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REINVENTING LITIGATION SOLUTIONS

Holographic Versatile Disc

The Future of Optical Discs

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1. Introduction

The increasing pace of technological change has dramatically affected the way we store data. This evolution has led to the shift from conventional optical discs/drives to Holographic Versatile Disc (HVD) technology which promises to be a possible successor to technologies such as Blu-ray and HD DVD, with a considerable and promising future market.

HVD is an optical disc technology developed between April 2004 and mid-2008 that can store up to several terabytes of data on an optical disc 10 cm or 12 cm in diameter. While a single layer Blu-ray disc holds about 25GB of data and dual-Layer discs can contain 50GB, a HVD disc can hold as much data as 200 standard DVDs and with a transfer speed of over 1 gigabit per second, or 40 times faster than a DVD.

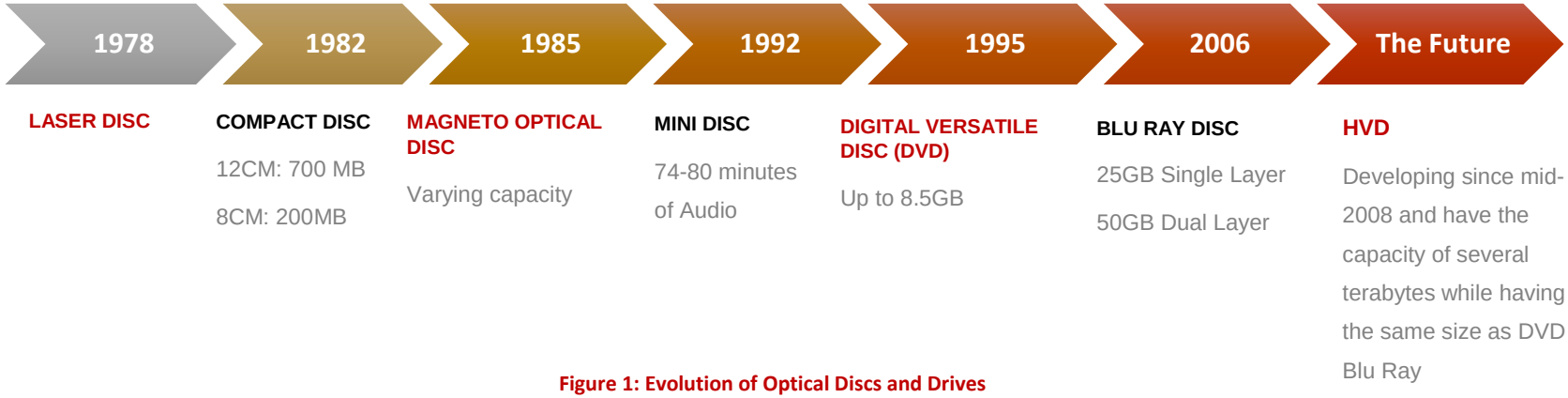


Figure 1: Evolution of Optical Discs and Drives

2. Overview: Holographic Recording Technology

Holographic recording technology is rapidly gaining attention as a high-capacity, high-speed data storage technology. Holographic data storage records information using an optical interference pattern within a thick, photosensitive optical material. It uses the properties of light to store massive amount of data onto a single plate. The stored data is read through the reproduction of the same reference beam used to create the hologram.

HVD offers several advantages over traditional storage technology.

Holographic Versatile Disc (HVD)	Conventional Optical disc
HVDs can store more than 1 terabyte (TB) of information by storing of holograms in overlapping patterns.	DVDs store bits of information side-by-side.
HVDs use thicker recording layers – Used to store information in almost the entire volume of the disc, instead of just a single, thin layer.	DVDs use Dual layer recording
HVDs have transfer rates of up to 1 gigabyte (GB) per second	Highest speeds of 30 MBPS, roughly 40 times lesser than HVDs
An HVD stores and retrieves an entire page of data, approximately 60,000 bits of information, in one pulse of light	A DVD stores and retrieves one bit of data in one pulse of light.

Table 1: Comparison between HVD and DVD

3. Product Development: Market Scenario

The Holography System Development Forum (HSD Forum) is a coalition of corporations formed to provide an industry forum for testing and technical discussion of all aspects of HVD design and manufacturing. The HSD Forum comprises of major corporations like Hitachi, Mitsubishi, Optware Corporation, Fuji Photo Film Company etc. The forum provides a venue for the technical discussions and information exchange among the disk manufacturers, material makers, device manufacturers and tester makers, and also takes initiative in developing and promoting this technology in the marketplace.

The technology behind HVD is based on holographic technology from Japan's Optware, one of the initial six founders of the consortium (then known as the HVD Alliance). Optware's exclusive development of the collinear technology is part of its effort to make holographic recording technology practical. Collinear holography combines a reference laser and signal laser on a single beam, creating a three-dimensional hologram composed of data fringes. This image is illuminated on the medium using a single objective. The introduction of this mechanism enabled reduced pickup size, elimination of vibration isolators, high-level compatibility with DVD and CD discs and low-cost operation, effectively obliterating the remaining obstacles to full commercialization.

HVD is currently in the research and development stage with many successful prototypes been built, but the technology is still being improved and has not yet been commercialized.

Competing Technologies. HVD was not the only technology in high-capacity, optical storage media. InPhase Technologies was developing a rival holographic format called Tapestry Media, which they claimed will eventually store 1.6 TB with a data transfer rate of 120 MB/s. But since InPhase Technologies were unable to deliver their promised product, they ran out of funds, and went bankrupt in 2010.

4. Trends in Holographic Versatile Disc (HVD) Technology

The aim of this section is to study overall environment of the intellectual property concerning the development of HVD technology. This analysis also gives a country wise patent filing trend over the recent years indicating an estimated technological growth that has taken place in a geographical region over the years. The analysis is conducted for a patent set of 273 relevant patents based on HVD technology published in the last 10 years.

