

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**RESONAC HARD DISK CORPORATION and
RESONAC CORPORATION,**
Petitioners,

v.

MR TECHNOLOGIES GMBH,
Patent Owner.

Case No. IPR2026-00015
U.S. Patent No. 11,138,997

DECLARATION OF JIAN-GANG ZHU, PH.D.

U.S. PATENT NO. 11,138,997 (CLAIMS 1-2, 4-7, and 9)

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EXHIBIT LIST

EXHIBITS FILED BY PETITIONERS	
Ex-1001	U.S. Patent No. 11,138,997 (“’997 Patent”)
Ex-1002	File History of the ’997 Patent
Ex-1003	Declaration of Dr. Jian-Gang Zhu
Ex-1004	CV of Dr. Jian-Gang Zhu
Ex-1005	U.S. Patent No. 8,329,321 (“Takenoiri”)
Ex-1006	U.S. Patent No. 6,834,026 (“Fullerton”)
Ex-1007	W. K. Shen et al., <i>Composite perpendicular magnetic recording media using [Co/PdSi]_n as a hard layer and FeSiO as a soft layer</i> . Journal of applied physics 97.10 (2005) (“Shen”)
Ex-1008	D. Suess et al., <i>Exchange Spring Recording Media for Areal Densities Up to 10 Tbit/in²</i> , Journal of Magnetism and Magnetic Materials 290 (2005): 551-554. (“Suess 2004”)
Ex-1009	A. Yu Dobin et al., <i>Domain wall assisted magnetic recording</i> . Applied Physics Letters 89.6 (2006). (“Dobin”)
Ex-1010	Reserved
Ex-1011	D. Suess et al., <i>Exchange spring media for perpendicular recording</i> . Applied Physics Letters 87.1 (2005). (“Suess 2005”)
Ex-1012	U.S. Patent No. 9,928,864 (“the ’864 Patent”)
Ex-1013	File History of the ’864 Patent
Ex-1014	Reserved
Ex-1015	Reserved

Ex-1016	U.S. Patent No. 5,536,570 (“Osato”)
Ex-1017	C. M. Christensen, <i>The rigid disk drive industry: A history of commercial and technological turbulence</i> . Business history review 67.4 (1993): 531-588.
Ex-1018	P. Gourevitch, R. Bohn, and D. McKendrick. <i>Globalization of production: insights from the hard disk drive industry</i> . World development 28.2 (2000): 301-317.
Ex-1019	<i>MR Technologies GmbH v. Western Digital Technologies, Inc.</i> , 8:24-cv-01848 (C.D. Cal.), Dkt. No. 195, Claim Construction Order
Ex-1020	S. Okamoto et al., <i>The anisotropy field of FePt L10 nanoparticles controlled by very thin Pt layer</i> . Journal of Physics: Condensed Matter 16.12 (2004): 2109.
Ex-1021	WIPO Patent Publication No. WO 2001/022407 A1
Ex-1022	U.S. Patent No. 7,846,564 (“Li”)
Ex-1023	K. Z. Gao, et al., <i>Magnetic recording configuration for densities beyond 1 Tb/in² and data rates beyond 1 Gb/s</i> . IEEE transactions on magnetics 38.6 (2002): 3675-3683.
Ex-1024	Reserved
Ex-1025	Reserved
Ex-1026	Reserved
Ex-1027	U.S. Patent Application Publication No. 2003/0096127 A1
Ex-1028	T. Shimatsu et al., <i>High perpendicular magnetic anisotropy of CoPtCr/Ru films for granular-type perpendicular media</i> . IEEE transactions on magnetics 40.4 (2004): 2483-2485.
Ex-1029	I. Kaitsu, R. Inamura, J. Toda, and T. Morita, <i>Ultra High Density Perpendicular Magnetic Recording Technologies</i> , Fujitsu Science and Technology Journal, vol. 42, No. 1, p.122-130 (January 2006).

Ex-1030	G. Asti et al., <i>Magnetic phase diagram and demagnetization processes in perpendicular exchange-spring multilayers</i> , 73 Phys. Rev. B 094406 (2006).
Ex-1031	S.S.P. Parkin, <i>Systematic Variation of the Strength and Oscillation Period of Indirect Magnetic Exchange Coupling through the 3d, 4d, and 5d Transition Metals</i> , 67 Phys. Rev. Lett. 398 (1991).
Ex-1032	M. Zheng et al., <i>Role of Oxygen Incorporation in Co-Cr-Pt-Si-O Perpendicular Magnetic Recording Media</i> . IEEE Transactions on Magnetics, 40.4 (2004): 2498-2500.
Ex-1033	Reserved
Ex-1034	CV of Sylvia Hall-Ellis, Ph.D.
Ex-1035	Reserved
Ex-1036	Declaration of Sylvia Hall-Ellis, Ph.D.

I, Jian-Gang Zhu, declare as follows:

I. ENGAGEMENT

1. I have been retained by Resonac Hard Disk Corporation and Resonac Corporation (“Resonac” or “Petitioners”) in connection with the petition for *Inter Partes* Review (“IPR”) of U.S. Patent No. 11,138,997 (“the ’997 Patent,” Ex-1001), which I may refer to subsequently as the “challenged patent.” I understand that the ’997 Patent has a sole inventor, Dr. Dieter Suess. I understand the ’997 Patent is currently assigned to MR Technologies GmbH (“Patent Owner” or “PO”).

2. I have been asked by Petitioners to offer opinions regarding the ’997 Patent, including the unpatentability of claims 1-2, 4-7, and 9 of the ’997 Patent, which I may refer to subsequently as the “challenged claims” in view of certain prior art. This declaration sets forth the opinions I have reached to date regarding these matters.

3. I am being compensated by Petitioners at my standard hourly consulting rate for my time spent on this matter. My compensation is not contingent on the outcome of the IPR or on the substance of my opinions.

4. I have no financial interest in Petitioners or Patent Owner.

II. PROFESSIONAL BACKGROUND

5. My qualifications are set forth in my curriculum vitae, a copy of which is attached as an Exhibit 1004. Exhibit 1004 also includes a list of my publications and the cases in which I have testified at deposition, hearing, or trial within the past four years. As set forth in my curriculum vitae:

6. I received my B.S. degree in Physics from Huazhong University of Science and Technology in China in 1982, and my M.S. degree and Ph.D. degrees, both in Physics, from the University of California at San Diego in 1983 and 1989, respectively. I was a faculty member as an assistant professor and later associate professor in the Department of Electrical Engineering at University of Minnesota from 1990 to 1996 prior coming to Carnegie Mellon where I became a full professor in 1998.

7. I'm currently the Director at the Data Storage Systems Center and a full Professor in the Department of Electrical and Computer Engineering at Carnegie Mellon University. At Carnegie Mellon, I was awarded the ABB endowed chair professor in Electrical and Computer Engineering in 2003 and I also hold courtesy professorship in Materials Science and Engineering and Physics.

8. My research has been in the field of magnetic data storage technologies. I have been conducting cutting edge research on magnetic thin film media for hard disk drives since 1986 when I was a Ph.D. student at Center for

Magnetic Recording Research in University of California, San Diego. I have pioneered the research on utilizing micromagnetic modeling for MRAM memory design and established some of the most fundamental design principles used today. For example, I was the first one to propose the non-magnetic grain boundary microstructure for disk media in 1987, which has been adopted by industry ever since and still today. My 2011 paper “SNR Enhancement in Segmented Media” provided clear insights and underlying physics on how exchange coupled layered thin film media enhances recording density performance. My extensive research in magnetics, magnetic materials, and material microstructures has established me as a leading expert in this field.

9. I am a recipient of the 1993 National Science Foundation Presidential Young Investigator Award. I also received the McKnight Land Grant Professorship from the University Minnesota Board of Regents in 1993. As a co-inventor of the CPP/GMR read sensor patent, I received the 1996 R&D100 Award. I was IEEE Distinguished Lecturer in 2004. I had also been on the Advisory Editorial Board for the Journal of Magnetism and Magnetic Materials, North-Holland, Elsevier from 1998 to 2008. Because of my contributions to hard disk drive technology, I was awarded IEEE Magnetic Society Achievement Award in 2011 and this award is the highest award in Magnetic Society.

10. I have, and continue to, teach classes in the magnetic recording, such as Data Storage Systems Design Project, Magnetic Materials and Devices, and Advanced Applied Magnetism. Over the course of my career, I have supervised and graduated 56 Ph.D. students (and many more M.S. students) in Materials Science, Physics, and Electrical and Computer Engineering with most of them now working in hard disk drive industry. I have presented over 100 invited papers at various international conferences, mainly on hard disk drive technologies. I have authored or co-authored over 350 peer reviewed journal papers in the field of magnetism and magnetic recording technology.

11. Additional information regarding my background, qualifications, publications, and presentations is provided in my CV (Exhibit 1004).

III. MATERIALS REVIEWED

12. In forming my opinions, I have reviewed the challenged patent and considered each of the documents listed in the Exhibit List above and all other materials discussed herein. In reaching my opinions, I have relied upon my experience, knowledge, and physical insights in the field and also considered the viewpoint of a person of ordinary skill in the art as of the time of the earliest claimed priority date of the challenged patent, *i.e.*, June 17, 2006. As explained below, I am familiar with the level of a person of ordinary skill in the art regarding

the technology at issue as of that time and all of the opinions I have formed have been assessed from the perspective of such a person of ordinary skill in the art.

