TDK, which was then well on its way to establishing its hold on the cassette market. So what was a natural move for TDK was also good for Taiyo Yuden.

"We were then, and still are, a company producing ferrite products. Since audio tape is based on ferrite material, it was a product that we could develop," explains Dr Ishiguro. Taiyo Yuden had worked on producing a 'metal' coated tape at a price that approached that of normal ferrite tapes. But while the tape was good, the fact that Taiyo Yuden was a relatively small company without the multi-million dollar marketing power of TDK or Maxell,

played against it in its export markets. (After many years of unequal battling, the company has now given up the fight and stopped tape production.)

But in the early 1980s the future for its audio market looked good enough to start work on the next development beyond cassette. Ishiguro marks 1985 as the starting point for CD-R.

"In 1985 Sony introduced the Discman and I think you can point to 1985 as being the real starting point of the CD market. We thought we would like to produce a recordable product that was fully compatible with these CD players. Fortunately, or unfortunately, we didn't have any background in recordable optical disc. We wanted to develop the product for marketing reasons, although we had no materials and no technology."

Ishiguro brought his team together to work on the practicalities of a fully compatible recordable format. He points out that CD player compatibility was not a pre-requisite for the other larger organisations working on recordable optical discs, as evidenced by the CD standards produced by Philips/Sony.

"In 1987, two years after we started work on recordable CD, Philips introduced the Blue Book, which was the standard for CD write-once based on Philips/Sony technology at that time. But this defined a product that had no compatibility with existing CD players because of its lower reflectivity. As it happened, at that time the pre-product we were producing was almost fully compatible with the Blue Book."

The Orange Book Part I was part of the same technical malaise. It defined the MO based CD format as one that also had no compatibility with the installed base of 44 million CD players at that time. The defining factor in all these options was the use of inorganic recording materials, which subsequently proved to be a blind ally for record-once media. However, one of the good things that came out of the development of the Blue Book was that Taiyo Yuden was brought into the periphery of the CD standards development cycle.

But, says Ishiguro, his team's approach was unique, working on dye absorption technology that differed from the low-reflectivity approaches followed by the others.

"When we started development in 1985, we understood that the important thing was get a higher reflectivity. So we developed a very different dye compared to the conventional dye system used in optical disc. Before we started the development of organic dye for CD-R, the most popular dye used a high extinction coefficient of around 0.6 to 0.8. But we introduced a different dye with a higher refractive index and a very low extinction coefficient - approaching 0.01. Our computer simulations led us to a big refractive index and lower extinction coefficient product, and in 1988 we found a combination of dye and a reflective layer that allowed us to meet the target of 70% reflectivity."

Another advantage of the organic approach was that the dye layer could be applied by spin coating rather than sputtering. It may seem self-evident now, but Ishiguro points out that at the time, applying a recording layer in a way that filled the pressed grooves and

controlled the layer thickness over the disc's surface did not have an obvious solution.

"By using spin coating with an organic dye, the dye layer could be levelled so that the thickness could be maintained, and that is a fundamental phenomenon that can only be produced by spin coating."

The development of the final CD-R disc was completed in a flurry of activity in the summer of 1988, with every aspect of the disc's technology finalised in June. Having already developed a Blue Book compatible disc, when it became known in May 1988 that the next development would need to be a CD compatible disc, the Taiyo Yuden team went back to their research to produce a fully Red Book compatible recordable disc.

"We had the technology for the computer simulation to design the optical disc; we had the technology for the organic materials, the injection moulding and the encoding all in place. That was an exciting two week's work. We invented CD-R in June '88 and applied for a lot of patents, and in September we gave the press conference, which was when the world first heard of CD-R."

Myths have grown around the licensing of CD-R, especially when other companies start discussing 'licence-free' dyes. Whilst Taiyo Yuden did a good job patenting its developments, the patents are much broader than simply defining the cyanine dye, Ishiguro says.

"We have patents on the optical structure, how to get the higher reflectivity; we have a patent on the recording mechanisms and a patent on how to track the disc - it is impossible to use CD-R without using our patents. We also have patents on the materials - but those are not so important for us."

Being a relatively small player in this market, Taiyo Yuden wasn't in a position to manage a comprehensive licensing programme, so it went to Philips to manage the licensing of the technology.