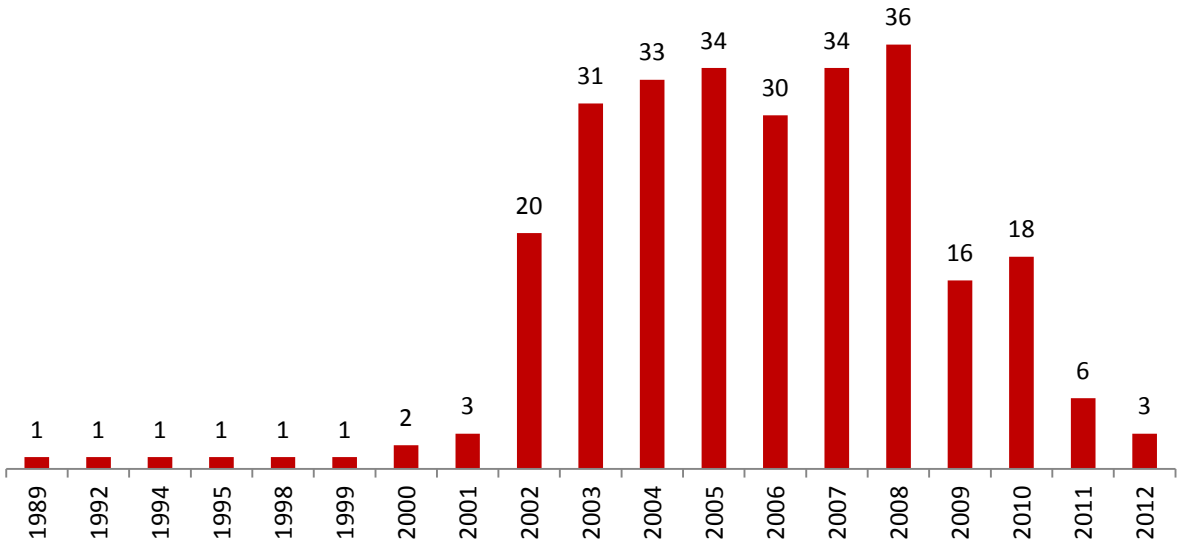


Figure 2: Year wise patent filing trend

Figure 2 shows the patent filing trend (based on priority year) in the field of Holographic Versatile Disc technology. A steep increase in the trend during 2002-2008 suggests the increased research that happened in this field at a global level with a major share in patent filings being held by US. The cumulative % growth rate during the period 2004-2008 was approximately 170% as compared to previous years.

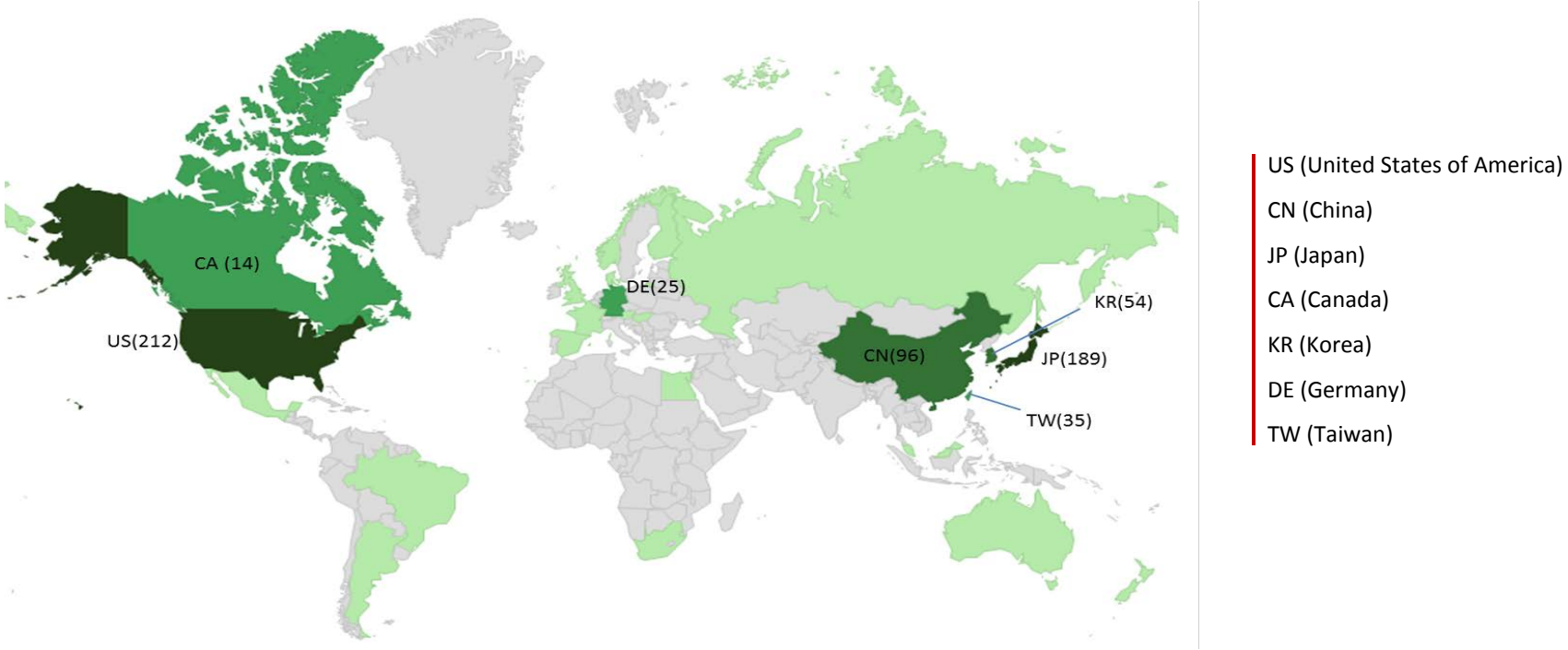


Figure 3: World Heat Map- Patent Distribution

Figure 3 represents the patent distribution in various geographical regions with highest filings in US (212) and Japan (189) in the last 10 years. The regions with darker color gradient have higher concentration of patents. Although top assignees in the field of holographic disc are based in Japan, US hold the highest number of patent filings. This can be indicative of the future market development which is focused in US followed by Japan and China. The analysis is performed considering one member per jurisdiction of the INPADOC families.