IV. DESCRIPTION OF THE RELEVANT TIMEFRAME, THE RELEVANT FIELD, AND A PERSON OF ORDINARY SKILL IN THE ART

13. I understand that the '997 Patent was filed on March 19, 2018 and through the '864 Patent claims the benefit of Patent Appl. NO. 11/424,859, now U.S. 9,978,413, filed on June 17, 2006.

14. Thus, for purposes of my analysis, I have treated June 17, 2006 as the relevant priority date for the challenged patent. I reserve the right to update my analysis should Patent Owner assert a different priority date.

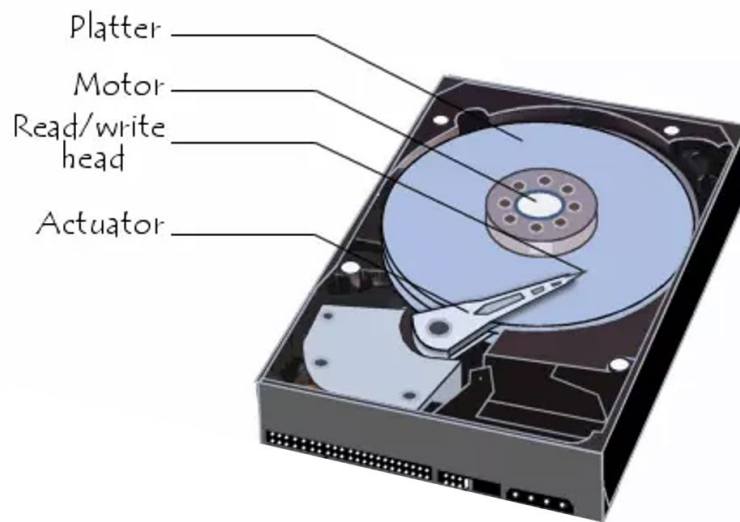
15. I have received and understand the specification, claims, and file history of the challenged patent.

16. In my opinion, a person having ordinary skill in the art ("POSITA") at the time of the effective filing date of the challenged patent was a person holding at least a master's degree in Physics, Materials Science, or Electrical Engineering with at least two years training or experience with magnetic recording, such as hard disk drives. My opinions presented herein are as viewed through the eyes of a POSITA prior to June 17, 2006.

V. TECHNOLOGY BACKGROUND

A. Hard Disk Drive

17. A hard disk drive (HDD) is an electromechanical data storage device that uses magnetic storage to store and retrieve digital information. It is a type of non-volatile storage, meaning it retains its stored data even when the power is turned off. Below is an illustration of a typical HDD.



18. An HDD includes one or more rigid, circular disks (typically made of glass, ceramic, or aluminum alloy) stacked very close to one another and called **platters**. The platters are coated with magnetic material and are the physical medium where all the data is stored. The **spindle motor** is a motor located in the center of the drive that holds the platters. It rotates the platters at a high and constant speed, usually measured in revolutions per minute (RPM).

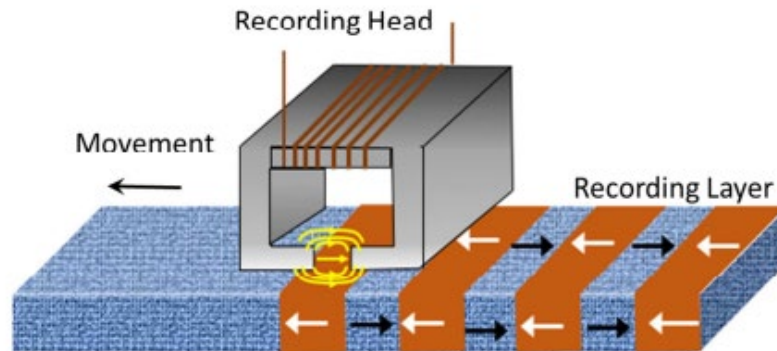
19. Most HDDs have a separate **read and write head** for each side of every platter, which are tiny electromagnets at the end of the actuator arms. They convert data from a magnetic state on the platter into an electrical current (reading) and convert an electrical current into a magnetic field to alter the orientation of magnetic grains within the platter (writing). The heads float on a cushion of air generated by the spinning platters, never actually touching the magnetic surface.

20. The **actuator assembly** includes actuator arms that hold the read/write heads and position them over the correct track on the platters, and a voice coil motor that controls the rapid and precise movement of the arms. The voice coil motor receives commands from the electronics board and uses magnetic fields to precisely move the head assembly across the disk. The precision of this movement is critical for high memory density.

B. From Longitudinal Magnetic Recording (LMR) to Perpendicular Magnetic Recording (PMR)

21. Longitudinal magnetic recording (LMR) is the traditional method for storing data on HDDs, where magnetic bits are aligned horizontally with the spinning disk platter, as shown in the figure illustration below. In the magnetic recording medium where bits are stored, adjacent bits with opposing magnetizations generally are separated by a transition region.

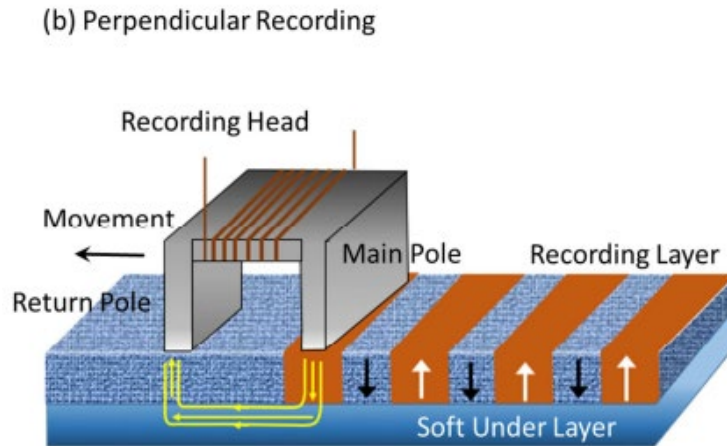
(a) Longitudinal Recording



22. As mentioned, to write data on the magnetic recording medium in HDDs, a write head (also known as recording head) is provided. Typically, the write head includes an electromagnet made of a tiny coil of wire wrapped around a magnetic core, which creates a magnetic field when an electrical current flows through the coil, and this magnetic field alters the polarity of the magnetic material on the disk, creating a bit (a 1 or a 0).

23. However, as data density increases, the smaller grains that store the data become unstable due to the superparamagnetic effect. Superparamagnetic effect (or superparamagnetic limit) refers to the effect where magnetic grains that make up the data bits are so small that their magnetic moment direction can be altered spontaneously simply from thermal agitation in ambient condition without a write head. Ex-1006, 1:54-59. Perpendicular magnetic recording (PMR), where

bits are aligned vertically, as shown in the figure illustration below naturally evolved from efforts attempting to address the superparamagnetic limit.



24. In perpendicular recording, the magnetic grains are oriented vertically, perpendicular to the surface of the disk. The perpendicular magnetic media offers a larger grain volume and stronger magnetic anisotropy with the same grain diameter as compared with LMR media, hence, having greater thermal stability.

C. Composite Magnetic Recording Media

25. As data density continues to increase in PMR, the superparamagnetic limit again becomes a limiting factor for PMR's areal density.

26. To overcome the superparamagnetic limit, which exists in both LMR and PMR, various ways have been proposed to increase the **energy barrier** of the magnetic bits (which represents the energy needed to flip the magnetic state).

With higher energy barriers, the magnetic bits can withstand higher thermal fluctuation, resulting in greater thermal stability.

27. The energy barrier of a magnetic grain/particle with uniaxial anisotropy used in data storage is typically denoted as E_b or ΔE . Under the Stoner-Wohlfarth (SW) model, the energy barrier can be approximated by: $\Delta E \approx KV$, wherein K is anisotropy constant and V is particle volume. The easy axis of the anisotropy refers to the direction within a material along which it is energetically most favorable for the magnetic moments (spins) to align. This direction is the preferred direction of spontaneous magnetization in the absence of an external magnetic field. According to the above formula, the energy barrier can be increased by increasing the anisotropy constant K and/or particle volume V .

28. I should note that increasing the volume of individual magnetic grains (or particle volume V) in the media for enhancing thermal stability is not an option since the increasing grain lateral size will increase medium noise and degrades storage density. In contrast, as storage density of disk drives continue to increase over time, the grain size of the magnetic media needs to be reduced proportionally. Therefore, the anisotropy constant of the magnetic material necessarily needs to increase to maintain thermal stability.

29. However, increasing anisotropy constant K results in an increase in coercivity (also known as coercive field or coercive force), which refers to the strength of the reverse magnetic field required to reduce a magnetic material's magnetization to zero after it has been saturated. Stated differently, the coercivity

is a measure of the strength of the external magnetic field needed to flip the magnetization of a grain after it has been magnetized. For hard disk drives, the coercivity of the recording media is, therefore, a measure of recording field strength needed for re-orienting the media magnetization to store binary bits. A high coercivity is desirable for high thermal stability of the stored binary bits, but only to a certain degree, because conventional write heads are only capable of generating a certain level of magnetic field. An high coercivity (which leads to **high thermal stability**) may result in the media not being writeable by a conventional write head (referred to as **poor writeability** or **poor recordability**). This issue was well recognized before 2006. Dr. Suess, the inventor of the challenged patent, was certainly neither the first to identify or appreciate this issue; nor was he the first to attempt to address it. *See, e.g.*, Ex-1005, Abstract; Ex-1006, 1:54-59; Ex-1007, Abstract; Ex-1036, ¶50; Ex-1009, p. 1; Ex-1036, ¶55.

