Why Physical Pits are Better

Development of CD-R Optical Disc

The first commercially-available optical disc was a CD-R, introduced in 1988 as an outgrowth of the CD audio or music disc. These earliest recordable discs were based on organic cyanine dyes. These dyes were very chemically unstable, causing these early discs to fade and became unreadable within a few years. Chemical stabilizers were eventually added to the manufacturing process but the dye-based discs were still sensitive to UV light and would often fail after only a week of exposure to sunlight.

A less UV-sensitive Phthalocyanine dye was later developed that was natively stable and required no chemical stabilizers. However, this dye was much more sensitive to laser power calibration errors and was much more difficult to write to with high quality. A third even less UV-sensitive Metallic Azo dye was later added to the market. This material also required no chemical stabilizers and could withstand several weeks of direct sunlight exposure but still had a lifetime rated only in terms of decades, with real-world experience usually realizing a fraction of that.

From CD-R to Recordable DVDs

Early DVD recordables used hybrid versions of these dyes but because they utilized much thinner recording layers they were much more sensitive to oxidation and dye degradation. Recordable DVDs performed poorly in longevity testing and were determined to be even less suitable than CD-Rs for archival use.

Rewritable CD & DVDs

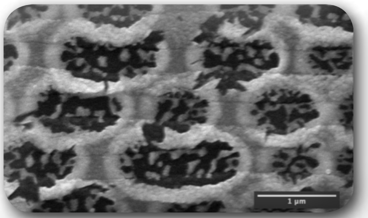
Rewritable CDs and DVDs operate on an entirely different principle than write once discs. A thin recordable layer is created by alloying antimony, germanium and tellurium. These three metals combined in tightly controlled amounts will produce a rewritable layer that can be recorded and rewritten many times.

The write process involves heating the write layer to two set temperature points. The higher temperature is known as the melting temperature and a lower temperature is known as the crystallization temperature. Heating the disc and controlling the rate of cooling with write laser produces a series of amorphous and crystalline "marks" along the track. The difference in reflectivity between these areas produces a signal similar to but less reflective than that of pressed optical disc. These "Phase Change" discs performed a little better in longevity testing, but since they could be easily erased by a standard drive they were a poor choice for archival applications.

CD-R & DVD-R Longevity Concerns

The factor that defines the longevity of CD-R, and DVD-R is the choice of materials in the write layer. The organic dye materials selected for CD and then translated over to DVD were chosen because of their compatibility with the laser and drive technology available at the time. They were not chosen with stability and longevity as primary goals. The materials selected for the M-DISC™ were chosen with stability and longevity as the primary goal. They were also chosen because they enabled the use of a more durable data mark — a physical hole or pit that could be formed in the data layer.

Stability & Longevity – Primary Goals



This new physical recording mechanism works with the durability of the materials in the data layer to enhance the stability of the data. For example, one advantage of the physical pit over the optical dye or phase-change data mark is the movement of material during the formation of the pit actually strengthens the edge of the mark. Since the nano-meter scale location of the edges is critical to the retention of data, enhancing the edges as shown in the nearby scanning electron microscope image builds in longevity. Another advantage is the excellent, permanent optical contrast that comes from making a physical mark. The difference in optical quality between the pit, where there is no material, and the areas adjacent to the pit, where the material remains, provides a definite advantage in retention of data and in ease of reading the disc decades into the future.