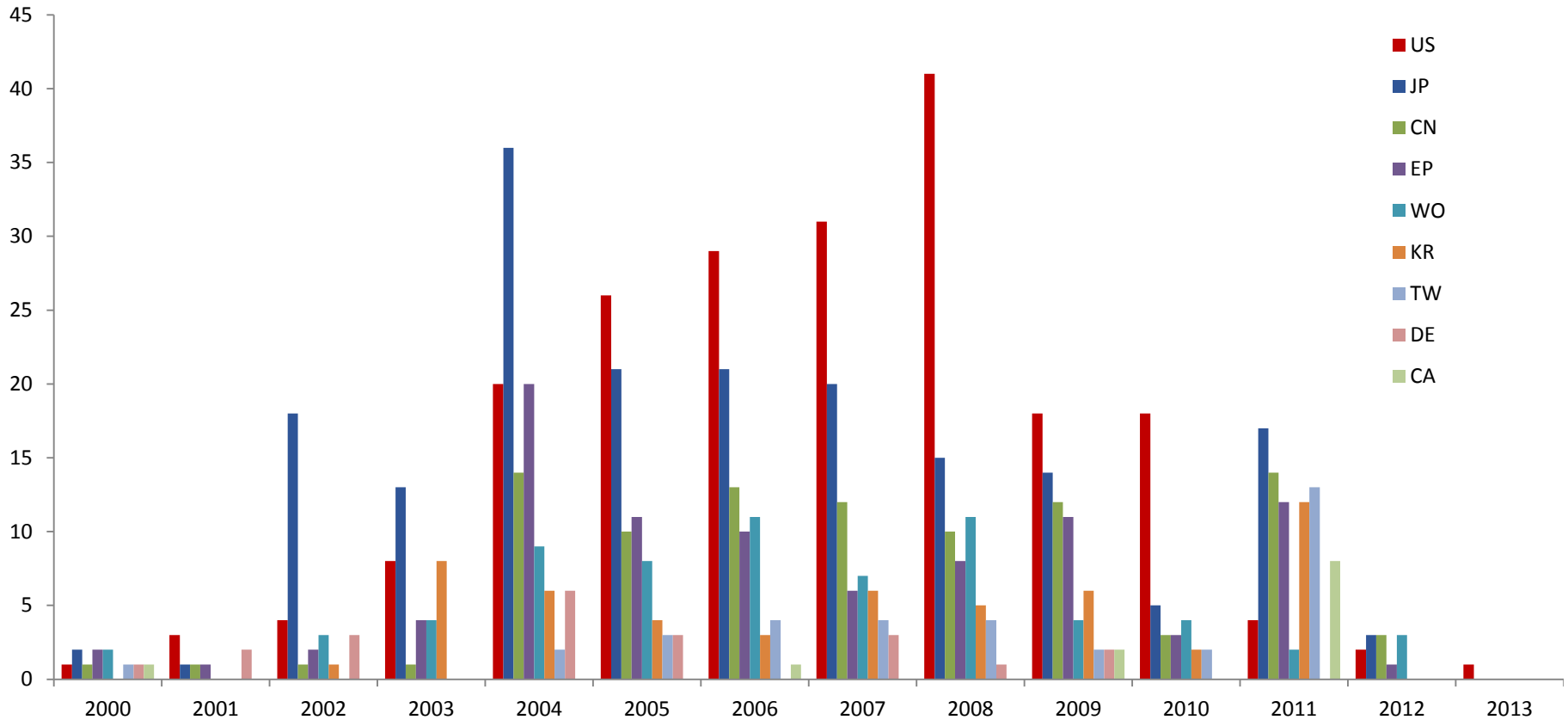


Figure 4: Country wise patent distribution on the basis of earliest filings in a geographgical region

Figure 4 shows the country wise distribution based on earliest patent filings. The analysis is performed considering earliest filed member per jurisdiction of the INPADOC families. While clearly an exponential growth is observed in patent filings in US in 2004-2008, other countries like Japan and China show moderate patent filing rate over the years. Also despite being a major filing country till 2004, the filing trend in Japan remains more or less constant.

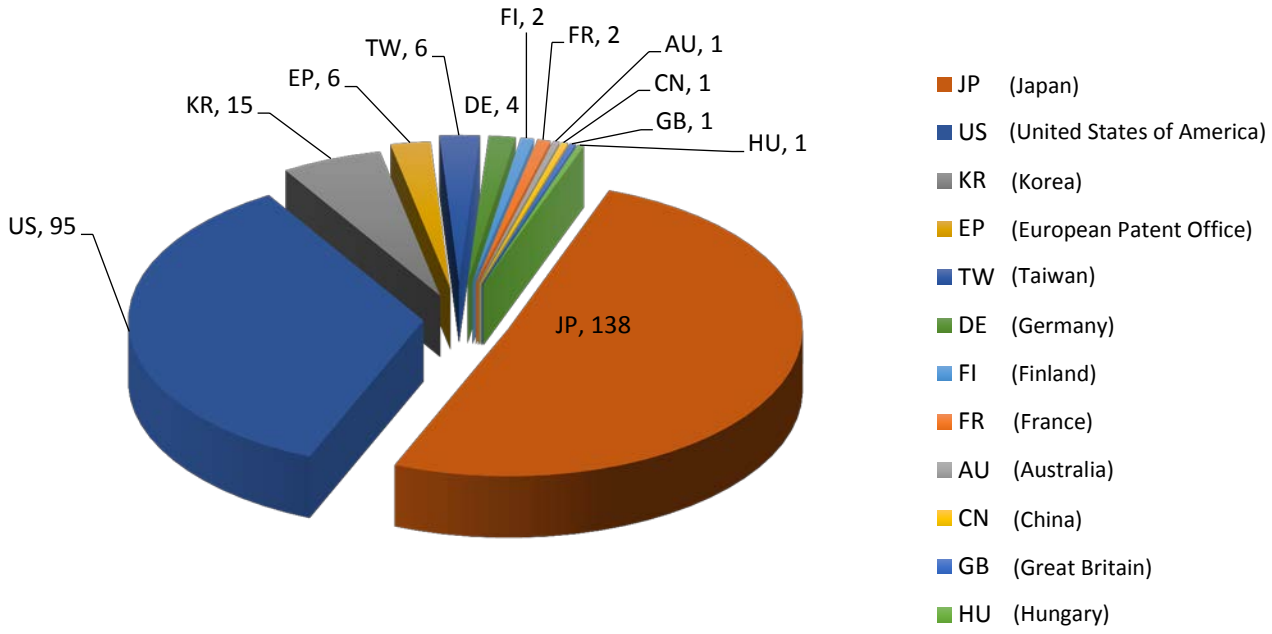


Figure 5: Priority country distribution

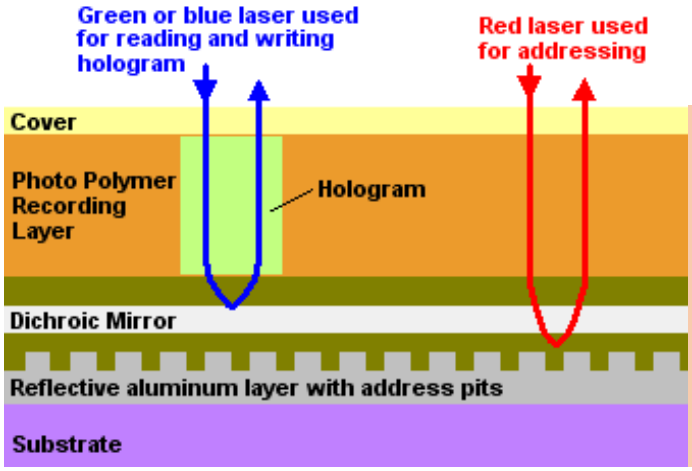
Figure 5 shows an analysis of the filings of priority patent applications in various geographical locations. The pie chart gives an overview of all countries where the research activities are going on. It can be observed that majority of research work is concentrated in Japan and US owing to the fact that all are major assignees are based in these countries only.

5. Holographic Versatile Disc (HVD)

5.1 Structure of HVD

The structure of the disc places a thick recording layer between two substrates and incorporates a dichroic mirror that reflects the blue-green light carrying the holography data but allows the red light to pass through in order to gather servo information.

The figure in the below shows the cross section of an HVD disc. As seen in this diagram, holographic recording layer is formed on top of a reflective layer. The Dichroic Mirror Layer is placed between the holographic recording layer and the substrate to block the green or blue lasers, which are used to read/write holographic information.