30. A common solution at the time to address the tension between wanting high thermal stability while still having reasonable writeability was to introduce additional “softer” magnetic recording layer(s) above a hard layer. A magnetic recording layer is considered “softer” when its coercivity and/or anisotropy is lower. By introducing these “softer” layer(s), the existing magnetic recording layer can have high coercivity and/or anisotropy (for itself so that good thermal stability is maintained) while the coercivity of the overall structure is low

(so that better writeability is achieved). Such a multilayer structure is often called composite magnetic recording media because two or more magnetic recording layers are used. What Dr. Suess claims in the challenged patent is merely a specific configuration of composite magnetic recording media, which I will discuss later in more detail.

31. Composite magnetic recording media comprises a stack of magnetic layers, all with uniaxial anisotropy with their easy axes aligned. Adjacent magnetic layers may be separated by a thin non-magnetic layer which facilitates adequate ferromagnetic exchange coupling between the magnetic layers. The anisotropy energy constant varies from magnetic layer to magnetic layer to match with recording head field profile in the direction perpendicular to the medium's horizontal plane to produce best recording performance. Taking a bi-layer structure as an example, such a magnetic recording medium may have a soft layer on top of a hard layer. When an external magnetic field is applied to the soft layer, the soft layer reverses magnetization first and pulls on the hard layer through exchange coupling, assisting in the hard layer's reversal. When the external magnetic field is removed, the magnetization of the soft layer is pulled back into alignment by the hard layer through the exchange interaction, which is the "spring" effect of an "exchange spring." This is why the composite magnetic recording media are also often referred to as exchange spring magnetic recording media. Because the soft

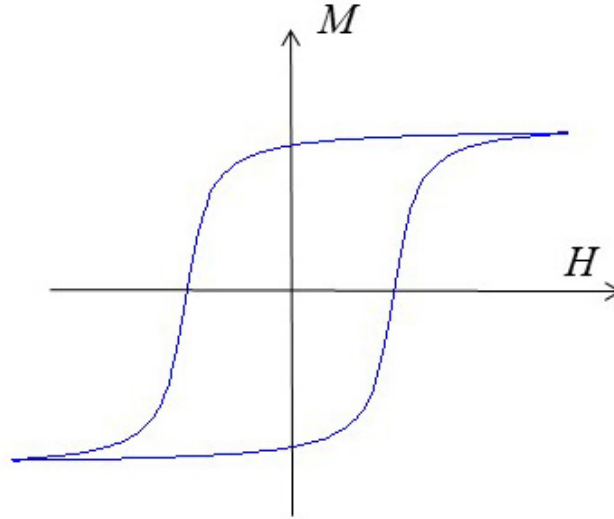
layer assists in the hard layer's reversal (due to exchange coupling between the soft and hard layers), the coercive field of the composite structure is lower than a structure with only the hard layer.

D. The Hysteresis Loop and Relevant Parameters

32. To facilitate discussion of the challenged patent and the prior art references mentioned herein, I will now introduce the parameters relevant to magnetic recording media.

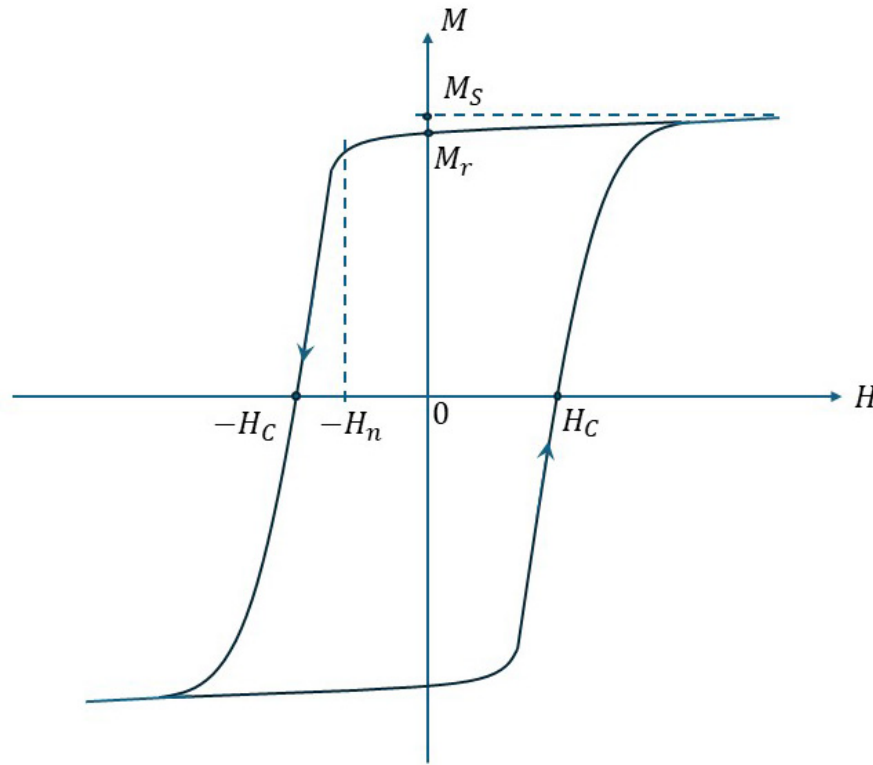
33. In magnetic recording, a variety of parameters are used to characterize the magnetic properties of media and guide design. These properties, many of which can be visualized on a magnetic hysteresis loop, are critical for determining a medium's ability to store information reliably and at high density.

34. A magnetic hysteresis loop is a plot of the medium's magnetization (M) in response to an externally applied magnetic field (H). This loop reveals several key material properties. Below is an illustration of a magnetic hysteresis loop.



35. As shown, the x axis above is an externally applied magnetic field (H), and y axis is the medium's magnetization (M). When the applied magnetic field is changed (i.e., value of x axis going from zero to $\pm H$), the magnetic moments of the material align, increasing the magnetization (i.e., value of y axis going from zero to $\pm M$). The loop shows that a material's magnetization depends not only on the applied field but also on its previous magnetic history—the phenomenon of hysteresis.

36. Now, I will discuss the key parameters of a magnetic recording medium that can be visualized in a magnetic hysteresis loop.



37. As shown, one parameter is **Saturation Magnetization** (M_s), which is the maximum magnetization that a material can achieve when exposed to a very large external magnetic field. At this point, all magnetic moments are aligned with the field, and increasing the field further will not increase the magnetization.

38. Another parameter is **Remanent Magnetization** (M_r), which is the residual magnetization retained in the material after the external magnetic field is removed (i.e., $H=0$), the material retains a residual magnetization. It is a measure of the magnetic recording medium's ability to store a signal permanently. In magnetic recording, the strength of this remanent magnetization directly impacts the strength of the readback signal.

39. Another parameter is **Coercivity** (H_c), which, as mentioned above, is also referred to as coercive field or coercive force. To reduce the material's magnetization back to zero after it has been saturated, an external magnetic field must be applied in the opposite direction. The magnitude of this reverse field is the coercivity (H_c). As discussed above, a high coercivity is desirable for recording media to ensure that recorded data bits are stable and resistant to external magnetic fields or demagnetization effects.

40. A parameter related to coercivity (H_c) is **Switching Field** (H_s), which refers to the specific field at which the magnetization of *a single magnetic grain or particle* reverses direction. The value of the switching field (H_s) for a single particle depends on its intrinsic magnetic properties, such as its anisotropy, as well as external factors like the field's angle and temperature. In contrast, coercivity (H_c) is defined as the reverse magnetic field needed to reduce the *net bulk magnetization of the material* to zero after it has been saturated. For an ideal material composed of identical, non-interacting particles, the coercive field (H_c) would be equal to the switching field (H_s) of a single particle. All particles would switch simultaneously, causing a sharp, square-like hysteresis loop. However, real-world magnetic media consist of a large collection of magnetic grains with a distribution of properties. Also, the magnetic grains interact with each other since each generates a magnetic field. The combination of the property distribution and

the interactions lead to a distribution of switching fields. However, people in the magnetic recording field often do not distinguish between coercive field (H_c) and switching field (H_s) and use them interchangeably. The reason behind is that when magnetization is zero where the coercivity is defined, the average interacting magnetic field among the grains is zero. The coercivity is thus the measure of switching field when nearly 50% of the grains have been switched and the other 50% are not. A POSITA would have understood that this is the case in the Challenged Patents, as well as in many of the prior art references discussed in this declaration. For purposes of this declaration, I also use coercive field (H_c) and switching field (H_s) interchangeably.

41. **Nucleation Field (H_n)** is the lowest field magnitude over which the magnetization reversal starts to significantly occur. It is a measure of the lowest switching field for the grains that can be most easily reversed. Often times, the nucleation field results from the grains which are most susceptible (vulnerable) to thermal agitation. A higher nucleation field implies greater thermal stability of the media.

42. Another parameter is **Squareness** or **Squareness ratio (S_q)**, which is defined as the ratio of the remanent magnetization (M_r) to the saturation magnetization (M_s) ($S_q = M_r / M_s$). This parameter indicates how “square” the hysteresis loop is. A high squareness value is preferred for magnetic recording

because it indicates that most of the material's magnetization is retained after the writing field is removed, resulting in a strong and well-defined recorded bit.

