
Holographic Storage Patent Portfolio

Northrop Grumman Corporation
Electronic Systems
Patent Information Package

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Contents

- Summary of offering
- Portfolio description
 - Key claims of exemplary patents
 - Forward references
- Patent landscape
- Market landscape
- Sale process

Holographic storage portfolio offered for sale by Northrop Grumman

- Seventeen US issued patents
 - Early inventions in holographic storage, filed between 1991 and 2002
 - Three have Europe and Japan counterparts
- Broad claims related to use of optical beams to address volume holograms on a storage medium such as a spinning disk
 - Multiplexers
 - Light modulators
 - Methods for improving signal-to-noise ratios
 - Media
- Large number of citations by major players in field
- Holographic storage products have been available in the commercial market for several years, and the market for these types of products is expected to experience high growth during the term of this portfolio

Portfolio contents

US Patent Number	Title	Filing Date	Forward References
5,235,439	Volume-holographic inner product processor	12/20/1991	9
5,436,867	Holographic random access memory	3/8/1993	10
5,642,210	Method for mitigating cross-talk in high-efficiency holograms	4/12/1995	3
5,648,856	Method for optically fixing holograms in photorefractive materials and a read/write memory based thereon	4/10/1995	8
5,717,508	Method for dynamically refreshing angle-multiplexed holograms in photorefractive media	4/13/1995	1
5,793,504	Hybrid angular/spatial holographic multiplexer	8/7/1996	74
5,877,875	Reference beam auto-focus apparatus for modularized volume-holographic memory	5/28/1997	5
5,896,359	Spinning disc volume holographic memory	3/18/1997	5
5,902,519	Process for oxidizing iron-doped lithium niobate	3/18/1997	1
5,914,802	Combined spatial light modulator and phase mask for holographic storage system	7/18/1997	7
5,963,346	Scatter noise reduction in holographic storage systems by two-step write	12/12/1997	2
5,966,361	Spinning disc volume holographic memory	1/6/1998	9
6,016,210	Scatter noise reduction in holographic storage systems by speckle averaging	12/15/1997	5
6,115,123	Holographic laser aimpoint selection and maintenance	4/12/1999	6
6,118,560	Scatter noise reduction in holographic storage systems by signal-noise orthogonalization	2/6/1998	4
6,418,106	Spinning disc volume holographic memory	8/13/1999	3
6,652,780	Process for oxidizing iron-doped lithium niobate	3/6/2002	0

US 5,436,867 “Holographic random access memory”

Inventor : Mok

- Priority date : 3/8/1993
- Filing date : 3/8/1993
- Issue date : 7/25/1995
- Expiration date : 3/8/2013
- Claims : 18
- Independent claims: 3
- Non US coverage : None
- Forward references : 10

Claim 10 : A spatial multiplexer for use with a holographic storage medium for directing a beam of optical radiation onto the storage medium, the storage medium having (n) rows and (m) columns of storage locations, said spatial multiplexer comprising an array of (n times m) discrete reflector elements each having a linear shape and being disposed in a parallel arrangement with one another upon a substrate, and wherein each of said discrete reflector elements has a different angular orientation with respect to one another.

Exemplary patent

US 5,793,504 “Hybrid angular/spatial holographic multiplexer”

Inventor : Stoll

- Priority date : 8/7/1996
- Filing date : 8/7/1996
- Issue date : 8/11/1998
- Expiration date : 8/7/2016
- Claims : 25
- Independent claims: 3
- Non US coverage : None
- Forward references : **74**

Claim 1: A hybrid angular/spatial holographic multiplexer comprising:

- a) a storage medium;
- b) a reference beam scanner for scanning a reference beam spatially through said storage medium;
- c) an object beam scanner for scanning an object beam spatially through said storage medium;
- d) a spatial light modulator for modulating a laser beam to form the object beam;
- e) a phase conjugator for conjugating the reference beam during read-out so as to excite a corresponding conjugate object beam;
- f) a detector array for converting the conjugate object beam into an electrical signal representative thereof; and
- g) wherein said reference beam scanner and said object beam scanner cooperate to form a plurality of angular/spatial multiplexed holograms within said storage medium.