Layer	Patent Distribution
Cover Layer	8
Hologram Recording Layer	80
Dichroic Mirror	4
Reflective Layer	33
Substrate	27

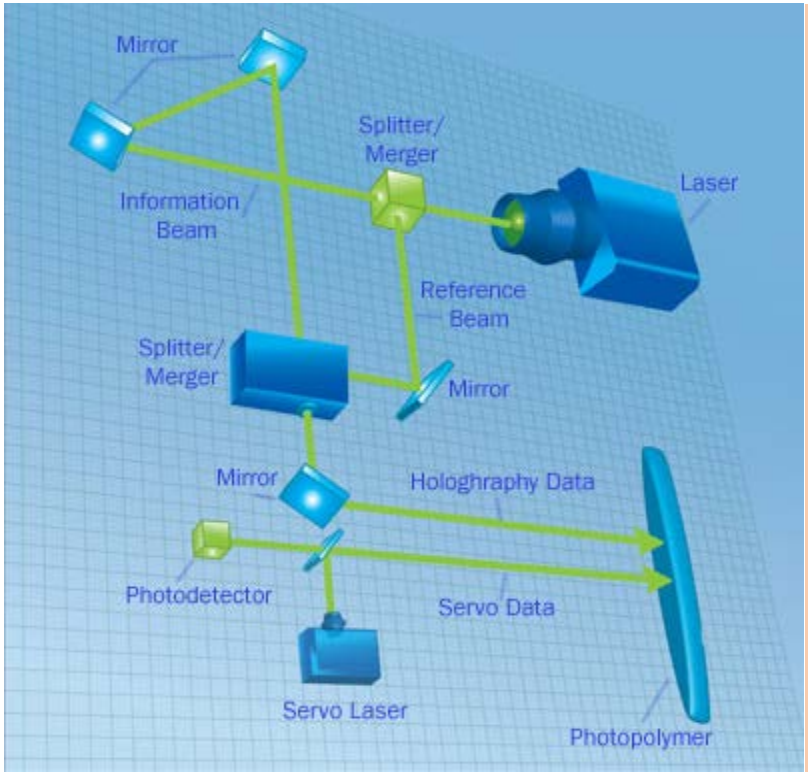
Other layers: Oxygen Barrier layer, Access layer, Bonding layer, Servo layer

Figure 6: Cross section of HVD Disc showing patent distribution (Image Source)

5.2 How HVD works?

Holography stores a three-dimensional volume of data with each flash of light. Each such pulse of light is called a page, with the data represented as a two-dimensional pattern or array. Holography therefore provides parallel access to data, and even multiplexed storage in the same location. In holographic data storage, the laser beam is divided into a signal beam and a reference beam. The signal beam conveys the data, and is combined with the reference beam to create a complex three-dimensional interference pattern that is stored three-dimensionally in the photopolymer storage medium. Out of 273 relevant patents analyzed, 89 patents focus on the writing/ reading methods of HVD system.

5.2.1 Writing data on HVD



A simplified HVD system consists of the following main components:

Blue or green laser, Beam splitter/merger, Mirrors, Spatial light modulator (SLM), CMOS sensor, Photopolymer recording medium

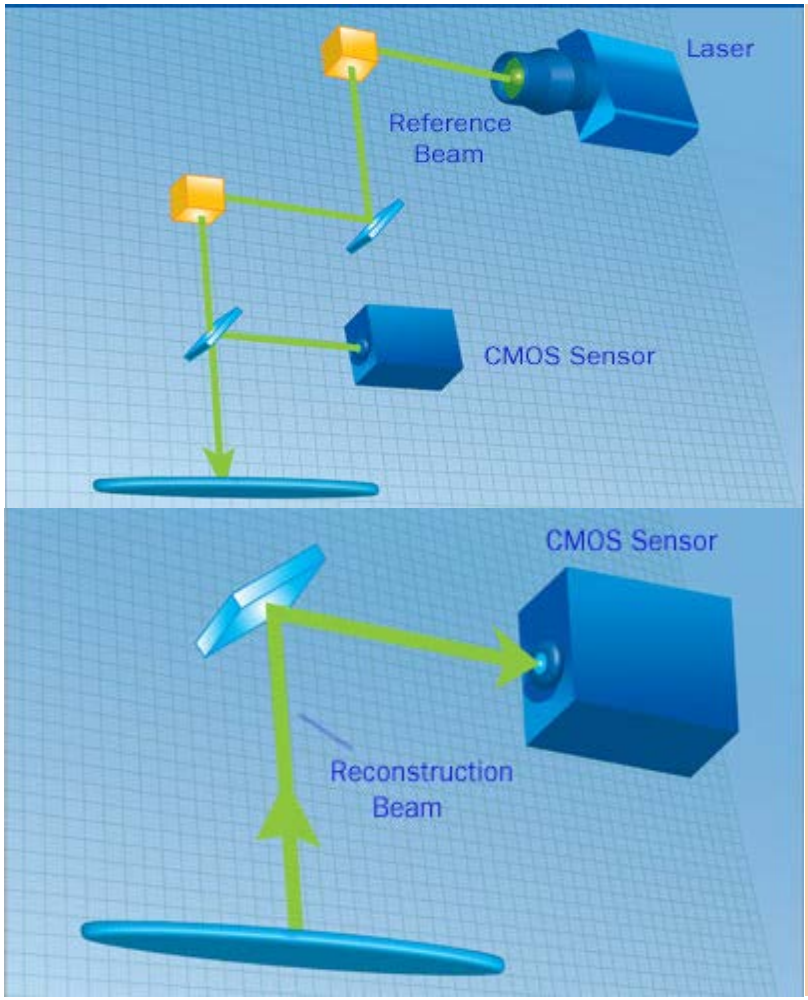
The process of writing information onto an HVD begins with encoding the information into binary data to be stored in the SLM. These data are turned into ones and zeroes represented as opaque or translucent areas on a "page" -- this page is the image that the information beam is going to pass through. Once the page of data is created, the next step is to fire a laser beam into a beam splitter to produce two identical beams. One of the beams is directed away from the SLM -- this beam becomes the reference beam. The other beam is directed toward the SLM and becomes the information beam. When the reference beam and the information beam rejoin on the same axis, they create a pattern of light interference -- the holography data. This joint beam carries the interference pattern to the photopolymer disc and stores it there as a hologram.

Source: Link

Note: Out of 89 patents analyzed for writing/reading methods, 79% patents disclose writing methods of HVD system.

Figure 7: Method of writing data on HVD

5.2.2 Reading data from HVD



HVD Read system

In the HVD read system, the laser projects a light beam onto the hologram -- a light beam that is identical to the reference beam (Read System 1). The hologram diffracts this beam according to the specific pattern of light interference it's storing. The resulting light recreates the image of the page data that established the light-interference pattern in the first place. When this beam of light -- the reconstruction beam -- bounces back off the disc (Read System 2), it travels to the CMOS sensor. The CMOS sensor then reproduces the page data.

Source: Link

Note: Out of 89 patents analyzed for writing/reading methods, 57% patents disclose reading methods of HVD system.