43. Referring back to the hysteresis loop I have shown above, I will now explain how to interpret a hysteresis loop. Starting with applying a very large external magnetic field in the direction perpendicular to the film media, the magnetization of all the magnetic grains in the media are aligned in the field direction to produce a saturation magnetization, M_s , provided that the field magnitude is sufficiently large. At this time, in addition to the externally applied magnetic field, there is a field inside the medium that is opposite to the magnetization direction, and its amplitude is proportional to the net magnetization of the medium, referred to as the demagnetization field. As the external field reduces its magnitude, such that the net magnetic field (which is the sum of the externally applied field and the demagnetization field) becomes opposite to the initial saturation direction, magnetization reversal of the grains in the medium can occur. The external field value at the first occurrence of grains magnetization switching multiplying by a negative sign is referred to as the nucleation field, H_n . Namely, if the external field value is positive when the nucleation happens, the sign of the nucleation field is negative. If the field is negative, the nucleation field is positive. As the external field reaches zero, the net magnetization reaches the value of magnetization remanence, M_r . If H_n is negative, M_r is smaller than M_s ,

otherwise, M_r is usually equal to M_s . As the external field continues in the negative direction, at some point, half of the magnetic grains reverse their magnetization direction, and the net magnetization of the medium reaches zero. The external field magnitude at this point is referred to as the coercivity of this medium. Since the net magnetization of the medium is zero at the point of coercivity, the demagnetization field in the medium is zero. The coercivity is the mean switching field, H_s , the field needed to reverse the magnetization of the grains on average. As the external field continues to increase its strength, the magnetization of all the grains reverses and an opposite saturation is achieved.

44. In addition to the parameters mentioned above, the following are some additional relevant parameters.

45. **Anisotropy Constant (K_u)**. Magnetic anisotropy is the energy required to deviate the magnetic moment from its preferred orientation (the “easy axis”). The anisotropy constant (K_u), which is also referred to as anisotropy for short, is a measure of this energy per unit volume. In modern magnetic recording, a high K_u is crucial for ensuring the thermal stability of very small magnetic grains. As discussed above, the thermal stability of a recorded bit is directly proportional to the product of the anisotropy constant and the grain volume ($K_u V$).

46. **Anisotropy Magnetic Field (H_k)** represents the magnitude of the magnetic field required to saturate the material along its hard axis (perpendicular to

the easy axis). It provides information about the material's intrinsic anisotropy.

For uniaxial material (which has a single "easy axis" of magnetization, along which it is energetically favorable for the magnetic moments to align), the relationship between anisotropy magnetic field (H_k) and anisotropy constant (K_u) is approximated by the formula: $H_k = \frac{2K_u}{M_s}$. Ex-1005, 8:15.

47. **Hysteresis loop of composite magnetic recording media:** As I mentioned above, a hysteresis loop measures the magnetization component in the direction of an externally applied magnetic field. For perpendicular recording, we are interested in the hysteresis loop with a perpendicular magnetic field. For a composite magnetic recording media with two magnetic layers, the hysteresis loop may have different shapes, depending on, for example, the strength of exchange coupling between these two magnetic layers.

48. For a decoupled composite magnetic recording medium, the hysteresis loop shows two distinct and separate switching events, resulting in a stepped loop. The soft layer starts reversal first. After the soft layer completes reversal, if the external magnetic field continues to increase, the hard layer then starts to reverse. Therefore, the overall coercivity is determined by the hard layer and the existence of the soft layer provides minimal impact.

49. When the soft and hard layers are exchange coupled, such a medium is often referred to as an exchange-coupled composite (ECC) medium.

50. For a **weakly coupled** composite magnetic recording medium, the hysteresis loop is smoother than the decoupled example but still exhibits two slopes. The effective coercivity for the structure is lower than that of the hard layer alone because by the time the hard layer switches, the soft layer has already started switching, which provides an additional magnetic field, often referred to as exchange coupling field, to the hard layer, assisting in switching of the hard layer.

51. When the soft and hard layers are **strongly coupled**, the hysteresis loop becomes a smooth single-step loop. The hysteresis loop for strongly coupled composite media is smooth and has a single step, similar to the hysteresis loop I have shown for a single layer magnetic recording medium above, but with much lower coercive field. Due to the strong exchange coupling between the soft and hard layers, the magnetization of the soft layer continuously pulls on the hard layer, causing it to switch more easily.

E. Additional Concepts in Magnetic Recording

52. **“Easy axis”**: The easy axis of a magnetic material is the energetically most favorable direction for its spontaneous magnetization to align. In other words, it is the direction along which the material is most easily magnetized. This

directional preference is a property known as magnetic anisotropy, which I have discussed above.

53. **“In-plane” vs “out-of-plane”**: In magnetism, in-plane and out-of-plane refer to the orientation of a material’s magnetization relative to the plane of the platter. Longitudinal Magnetic Recording (LMR) uses in-plane magnetization, where the material’s easy axis is parallel to the disk surface. Perpendicular Magnetic Recording (PMR) uses out-of-plane magnetization, where the material’s easy axis is perpendicular to the disk surface.

54. **“Ferromagnetic coupling” vs “antiferromagnetic coupling”**: Ferromagnetic and antiferromagnetic coupling are two types of exchange coupling, both a quantum mechanical effect that dictates the alignment of electron spin in a material. The key difference between them is the direction in which neighboring spins align relative to each other. For ferromagnetic coupling, neighboring electron spins align parallel to each other in the same direction; for antiferromagnetic coupling, neighboring electron spins align antiparallel to each other in opposite directions.

55. **“Soft” vs. “hard”**: Magnetic material often is characterized by the strength of the magnetic field needed to change their magnetization direction. If the magnetization direction can be reversed by a relatively weak magnetic field (field strength is relatively low), the material is often said to be “soft.” If the magnetic

field needed to change the magnetization direction is relatively strong (field strength is relatively large), the material is then often referred to as a “hard” magnetic material. “Soft” and “hard” are often used as relative terms, although, as I discuss below, the ’734 Patent claims recite certain requirements for a “hard” layer, for example.

VI. OVERVIEW OF THE CHALLENGED PATENTS

56. I understand that the application resulting in the ’997 Patent was filed on March 19, 2018, and through the ’864 Patent claims the benefit of Patent Appl. No. 11/424,859, now U.S. Patent No. 9,978,413, filed on June 17, 2006. For purposes of this declaration, I assume that the challenged claims are entitled to the priority date of June 17, 2006.

57. Now I will give an overview of the ’997 Patent.

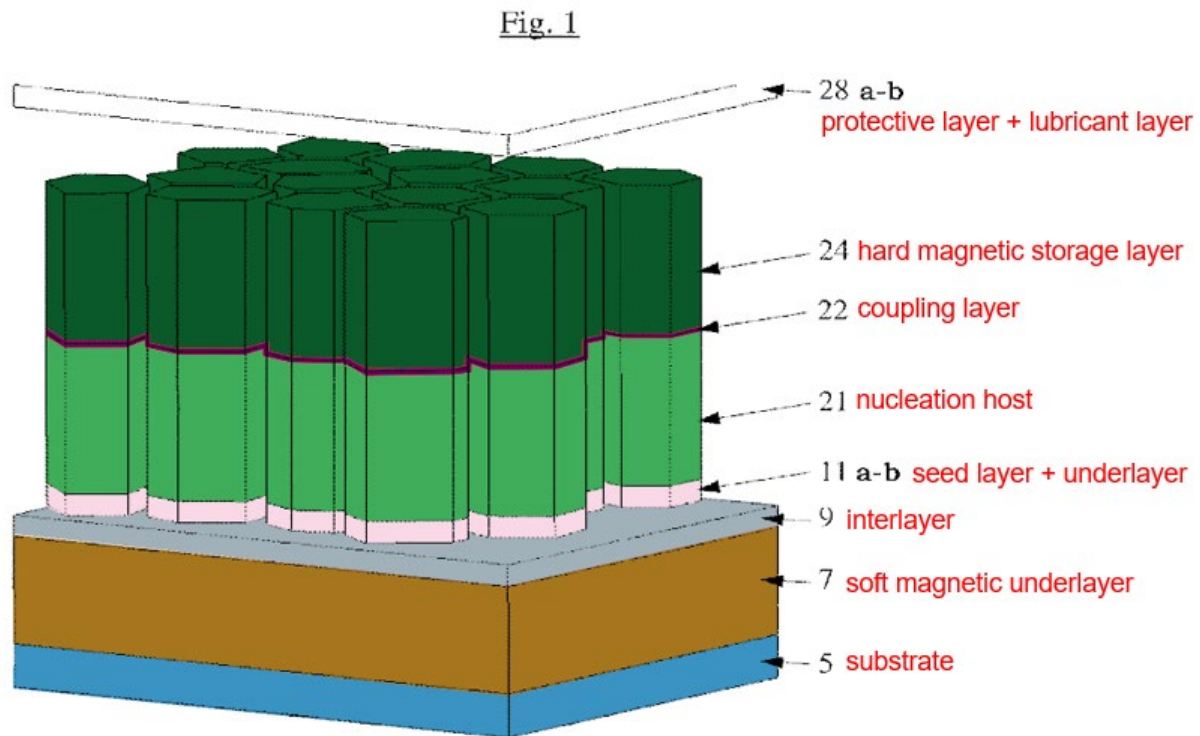
58. As already explained above, with recording densities increasing for magnetic recording media, continued decrease in the magnetic grain size is no longer feasible due to the well-known superparamagnetic limit—energy stored in a magnetic grain is proportional to the grain size. When the grain size is small enough, thermal fluctuations at room temperature become capable of switching the grain’s magnetization (i.e., “thermal instability”), resulting in loss of information stored in the media. Ex-1001, 1:14-24. While increasing the material’s anisotropy constant (K_u) (denoted as K by the challenged patent) helps overcome such

superparamagnetic limit by making the grains difficult to switch, according to the '997 Patent, "such an increase also results in an unfavorable increase of the coercivity H_c ," making it harder to write (i.e., "writeability problem"). *Id.*, 1:22-31.