Exemplary patent

US 5,877,875 “Reference beam auto-focus apparatus for modularized volume-holographic memory”

Inventor : Reis, Davis, and Stoll

- Priority date : 4/12/1995
- Filing date : 5/28/1997
- Issue date : 3/2/1999
- Expiration date : 4/12/2015
- Claims : 8
- Independent claims: 1
- Non US coverage : None
- Forward references : 5

Claim 1: A method for addressing a hologram stored in a storage media, said method comprising the steps of:

- a) directing a reference beam to a linear array of beam splitters;
- b) each beam splitter of the array directing a portion of the reference beam to a different location proximate a reference plane within a common storage medium;
- c) focusing the reference beam so as to obtain a substantially flat wavefront within the reference plane of the storage medium; and
- d) said reference beam reading a hologram stored within the storage medium.

Exemplary patent

US 5,896,359 “Spinning disc volume holographic memory”

Inventor : Stoll

- Priority date : 3/18/1997
- Filing date : 3/18/1997
- Issue date : 4/20/1999
- Expiration date : 3/18/2017
- Claims : 32
- Independent claims: 10
- Non US coverage : None
- Forward references : 5

Claim 18: A method for reading volume holograms, the method comprising the steps of:

- a) spinning a disk comprised of photo-refractive medium about an axis thereof, said disk having an outer edge;
- b) directing a reference beam through the outer edge of the disk;
- c) directing the reference beam onto a phase conjugator after the reference beam has passed through the disk, the phase conjugator directing a conjugate reference beam back through the disk, so as to form a conjugate object beam; and
- d) sensing the conjugate object beam and converting the conjugate beam into an electronic signal representative thereof.

Exemplary patent

US 5,966,361 “Spinning disc volume holographic memory”

Inventor : Stoll

- Priority date : 3/18/1997
- Filing date : 1/6/1998
- Issue date : 10/12/1999
- Expiration date : 3/18/2017
- Claims : 12
- Independent claims: 3
- Non US coverage : None
- Forward references : 9

Claim 7: A holographic storage medium comprising:

- a) photorefractive material configured as a disk having an upper surface, a lower surface, and an outer edge;
- b) said upper surface having a first groove formed therein; and
- c) said lower surface having a second groove formed therein;
- d) wherein said first and second grooves define a generally hourglass-like cross section of said disk.

Exemplary patent

US 6,418,106 “Spinning disc volume holographic memory”

Inventor : Stoll

- Priority date : 3/18/1997
- Filing date : 8/13/1999
- Issue date : 7/9/2002
- Expiration date : 3/18/2017
- Claims : 5
- Independent claims: 3
- Non US coverage : None
- Forward references : 3