Figure 8: HVD Read System

6. Technical Analysis

6.1 IPC Class based Analysis

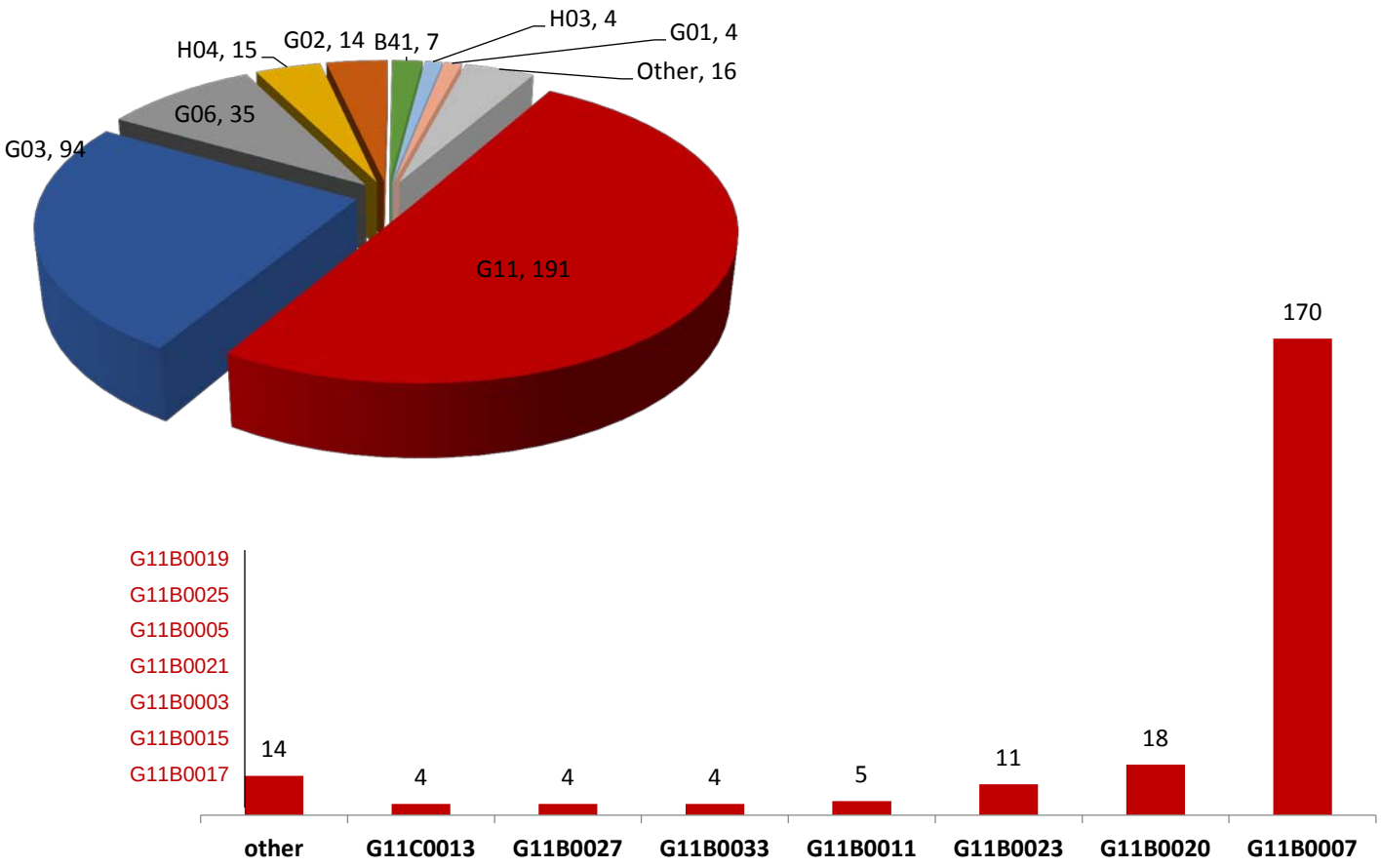


Figure 9: Patent Distribution based on IPC classes, further showing major sub-classes of G11 IPC Class

6.2 IPC Class Definitions

IPC Class	Class Definition
G11C 13/00	Physics: Information Storage: Static Stores: Digital stores characterized by the use of storage elements
G11B 27/00	Physics: Information Storage: Information Storage Based On Relative Movement Between Record Carrier And Transducer: Editing; Indexing; Addressing; Timing or synchronizing; Monitoring; Measuring tape travel
G11B 33/00	Physics: Information Storage: Information Storage Based On Relative Movement Between Record Carrier And Transducer: Constructional parts, details or accessories
G11B 11/00	Physics: Information Storage: Information Storage Based On Relative Movement Between Record Carrier And Transducer: Recording on, or reproducing from, the same record carrier
G11B 23/00	Physics: Information Storage: Information Storage Based On Relative Movement Between Record Carrier And Transducer: Record carriers not specific to the method of recording or reproducing; Accessories, e.g. containers, specially adapted for co-operation with the recording or reproducing apparatus
G11B 20/00	Physics: Information Storage: Information Storage Based On Relative Movement Between Record Carrier And Transducer: Signal processing not specific to the method of recording or reproducing; Circuits therefore
G11B 7/00	Physics: Information Storage: Information Storage Based On Relative Movement Between Record Carrier And Transducer: Recording or reproducing by optical means, e.g. recording using a thermal beam of optical radiation, reproducing using an optical beam at lower power; Record carriers therefore