59. To address this, prior designs used a soft magnetic layer on top of the hard layer. Ex-1001, 1:55-59. These layers are exchange-coupled, allowing the write head to flip the soft layer, which in turn switches the hard layer, thereby reducing the required write field while preserving thermal stability.

60. The '997 Patent purportedly adds a second soft layer on top of the existing soft layer, forming what it calls a "nucleation host." This nucleation host consists of "ferromagnetic layers with increasing anisotropy constant K from layer to layer," exchange-coupled to the hard layer beneath. Ex-1001, 12:50-53. The patent asserts that with its structure, "the coercive field is reduced..., while the thermal stability is...not influenced." Ex-1001, 3:53-59. It claims to "overcom[e] the writeability problem of extremely hard magnetic storage layers." Ex-1001, 3:64-67. In particular, the '997 Patent proposes "a magnetic recording media wherein the magnetic recording layer consists of a multilayer structure, with a special multilayer... nucleation host[] and a hard magnetic storage layer..." *Id.*, 2:48-52. The '997 Patent depicts the structure of its magnetic recording medium in

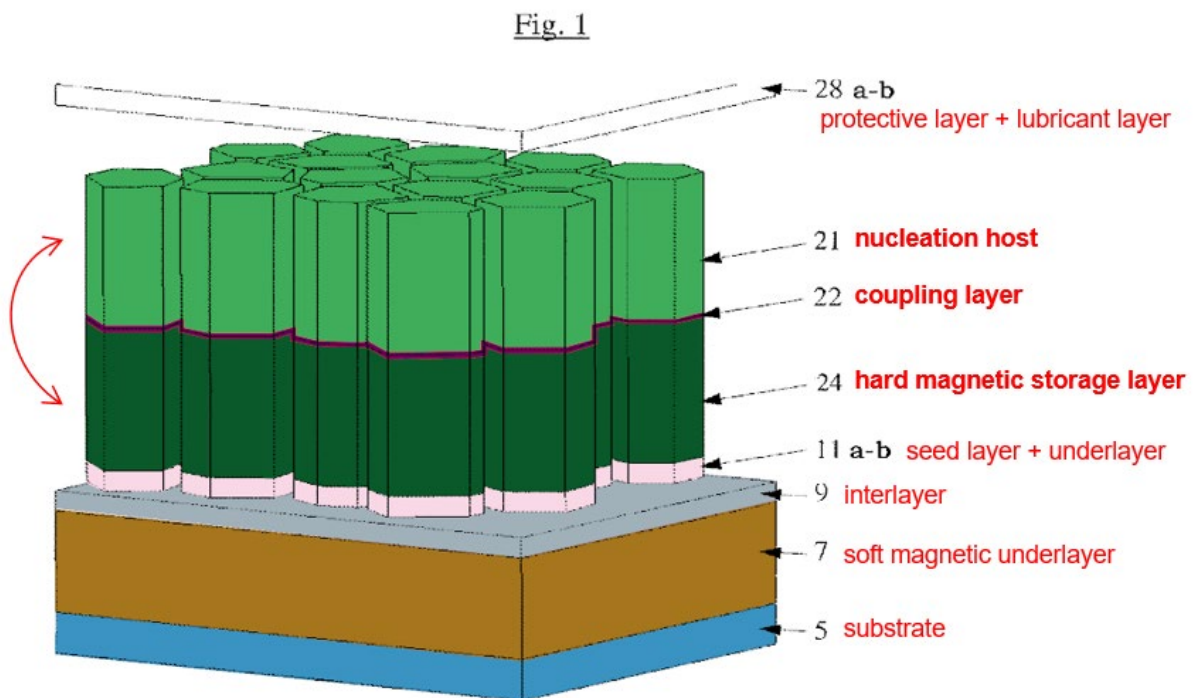
Figure 1 below, to which I have added coloring and annotations to facilitate understanding.



Ex-1001, Fig. 1, 4:17-23. I also note that unless I mention otherwise, all coloring and annotations to the figures were added by me. Bolded text has also been added throughout my declaration for emphasis unless otherwise indicated.

61. As shown in Figure 1 above, the '997 Patent's "recording media includes hard magnetic storage layer 24 and softer nucleation host 21" with an "optional coupling layer 22" between them. *Id.*, 4:53-54, 5:35-40. The nucleation host 21 (**green**) is "softer" because its coercive field H_c is lower than that of the hard magnetic storage layer 24 (**dark green**). *Id.*, 5:29.

62. However, it should be noted that Figure 1 (as shown above) is the only figure in the '997 Patent that depicts the structure of a magnetic recording medium. Figure 1, however, fails to depict the structure of the claimed magnetic recording medium, i.e., it does not depict “a nucleation host [21]... formed on the hard magnetic storage layer [24] such that the hard magnetic storage layer [24] is between the nucleation host [21] and the non-magnetic substrate [5],” as required by claim 1 of the '997 Patent. For purposes of this declaration, I have revised Figure 1 of the '997 Patent to show the structure of the magnetic recording medium as claimed:



Ex-1001, Fig. 1 (revised, to show nucleation host on top).

63. As the '997 Patent itself acknowledges, “magnetic multilayer structures composed of magnetically hard and magnetically soft layers” were nothing new. *Id.*, 1:54-58. What was purportedly new was the “special **multilayer** host layer (nucleation host).” *Id.*, 2:48-52. For example, “the nucleation host[] comprises of ferromagnetic layers with increasing anisotropy from layer to layer” *Id.*, 10:53-55. By introducing “the spatially varying anisotropy in the nucleation host,” the '997 Patent expects that “the coercive field is reduced..., while the thermal stability is... not influenced...” *Id.*, 3:48-53. However, as I will show below, introducing increasingly softer layers as one gets further from the hard magnetic storage layer, having decreasing anisotropy to achieve a reduction in coercive field without impairing thermal stability, was well known in the art at the time of the alleged invention.

64. I have also reviewed the prosecution history the '997 Patent.

65. I understand during prosecution of the '997 Patent, in a first Office Action, the Examiner rejected all claims on multiple grounds of non-statutory double patenting. Ex. 1002, xx-xx. The Examiner further rejected claims 13, 16, 17, 22-24 under pre-AIA U.S.C. §103(a) as being unpatentable over U.S. Pub. No. 2007/0243418 (“Fullerton 1”) and claims 14, 15, and 18-21 under pre-AIA U.S.C. §103(a) as being unpatentable over Fullerton 1 in view of 2003/0108721 (“Fullerton

2”). Ex-1002, 153. In response, the Applicant filed multiple terminal disclaimers and cancelled all claims rejected under §103(a). Ex-1002, 139-142.

66. I understand in a second Office Action, the Examiner rejected claims 1, 2, 4-8, 11, and 12 on the ground of non-statutory double patenting. Ex-1002, 87-90. Applicant filed a terminal disclaimer, which led to allowance of the '997 Patent. Ex-1002, 62-63.

VII. OVERVIEW OF THE PRIOR ART

A. Takenoiri

67. U.S. Patent No. 8,329,321 (“Takenoiri,” Ex-1005) was filed on **July 1, 2005** and issued **December 11, 2012**. I understand that Takenoiri is prior art to the challenged patent. I also understand that the Examiner was not aware of Takenoiri during prosecution.

68. Like the '997 Patent, Takenoiri recognizes the same trade-off between thermal stability and writeability (or “recordability” as used in Takenoiri): “The miniaturization of the magnetization reversal unit and the increase of Ku, both directed to high recording density, contribute to improve the recording resolution and the **thermal stability** of a magnetic recording medium. However, both of these tend to **lower the easiness** with which a magnetic recording medium is recorded, referred to as ‘**recordability**.’” Ex-1005, 1:62-67. Also, like the '997 Patent, Takenoiri introduces a softer magnetic recording layer 7 (**green**) on top of a hard

magnetic recording layer 5 (dark green), coupled by a coupling layer 6 (purple), as illustrated below. Again, I have colored the figures to facilitate their understanding.