With CD-R a technological reality, the company started test production in 1989. The release of the Orange Book Part II later in 1989 set the scene for full scale commercial production in 1990 at the rate of 10,000 discs a month - sold under the That's brand. With CD-R writers costing thousands of dollars, Ishiguro perceived CD-R as a niche business to support the hardware manufacturers and authoring work.

"We didn't have any definite plans for CD-R when we first started its development," says Ishiguro. "We thought that CD-R could be a key technology for authoring CD-Audio and CD-ROM, and we also thought that this was a way to support the recorder manufacturers. CD-R proved to be 'slow burner' format, rather than one released with a huge amount of publicity and massive roll-out programme. This was fortunate as the big launch approach was simply not viable for a company the size of Taiyo Yuden."

"It took a long time, it was a kind of a step-by-step business. With Taiyo Yuden being a small company, we could make a good business with CD-R, even when there were just a few recorders. It is totally different to a format like DAT, DCC or MD, where you have to

introduce a lot of media and a new hardware system in a short time. You have to be a very big company to introduce those types of products."

CD-R took off in a few niche markets - broadcasters especially found it a useful way of putting a collection of jingles on a disc that would play on any broadcast CD player. A CD-R offered better sound quality and longevity than the commonly used NAB tape cartridge, and was considerably more compact than a pile of carts.

But it was the commercial introduction of the CD-ROM drive in 1992 that heralded the real opportunity for CD-R. Ishiguro reckons that in the early years of CD-ROM, nearly all the CD-R media was used for audio applications and just a few percent for computer use, but the situation has now reversed.

"I think that 1992 was the turning point from audio to CD-ROM. In 1992, audio was a big percentage. But over the next year the data market expanded very quickly, and by the end of 1993 the PC market had become more important. CD-R grew quickly for computer and I think now it is more than 95% for computer use."

What happens to that balance now, with the introduction of lower cost audio recorders, is far from certain. Whilst users who are already technologically aware enough to know about CD-R are also likely to be computer literate, Ishiguro believes that CD-R equipped consumer hi-fi audio systems will expand the market.

"Now Philips have the CD-R audio recorder, we are manufacturing media for audio which has the different application code and SCMS implemented, and I think that these audio recorders will increase the use of CD-R."

While Taiyo Yuden's manufacturing capacity has multiplied a thousand-fold to 10 million discs a month from its original 10,000 a month, the company has never had the luxury of sitting on its laurels as inventor of CD-R. As the market has progressed over the last five years, there is more pressure to ensure discs will work on a wide range of writers and readers, and an ever-increasing range of write speeds. There is also the matter of cutting production costs in response to the free-fall in disc prices last year.

Compatibility between drives and extending the speed range are important development issues, says Ishiguro.

"At first there was only Taiyo Yuden media so there wasn't a compatibility problem. But with a range of media available, compatibility issues had to be resolved by adding the media code into the ATIP of the disc. This way a drive can choose from a table of write strategies and use the optimum write strategy for a particular disc.

"But it is also very important that the media can support a wider range of writing speeds. Thermal interference during writing is an important issue and we have solved this by using super-cyanine dye so that our media is supporting 8x recording. As well as the dye, the groove geometry and the materials for the top coating are also important parameters to meet the requirements of 8x recording.

"It is not just the maximum recording speed that is an issue, it is also important that you can support audio recording at 1x. In terms of, say, computer hard disk drives, only the higher speeds are meaningful - but in the case of CD-R, 1x is still important."

Manufacturing cost

Manufacturing cost is now the biggest issue for all CD-R media producers. That's CD-R media turned to a silver reflective coating earlier this year as one of the moves to help reduce costs. What does Dr Ishiguro think is going to happen to prices next?

"Prices have now stabilised, but we think that the price might go a little lower as the market expands. I hope the price will remain at least stable this year - but of course, only the markets can determine the price in the future."

Now it is only the top few companies that make money from CD-R. Some are announcing that they are dropping CD-R, while others have said that they never made money from the format.

Ishiguro believes that further cost trimming is still a possibility - but from an unexpected element of the product.

"We can reduce the cost through manufacturing techniques by increasing the yield and the productivity. But it is very difficult to reduce the materials cost as we have already gone to silver and the cyanine cost is not so significant. It is the packaging that has now become a substantial proportion of the final cost. This is a big problem for CD-R production - the jewel box adds a significant cost to the disc and we have to develop much lower cost packaging. Some companies are using slim jewel boxes or paper slipcases, and although the packaging must be cheap to produce, we have to be very careful that it doesn't look cheap - cheap looking packaging is not a good idea with CD-R."