Table 2: IPC Class Definitions

6.3 Feature wise Patent Distribution Analysis

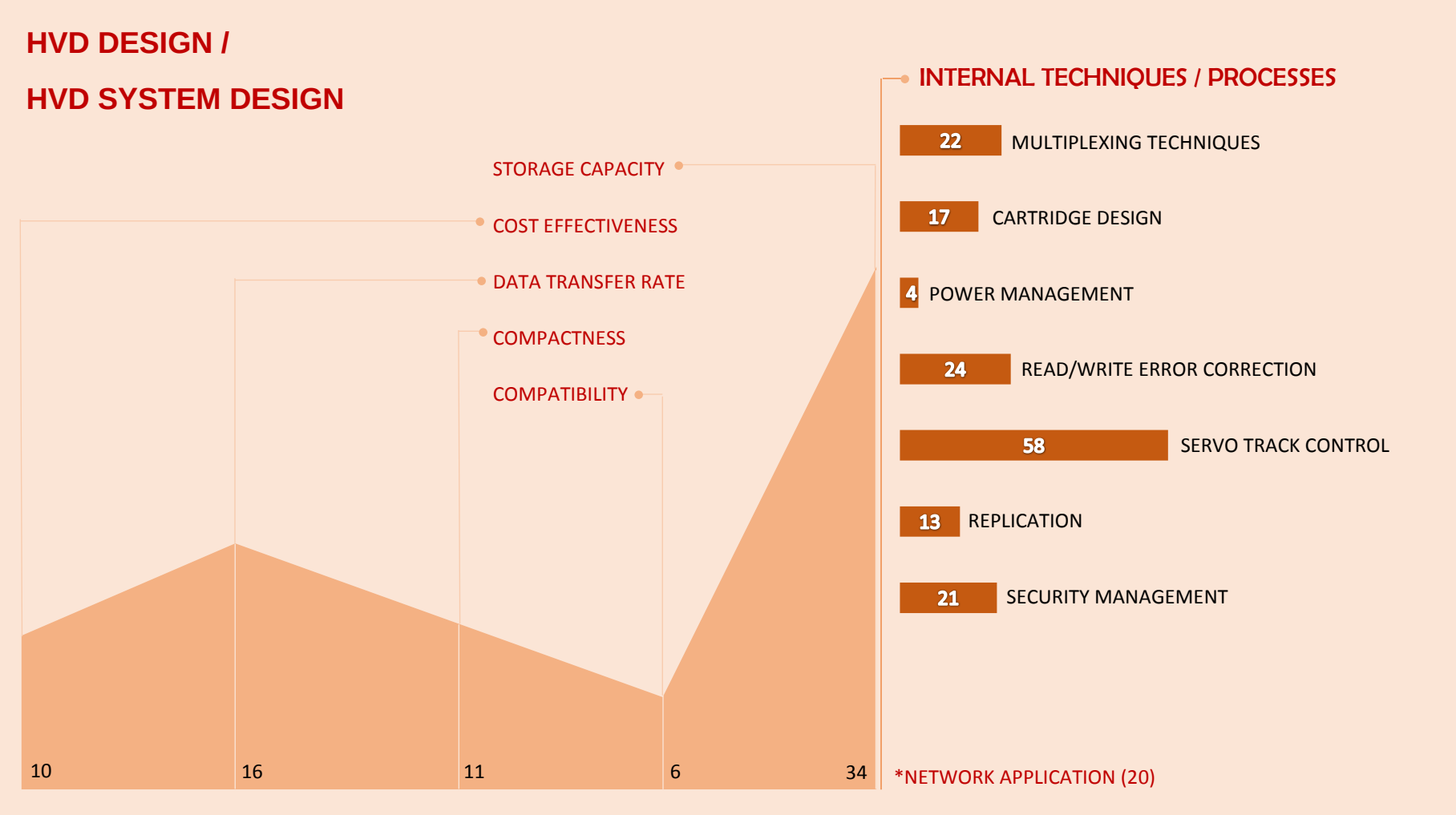


Figure 10: Feature wise Patent Distribution Analysis

7. Assignee Analysis

7.1 Major Assignees and Inventors

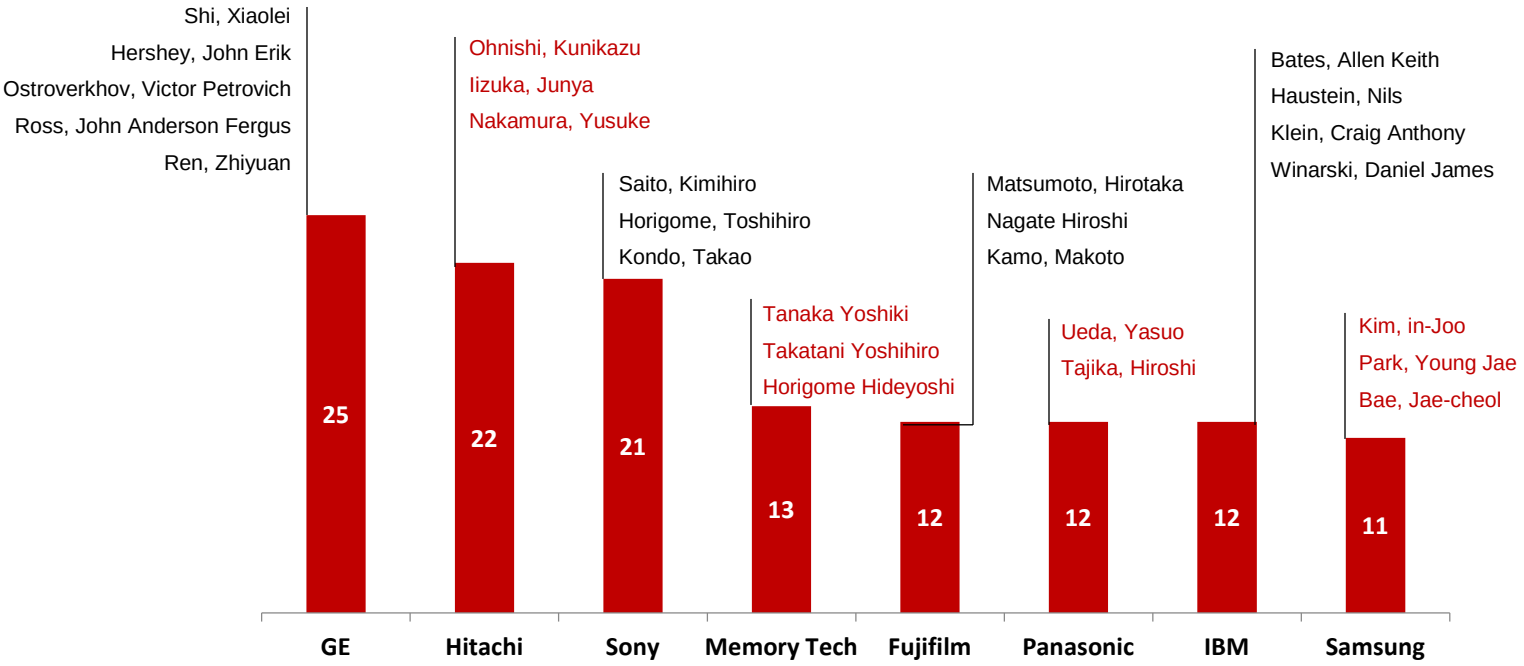


Figure 11: Patent portfolio of dominant assignees in the field of HVD Technology

Figure 11 shows the patent distribution for major assignees in the field of HVD Technology along with their top inventors. Clearly, GE, Hitachi and Sony have emerged as big players in development of HVD Technology.