<div><p>Fig. 1 bi-layer</p><p>9 8 7 second magnetic recording layer 6 coupling layer 5 first magnetic recording layer 4 nonmagnetic intermediate layer 3 underlayer 2 soft magnetic backing layer 1 nonmagnetic substrate</p></div> <div>Ex-1005, Fig. 1</div>	<div><p>Fig. 1</p><p>28 a-b protective layer + lubricant layer 21 nucleation host 22 coupling layer 24 hard magnetic storage layer 11 a-b seed layer + underlayer 9 interlayer 7 soft magnetic underlayer 5 substrate</p></div> <div>Ex-1001, Fig. 1 (revised, to nucleation host on top)</div>
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69. According to Takenoiri, this structure achieves “simultaneous improvements in thermal stability and recordability” because “each magnetic layer reverses magnetization individually.” Ex-1005, 5:8-15. For example, when an external magnetic field is applied, the second magnetic recording layer 7 with lower coercive field reverses first. *Id.*, 5:15-20. Now, the magnetization of the soft layer (i.e., the second magnetic recording layer 7) is opposite to that of the hard layer (i.e., the first magnetic recording layer 5), providing an additional magnetic field, often referred to as exchange coupling field as I mentioned above, to the hard layer, assisting the switching of the hard layer. Consequently, the first magnetic recording layer 5 with higher coercive field then switches at a lower external magnetic field in comparison with the case when the second magnetic recording layer 7 is absent. *Id.*,

5:36-40. For the bi-layer structure illustrated in Takenoiri's Figure 1 above, such individual or sequential magnetization switching is enabled by satisfying the conditions, for example, $H_{k1} > H_{k2}$ and $K_{u1}T_1 > K_{u2}T_2$, where H_{k1} , K_{u1} , and T_1 are an anisotropy magnetic field, a uniaxial anisotropy constant, and a thickness of the first magnetic recording layer, respectively, and H_{k2} , K_{u2} , and T_2 are an anisotropy magnetic field, a uniaxial anisotropy constant, and a thickness of the second magnetic recording layer, respectively. *Id.*, claim 1.

70. Takenoiri explains:

At the moment of the magnetization reversal in the first magnetic recording layer [5], the second magnetic recording layer [7] has already reversed the magnetization thereof. So, the magnetization reversal in the first magnetic recording layer [5] is easy owing to the effect of the magnetic field of the second magnetic recording layer...

On the other hand, because the ferromagnetic coupling exists between the magnetic recording layers, as shown in FIG. 2, the energy barrier is high and thermal stability is kept high. By reversing the magnetization of each magnetic recording layer individually and sequentially, **the switching field can be more effectively lowered without impairing thermal stability.**

Ex. 1005, 5:41-59.

71. While Takenoiri does not use the exact term "exchange spring," the term "exchange coupling" is at the center of the patent and used numerous times. A POSITA would have understood that Takenoiri's magnetic recording medium is a type of exchange spring magnetic recording media because Takenoiri's magnetic

recording medium includes exchanged coupled magnetically soft and hard layers.

See Section V.C.

72. While Takenoiri depicts a bi-layer structure in Figure 1, it also expressly discloses that “structure having **three or more magnetic recording layers** still produces the effect of improving thermal stability and the effect of reducing switching field at the same time” when the individual or sequential magnetization reversal can be maintained by satisfying similar conditions for H_k , K_u , and T across these three or more layers. Ex-1005, 10:7-18. I will discuss Takenoiri’s tri-layer structure in more detail below in Section XII.A. And as I will explain for claim 1 below, Takenoiri’s tri-layer structure teaches the exact same “nucleation host” (with varying anisotropy) that the challenged patent claims.

B. Li

73. U.S. Patent No. 7,846,564 (“Li,” Ex-1022) was filed on September 27, 2005, and issued December 7, 2010. I understand that Li is prior art under to the challenged patent. I also understand that there is no indication that the Examiner was aware of Li during prosecution. As I will explain below, Li discloses a magnetic recording medium with three sub-layers, with a grain size as relevant to dependent claims 4 and 9 of the ’997 Patent.

VIII. CLAIM CONSTRUCTION

74. I understand that the court in *MR Technologies GmbH v. Western Digital Technologies, Inc.*, 8-22-cv-01599 (C.D. Cal.) (the “Western Digital case”) issued a claim construction order, which construes certain terms in the ’997 Patent. I understand that the claim constructions from the Western Digital case are not binding in this proceeding.

75. For purposes of this declaration, I have applied the plain and ordinary meaning of all terms, as I do not believe that any of the claim terms deviate from their common and well understood meanings to POSITAs at the relevant time.

IX. ANTICIPATION

76. I have been instructed as to the definition of “anticipation” in the context of the patent laws.

77. I understand that anticipation of a claim requires that every element of a claim be disclosed expressly or inherently in a single prior art reference, in combination, as claimed. I understand that a single prior art reference may anticipate claims without expressly disclosing a feature of the claimed invention if that feature is necessarily present, or inherent, in that reference. I understand that a reference is read from the perspective of one of ordinary skill in the art at the time of the invention.

X. OBVIOUSNESS

78. I have been instructed as to the definition of “obviousness” in the context of the patent laws.

79. It is my understanding that obviousness is a question of law based on underlying factual issues including (1) the scope and content of the prior art, (2) the differences between the prior art and the challenged claims, (3) the level of ordinary skill in the pertinent art, and (4) the existence of secondary considerations such as commercial success, long-felt but unresolved needs, failure of others, copying, industry praise, etc.

80. It is also my understanding that I should first determine the scope and content of the prior art, then consider the differences, if any, between the prior art and each challenged claim; and that in doing so, although it is proper to consider differences between the claimed invention and the prior art, I should not focus on only the differences, because the test is whether the claimed invention as a whole would be obvious over all of the prior art. It is also my understanding that, in evaluating validity, each claim of the patent must be considered separately and in its entirety.

81. It is my understanding that the next step is to determine the level of ordinary skill in the art to which the claimed invention pertains at the time the invention was made.

82. It is my understanding that a POSITA is presumed to have knowledge of the relevant prior art at the time of the claimed invention; and that if I find that the available prior art shows, discloses, teaches or suggests each of the elements of the challenged claims, I should determine whether a POSITA would have had a reason to combine or coordinate these elements in the same manner as the challenged claim.

83. I understand that an obviousness evaluation can be based on a single reference or a combination of multiple prior art references.

84. I understand that for a single reference or a combination of references to render obvious the claimed invention, a POSITA must have been able to arrive at the claimed invention by altering or combining the applied reference or references. I also understand that obviousness arises where it is determined that the claimed invention implemented a predictable variation of prior art elements or amounts to nothing more than the predictable use of prior art elements according to their established functions.

85. I understand that the prior art references themselves may provide an explicit suggestion, motivation, or reason to combine, but that the suggestion to combine may also arise from the state of the prior art generally. I also understand that when considering the obviousness of a patent claim, one should consider whether a teaching, suggestion, or motivation to combine the references exists to

avoid impermissibly applying hindsight when considering the prior art. I understand this test should not be applied rigidly, but that the test can be important to avoid such hindsight.

XI. OPINIONS REGARDING PATENTABILITY

86. In my opinion, claims 1-2 and 5-7 of the '997 Patent are obvious over Takenoiri. Additionally, claims 4 and 9 are obvious over Takenoiri in view of Li.

87. I have based my opinion on the following references:

- **Takenoiri:** U.S. Patent No. 8,329,321 titled “Perpendicular Magnetic Recording Medium” to Shunji Takenoiri and Yasushi Sakai (“Takenoiri,” Ex-1005), was filed July 1, 2005 and issued December 11, 2012. I understand that Takenoiri is prior art to the challenged patent.

- **Li:** U.S. Patent No. 7,846,564 titled “Perpendicular magnetic recording media with magnetic anisotropy/coercivity gradient and local exchange coupling” to Shaoping Li, Kaizhong Gao, Lei Wang, Wenzhong Zhu, and Xiaobin Wang (“Li,” Ex-1022), was filed on September 27, 2005, and issued December 7, 2010. I understand that Li is prior art under to the challenged patent.

88. In my opinion, the challenged claims of the '997 Patent are unpatentable based on the following grounds:

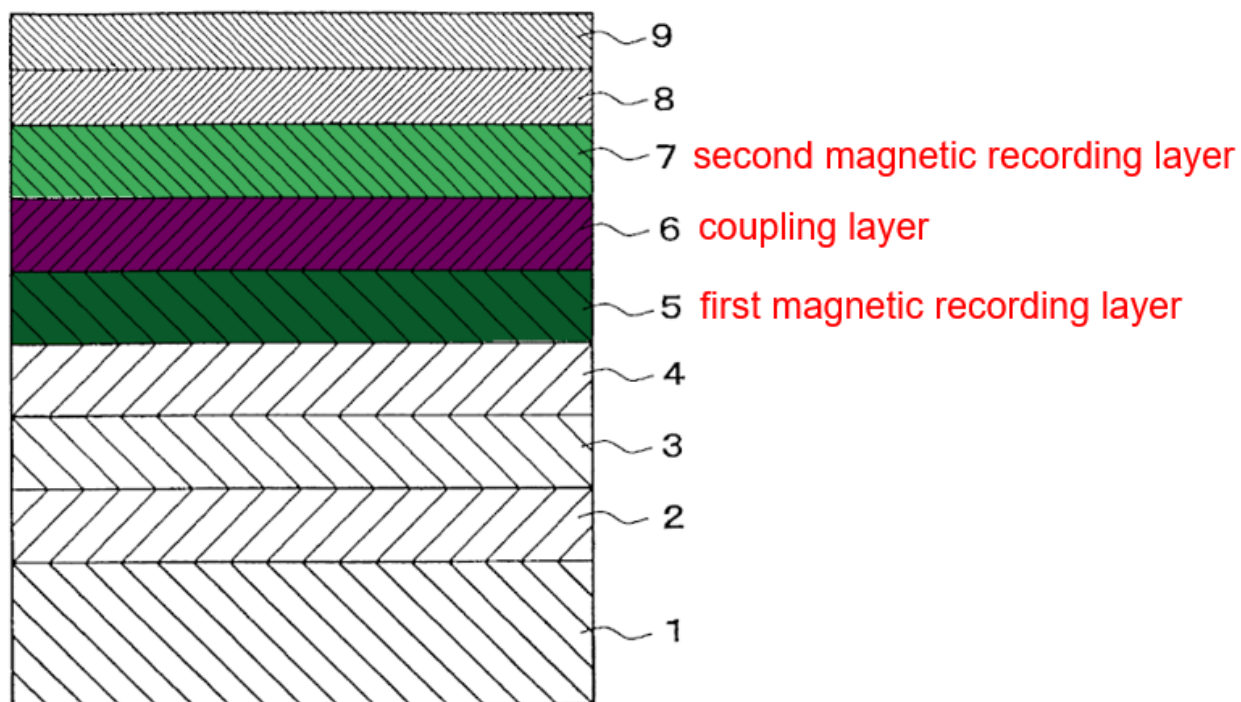
Ground	Statute	Reference(s)	'997 Patent Claims
1	§103	Takenoiri	1-2, 5-7
2	§103	Takenoiri + Li	4, 9

XII. MY OPINIONS AS TO THE CHALLENGED CLAIMS OF THE '997 PATENT

A. Takenoiri's tri-layer structure

89. As I discussed in Section VII.A above, Takenoiri discloses a bi-layer embodiment shown in Figure 1, which includes two magnetic recording layers: first magnetic recording layer 5 and second magnetic recording layer 7, coupled by coupling layer 6. Ex-1005, 5:65-6:6.