Whilst the plummeting price caused grave concerns about the profitability of CD-R, it has also made the format infinitely more attractive to the end-user. \$10 media gave users pause to think before burning a disc. But at \$1-\$2 each, CD-R falls into the same category as floppy disk as a cheap and universal storage and interchange media. This has had a dramatic effect on Ishiguro's prediction of the life expectancy of the format.

"Before, I thought that the CD-R market would change to DVD-R once it had reached 8x write speeds, since 1x DVD-R is the equivalent of 8x CD-R. 8x was going to be critical - that was my understanding. But as the price erosion of CD-R was so huge last year, so the situation has changed. At the start of last year, I would have said CD-R had three or four years, but this year my answer is possibly ten years, and certainly at least until 2005."

That inevitably brings up the question of DVD-R, and all the other DVD recordable formats - Forum approved or otherwise.

Ishiguro's team is not looking at rewritable discs for two

specific reasons. The first is the technological one. Everything that Taiyo Yuden has worked towards has been in the realm of write-once. The company hasn't tried to spread itself too thinly to work on non-organic materials or sputtering technologies. Ishiguro points out that being single-minded and focusing only on record-once media has been a key company strength.

The other issue is a more pragmatically commercial one - the market for re-useable and rewriteable media is traditionally just one tenth of the market for the lower cost, disposable record-once media. If that follows through for DVD, then the rewriteable media business will remain tiny, even for a relatively successful format.

Taiyo Yuden has plans to start 4.7GB DVD-R media production, and if predicting what will happen with CD-R is difficult, Dr Ishiguro points out that DVD-R's future is intertwined with even more variables.

"It is very difficult to predict what will happen with DVD-R," he says. "You cannot use the example of CD-R, as the situation is very different. When CD-R was developed there was already CD-Audio, but no other recordable formats. With DVD-R, there is DVD-Video, DVD-ROM and DVD-RAM all available at the same time."

What is certain is that, intrinsically, DVD-R will not be significantly more expensive to manufacture than CD-R media. Apart from DVD's substrate-sandwich, the significant changes compared with CD-R are the wavelength sensitivity of the dye and the pit geometry - neither of which add dramatically to manufacturing costs. It's a quantity issue rather than anything else, says Ishiguro.

"DVD-R media could go onto the market for a few dollars, but it really depends on the expansion of the DVD-R business. If the DVD-R business starts increasing, we can increase our output by changing the production lines from CD-R to DVD-R."

DVD-R (as well as DVD-RAM and RW for that matter) may remain as just niche computer market products. Ishiguro subscribes to the general view that 4.7GB is simply not enough storage capacity for home video recording and that a continuous 10GB or more is needed to give adequate record time. Single surfaces that can store 10GB or more will require writing with blue lasers, and these are still several years away.

The industry view is that DVD-R is going to be primarily used for authoring DVD-Video and DVD-ROM, and as a support for the hardware manufacturers. Despite Dr Ishiguro's protests that the DVD-R market is totally different, this is, of course, exactly the same as CD-R's profile in its early years. DVD-R media at, say, a tenth of the cost of DVD-RAM discs could potentially tempt the professional user who is getting through hundreds or thousands of discs a month to move over to DVD-R - even if DVD-R writers are four or five times the cost of RAM drives. The perversity of the market to choose not the most heavily promoted or most instantly available format, but something that just catches the imagination at the right time, might eventually play in DVD-R's favour.

In the meantime CD-R is going from strength to strength and Dr Ishiguro considers that fortune has already played him a good hand.

"We are looking at new businesses for the future, but there's no easy answer to what is going to happen next. It is very difficult to find another product like this. I think it was very lucky for us to find CD-R."

Author's note:

The Taiyo Yuden launch of CD-R came with a set of briefing notes for journalists, which I kept, knowing it would come in handy one day. It outlines the applications that were predicted for CD-R. These were split into professional audio and computer uses: "Broadcasting stations using music recorded CD-R for production of classic FM programs" and recording studios making CD-Rs "for promotion, custom pressings, etc", while under the second category Taiyo Yuden predicted that "CD-R will be available for CD-ROM and CD-i editing and development". With even more accuracy it was predicted that "CD-R will be applied for small size publishing for databases, education, amusement (TV games) and electronic publishing.

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