7.2 Top Assignees: Citation Analysis

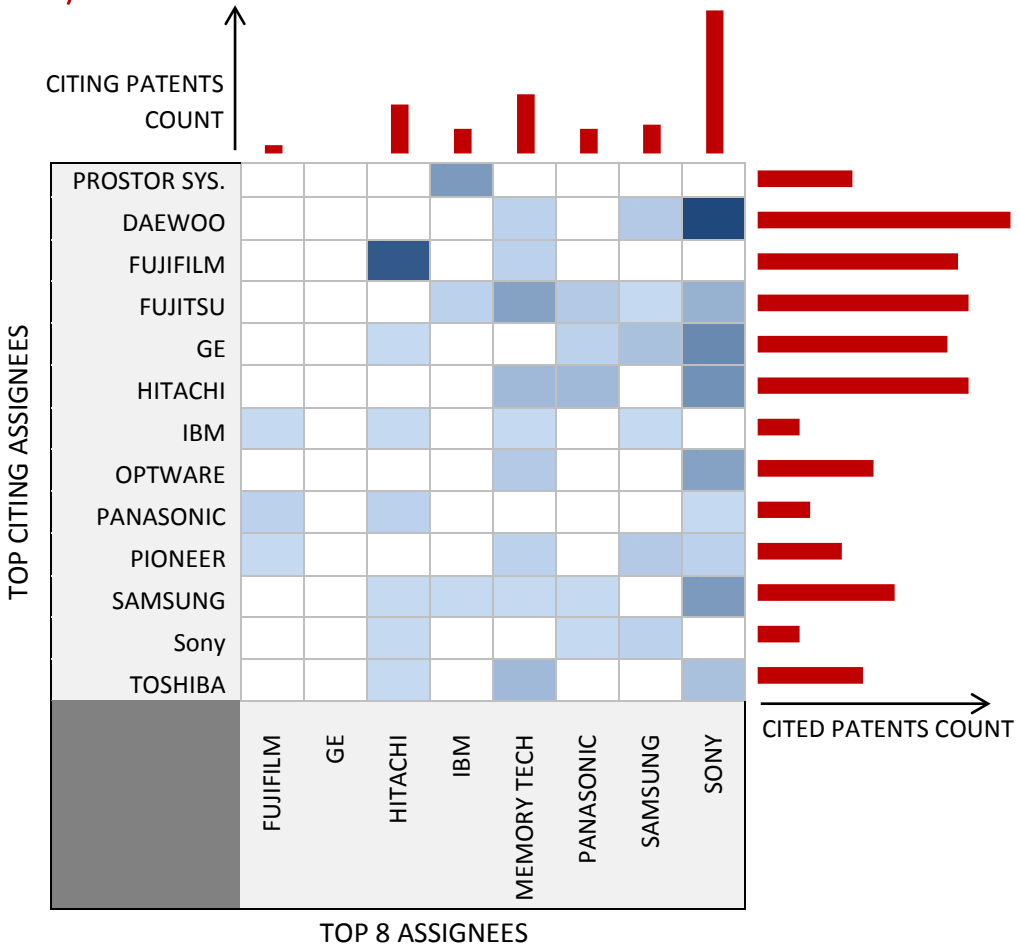


Table 3: Top Assignee Citation Analysis

Table 3 represents the correlation between the top 8 assignees and their top citing assignees. For example, Daewoo is citing maximum number of patents filed by Sony in HVD technology (as denoted by the darker gradient of blue color).

INPADOC Family ID	Assignee	Citations	Technical Area
20080320WO2008032865A1	Sony	18	Optical disc apparatus focus position control method and recording medium.
20060908WO2006093196A1	Panasonic	12	Holographic optical information recording/reproducing device & method used in an external storage unit of a computer, a video/sound information storage unit or the like.
20040325DE20215634U1	IBM	11	Method for generating a hologram on a disc surface.
20050915KR2005091617A	Samsung	11	Hologram recording medium having phase difference layers arranged above and below recording layer, respectively, to convert polarization of object and reference beams.
20080306US20080059144A1	Hitachi	11	Monocular holographic data storage system architecture.
20070425CN1952869A	IBM	7	Apparatus, system, and method for writing data to protected partitions of storage media.
20060622JP2006162928A	Sony	7	Hologram-recording apparatus having a controller that changes incidence angle value during change in hologram row produced through continuous multiplex recording.
20070322US20070064578A1	Fujifilm	6	Photosensitive recording medium, and recording and reproducing apparatus for same.
20060727US20060166104A1	Hitachi	6	Holographic recording medium and method of making it.
20040603JP2004158113A	Memory tech	5	Optical disk having marks for positioning of holograms in reflection layer of recording area

Table 4: Top 10 Cited Patents for major assignees

Table 4 represents the top 10 cited patents by 8 major assignees in the field of HVD Technology along with the number of forward citations and the technical domain covered by them. The analysis doesn't include the self-citations for e.g. if an assignee cites a patent of its own portfolio, that citation is kept out of consideration.

7.3 Relative Specialization Index: Assignee based

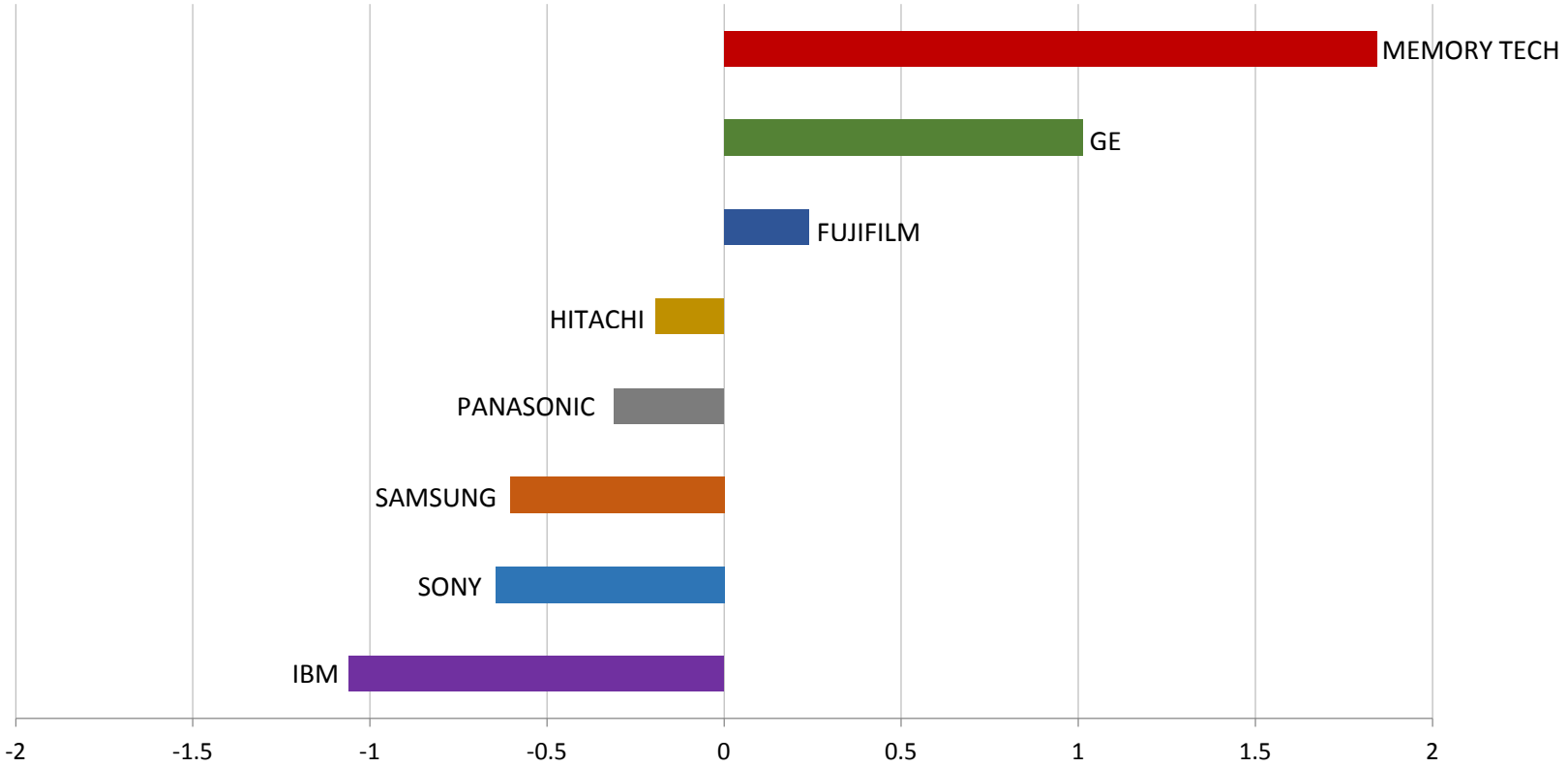


Figure 12: Relative specialization index- Assignee based

Relative Specialization Index (RSI) for top assignees are calculated and shown in Figure 12. RSI of assignees gives an indication of the level of invention in Holographic Versatile Disc for each assignee compared to the overall level of invention in 'Optical discs' by that assignee. Memory tech's RSI is highest as out of its overall patenting activity in 'Optical discs', it has the maximum patenting activity focused on HVD only.