Fig. 1 **bi-layer**



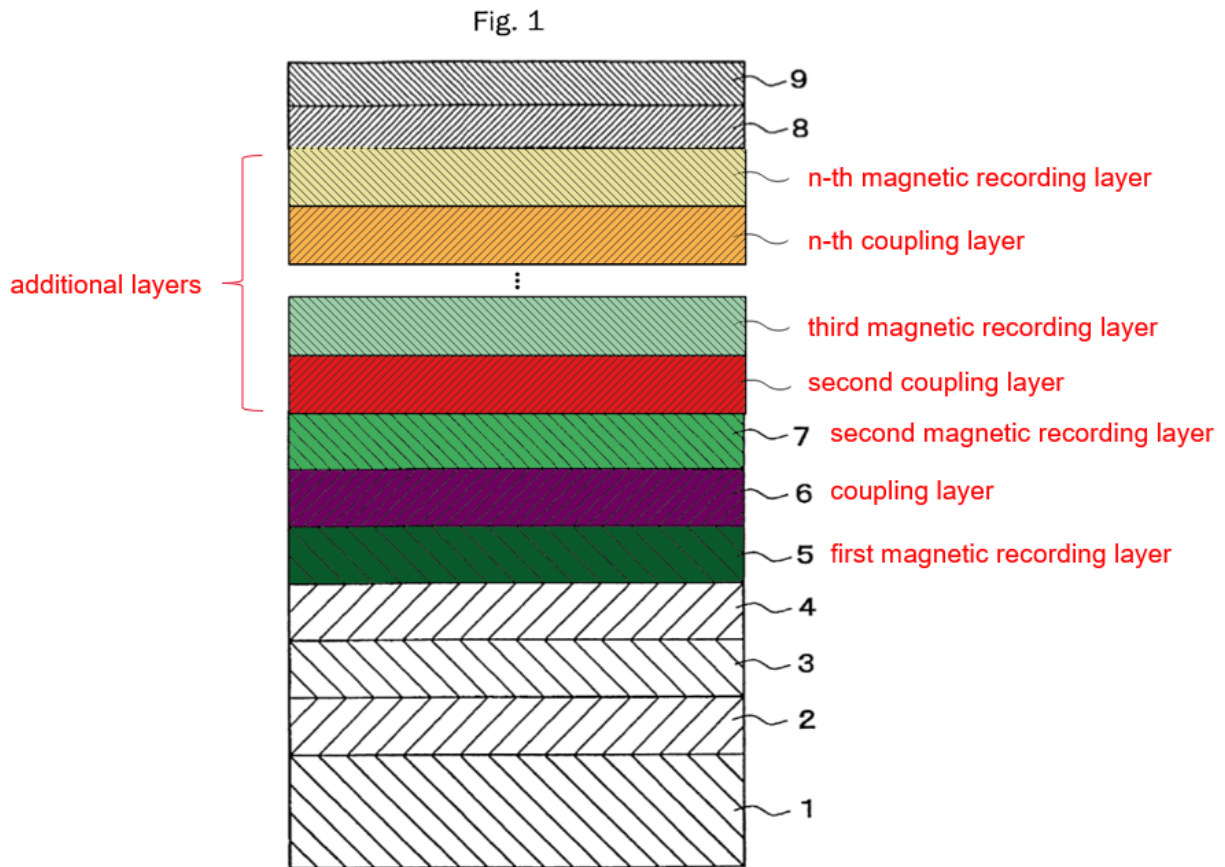
Ex. 1005, Fig. 1.

90. Takenoiri expands on the disclosure, teaching that the structure can have “three or more layers” where “[t]he ferromagnetic coupling is provided between every two magnetic recording layers through a coupling layer.” *Id.*, 10:7-10.

91. While Takenoiri does not explicitly state where a third magnetic recording layer would be positioned in its bi-layer structure, it is my opinion that a POSITA would have found it obvious to put it above the second magnetic recording layer 7. For example, Takenoiri compares its bi-layer structure against the single layer structure (e.g., Takenoiri’s Examples 1-6), where the bi-layer structure introduces a second magnetic recording layer on top of the first magnetic recording layer. Thus, when it comes to multilayer structure with three or more layers, a POSITA would have naturally added the third magnetic recording layer on top of the second magnetic recording layer, etc. Moreover, a POSITA would have recognized that there are only three logical options to place the additional magnetic layer(s): (i) above the second magnetic recording layer 7, (ii) between the first magnetic recording layer 5 and the second magnetic recording layer 7, or (iii) below the first magnetic recording layer 5. Of these options, placement above the second layer would be the overwhelmingly expected default, absent any contrary disclosure. This is because layer numbering in Takenoiri’s thin-film stack structure proceeds

from the bottom upward—“first” denotes the lower layer, “second” the layer above it, and so on. Accordingly, where a device is described as having “first” and “second” magnetic recording layers, a POSITA would expect that a “third” layer, unless otherwise specified, would naturally be formed above the “second” layer. No deviation from this convention is suggested or implied in the reference. Thus, it is my opinion that it would have been obvious to a POSITA to at least try option (i). For purposes of this declaration, I focus on the first configuration, although it is my opinion that the relative coercive field H_c relationship and relative anisotropy constant K_u relationship across these layers (as I will discuss for claim 1 below) remain the same regardless of which configuration is implemented for the same reasons explained in this declaration.

92. Below is Takenoiri’s Figure 1 with my revision to illustrate a three (or more) magnetic recording layered structure, with additional layers added to the bi-layer structure.



Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1). To distinguish from Takenoiri's bi-layer structure, I will refer to Takenoiri's multilayer structure with three or more magnetic recording layers as "tri-layer structure."

93. As shown above, a second coupling layer (red) is disposed between the second magnetic recording layer 7 (green) and the third magnetic recording layer (light green) as taught by Takenoiri: "[t]he ferromagnetic coupling is provided between every two magnetic recording layers through a coupling layer." *Id.*, 10:8-10.

94. Therefore, it is my opinion that Takenoiri discloses, or at least renders obvious, a tri-layer structure, as illustrated in the revised Figure 1 above.

B. My Opinions as to Claims 1-2 and 5-7 in view of Takenoiri alone

1. Claim 1

95. In my opinion, claim 1 of the '997 Patent is unpatentable because it is obvious over Takenoiri. Claim 1 of the '997 Patent recites the following. I address each of these limitations in my analysis below.

1[P]: A magnetic recording system, comprising:

1[A]: a writing head;

1[B]: a disk, including a magnetic recording medium, comprising

1[C]: an essentially non-magnetic substrate

1[D]: an underlayer formed on the non-magnetic substrate; and

1[E]: an exchange coupled magnetic multilayer structure, including

1[F]: a hard magnetic storage layer, having a first coercive field $H_s > 0.5$ T, formed on the underlayer

1[G]: a nucleation host, having a second coercive field H_n without the hard magnetic storage layer, lower than the first coercive field, $H_n < H_s$, wherein

1[H]: said nucleation host is formed on the hard magnetic storage layer such that the hard magnetic storage layer is

between the nucleation host and the non-magnetic substrate

1[I]: [said nucleation host] is exchange coupled to the hard magnetic storage layer, and

1[J]: [said nucleation host] comprises ferromagnetic layers with increasing anisotropy constant K from layer to layer.

a. 1[P]

96. The preamble of claim 1 recites “[a] magnetic recording system.” If the preamble is considered a limitation of the claim, it is my opinion that Takenoiri discloses it.