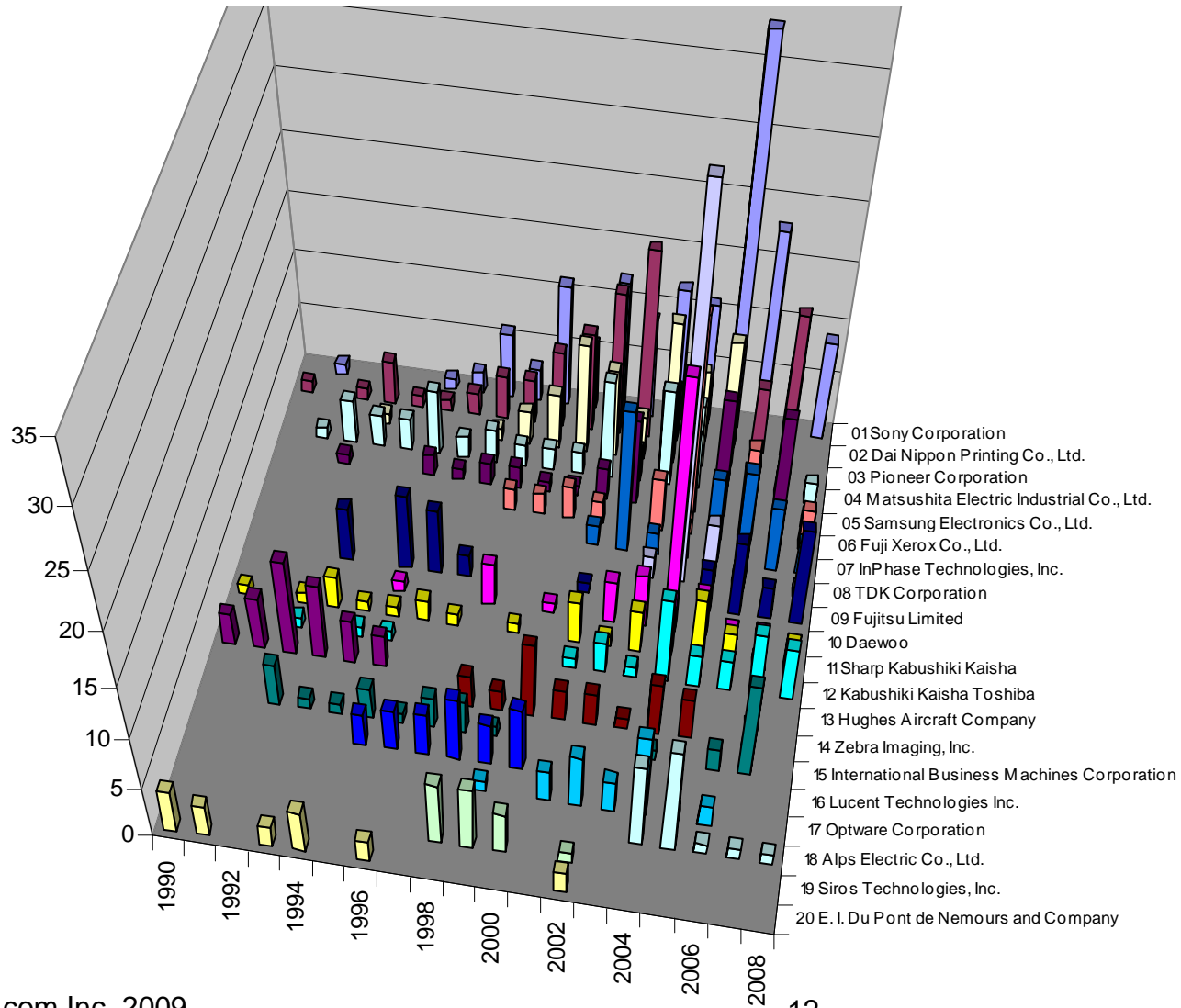
Claim 1: A volume holographic memory comprising:

- a) a disk comprised of photorefractive medium, said disk having an outer edge and a central opening;
- b) object beam optics configured to direct an object beam through the outer edge of said disk;
- c) reference beam optics configured to direct a reference beam through the outer edge of said disk; and
- d) a sensor for measuring the intensity with which the holograms are formed;
- e) wherein said object beam and said reference beam cooperate within said photorefractive medium to sequentially form a plurality of volume holograms therein, said disk spinning as the holograms are formed.

Forward references - select assignees

Qualcomm MEMS Technologies, Inc./ Iridigm Display Corporation	57
Pioneer Electronic Corporation	6
Daewoo Electronics Corp.	6
Siros Technologies, Inc.	5
Lenslet Ltd.	4
Tesa Scribos GmbH	4
DigiLens, Inc.	2
General Electric Company	2
Inphase Technologies, Inc.	2
Nippon Telegraph & Telephone Corporation	2
Lucent Technologies Inc.	2
International Business Machines Corporation	1
Fuji Photo Film Co., Ltd.	1
Compound Photonics U.S. Corporation	1
Micron Technology, Inc.	1
NEC Research Institute, Inc.	1
Imation Corp.	1
Brilliant Corporation	1
Digital Software Corporation	1
Canon Kabushiki Kaisha	1
Sony Corporation	1
Tamarack Storage Devices, Inc.	1
The Boeing Company	1
Fuji Xerox Co., Ltd.	1
Other	21
Total	126

Frequent patentees in holography



Market landscape

The market for holographic storage appears to be growing and evolving as evidenced by recent product and technology announcements by:

- GE

- <http://www.genewscenter.com/Content/Detail.asp?ReleaseID=6676&NewsAreaID=2>

- Sony

- http://techon.nikkeibp.co.jp/english/NEWS_EN/20070528/133217/

- InPhase Technologies

- <http://www.inphase-technologies.com/>

- Daewoo Electronics

- <http://www.dailytech.com/article.aspx?newsid=1878>

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