7.4 Assignee - Technical Analysis

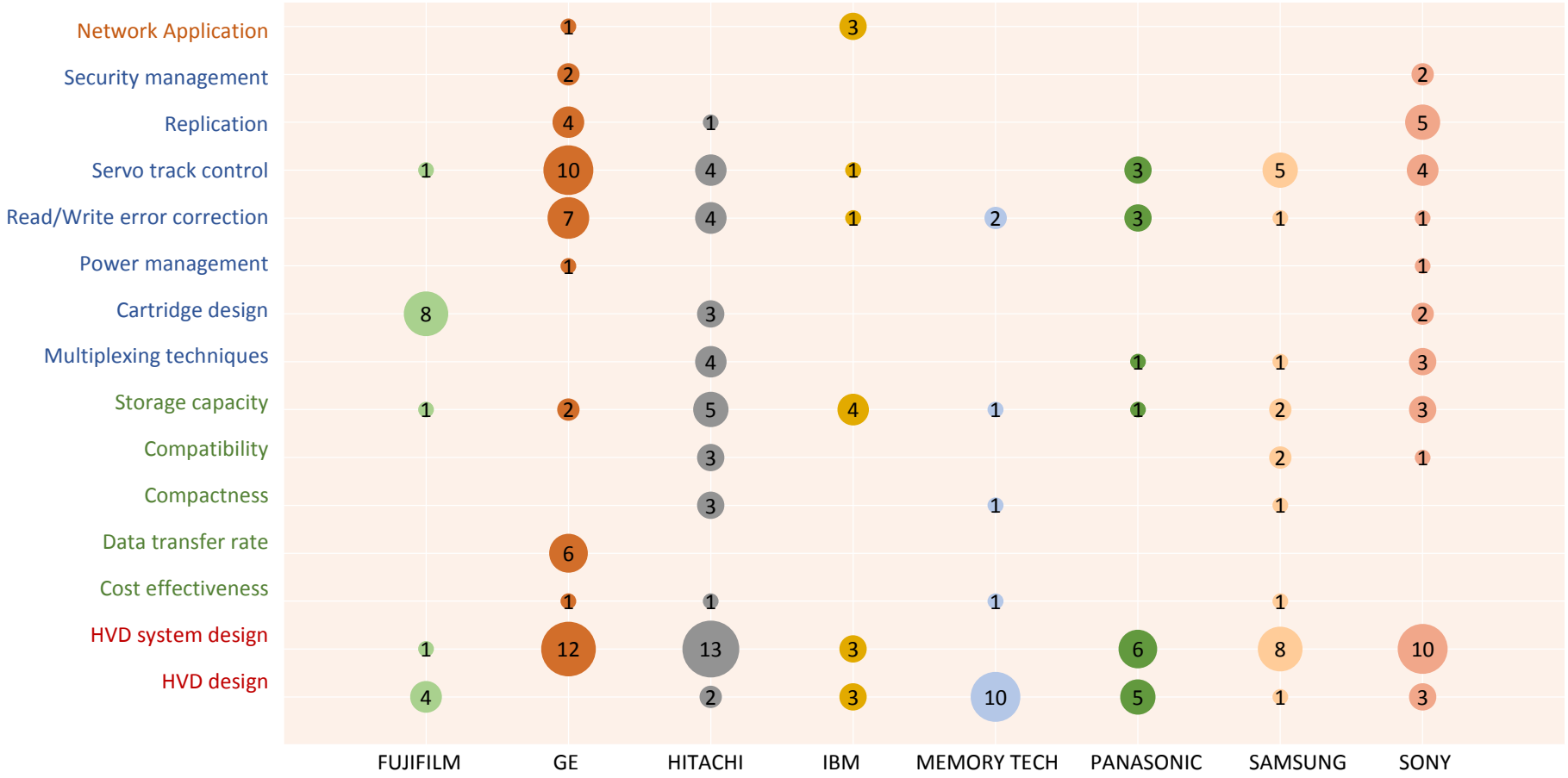


Figure 13: Assignee technical analysis

Figure 13 reveals the number of patents filed by an assignee in the HVD technology relating to the various technology heads. Sony and Hitachi have patent filings covering almost all aspects of HVD technology. The white spaces can be seen in power management and network application domains.

8. Feature-wise patent protection in different jurisdictions

Feature/Country	US	JP	CN	EP	WO	KR	TW	DE	CA	AT	AU	GB
HVD system design	83	80	42	38	22	27	13	13	7	5	2	3
Servo track control	53	46	33	25	11	21	13	6	7		1	1
HVD design	39	44	19	23	19	8	4	8	2	5	2	
Storage capacity	28	25	14	14	8	6	5	2	2			
Multiplexing techniques	18	19	11	11	7	5	3	2		2		
Read/Write error correction	18	19	11	6	3	7	5		2	1		2
Network Application	18	5	6	8	8	4	1	2	1	2	3	
Data transfer rate	15	9	7	9	5	5	4		3			
Security management	20	5	4	7	13	2	2				1	1
Replication	10	13	6	6	1	5	3		3			
Cartridge design	8	16	1	3	2	2		2				
Cost effectiveness	8	9	3	4		4	1	2	1			
Compactness	8	11	3	3	1	1		2		2		
Compatibility	5	4	4	2	2	2	1	1		1		
Power management	3	3	1		1	1	1					1

Hot Zone
High feature protection zone

Warm Zone
Moderately protected zone

Cold Zone
White spaces

Table 5: Country wise Feature Protection Analysis by count

Table 5 represents the heat map of the number of patents filed under various technical heads in different jurisdictions. This analysis is performed by considering one member per jurisdiction for a particular INPADOC family. The analysis shows the amount of patent activity done for a particular technological feature in a particular country. This analysis helps in identifying white spaces, where the technology is yet to be protected (denoted by “Cold Zone”). It also identifies high feature protection zones, where the technology is highly protected (denoted by “Hot Zone”) E.g. “servo track control” feature is highly protected in US, Japan and China. Using this information companies can place them in international market and even plan their future patent activity.

About Us

LexInnova provides advanced patent litigation consulting and technical services that allow innovative clients to improve quality, drive profitability, and enhance the effectiveness of legal matters. LexInnova draws on a combination of technical and project management expertise to solve the challenges that arise at the intersection of technology and the law. From pre-litigation assessment through claim construction and trial, LexInnova provides consulting services to help analyze, leverage and protect intellectual property. For high-volume matters, we provide true project management – combining the ideal mix of people, processes, and technology – to improve the ability of our clients to optimize their litigation.

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