97. Takenoiri is directed to “a perpendicular magnetic recording medium mounted on various **magnetic recording devices**,” such as “**a hard disk drive** used for an external storage device of computers, AV equipment, and other apparatus.” Ex-1005, 1:14-19; *see also id.* at 1:20-33 (discussing development of “a perpendicular magnetic recording system” in place of “the longitudinal magnetic recording system” used in “hard disk drives (HDDs)”). Moreover, as I will discuss below, Takenoiri discloses all remaining claim elements, and as such discloses “[a] **magnetic recording system** [e.g., a magnetic recording device, such as a hard disk drive, having the claimed elements described below].”

b. 1[A]

98. Limitation 1[A] requires: “a writing head.”

99. Takenoiri discloses a “magnetic head used for magnetic recording.” Ex-1005, 6:13-16 (“Soft magnetic backing layer 2 is preferably formed to improve **read/write characteristics** by controlling the magnetic flux from the **magnetic head used for magnetic recording.**”); *see also id.*, 6:21-22 (“magnetic head used for recording”), 6:49 (“recording head”), 16:41 (“magnetic recording head”). In the field of magnetic recording media, recording means writing. Further, a “writing head” is a necessary component of a hard disk drive to enable “recording” or “writing.” *See, e.g.*, Ex-1017, p.9 (“critical disk drive components such as read-write heads”); Ex-1036, ¶74; Ex-1018, pp.3-4 (“Hard disk drives are built in four main subchains: electronics, head subassemblies, media, and motors... These four parts constitute the major subassemblies of disk drives.”); Ex-1036, ¶78. Thus, Takenoiri’s “magnetic head” used for writing, discloses the claimed “writing head.”

100. Therefore, in my opinion, Takenoiri discloses “**a writing head** [e.g., Takenoiri’s magnetic head used for writing].”

c. 1[B]

101. Limitation 1[B] requires: “a disk, including a magnetic recording medium.”

102. Takenoiri discloses “a perpendicular **magnetic recording medium** mounted on a **hard disk drive**,” which applies to the embodiment described in Figure 1 and the tri-layer structure. Ex-1005, 1:14-19. In my opinion, a POSITA would have understood that, as its name confirms, a hard **disk** drive includes a **disk** and that Takenoiri’s magnetic recording medium is part of the **disk**. *See also* my discussion about “platter” in Section V.A above.

103. The ’997 Patent also confirms that a disk was a well-known component of a magnetic recording device. *See, e.g.*, Ex. 1001, 6:24 (“conventional disk overcoat”), 6:29 (“commercially available single disk systems”).

104. Therefore, it is my opinion that Takenoiri discloses “**a disk** [e.g., a disk as a necessary part of Takenoiri’s hard disk drive], **including a magnetic recording medium** [e.g., Takenoiri’s perpendicular magnetic recording medium].”

d. 1[C]

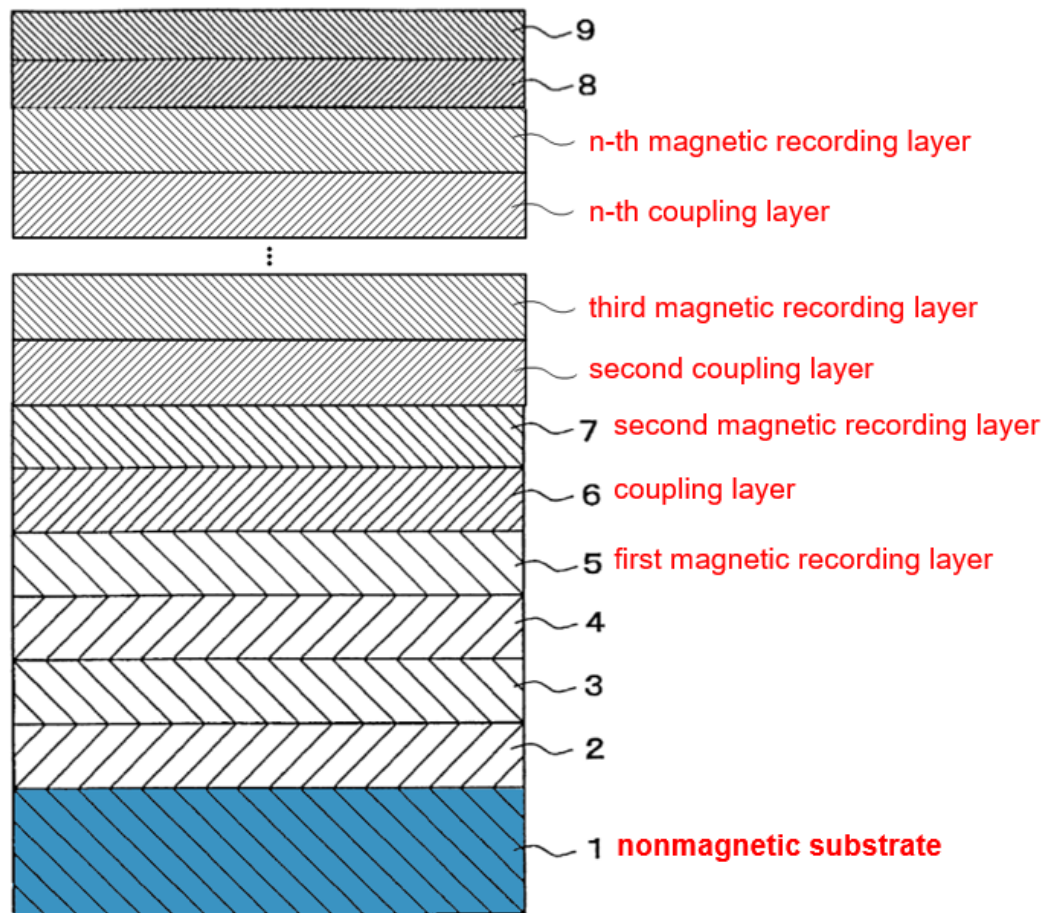
105. Limitation 1[C] requires: “an essentially non-magnetic substrate.”

106. I note that the ’997 patent specification only mentions an “essentially non-magnetic substrate” once in passing (Ex-1001, 10:26) and does not provide any explanation as to what it means to be “essentially” non-magnetic. Instead, the ’997 patent specification repeatedly uses the term “non-magnetic substrate.” *See, e.g., id.*, 10:17, 11:64, 12:5. Moreover, later limitation in claim 1 (i.e., limitation 1[H]) uses the term “the non-magnetic substrate” but does not provide any antecedent basis

for this different term. It is my opinion that a POSITA would have understood that the term “the non-magnetic substrate” in limitation 1[H] refers to the “essentially non-magnetic substrate” in the present limitation. Therefore, in my opinion, a POSITA would have understood “essentially non-magnetic substrate” to at least include a “non-magnetic substrate.”

107. Takenoiri discloses a “[n]onmagnetic substrate 1 [blue]...composed of an **aluminum alloy with NiP plating, strengthened glass, crystalline glass, or the like.**” Ex-1005, 6:7-10. These are the same or similar substrate materials in the ’997 Patent. *See* Ex-1001, 4:31-33 (“Substrate 5 may be made of any suitable material such as **ceramic glass, amorphous glass, or NiP plated AlMg or an AlMg alloy** base with a NiP surface coating.”).

Fig. 1



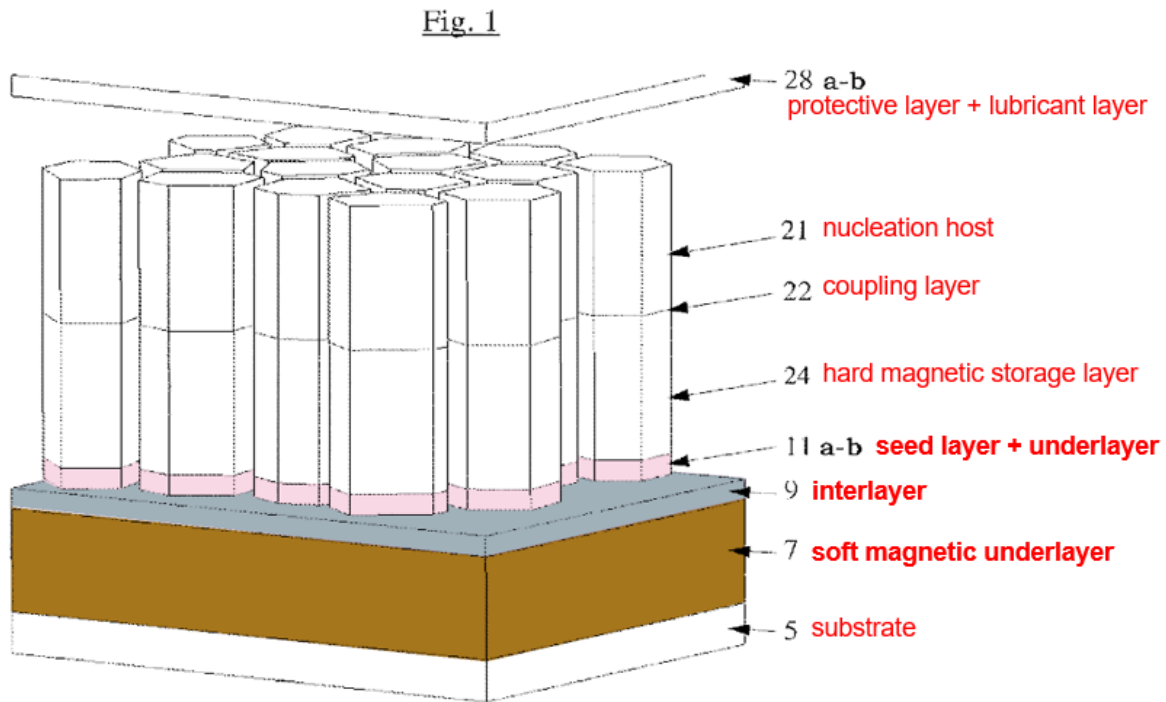
Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1).

108. Therefore, it is my opinion that Takenoiri discloses “**an essentially non-magnetic substrate** [e.g., Takenoiri’s non-magnetic substrate 1].”

e. 1[D]

109. Limitation 1[D] requires: “an underlayer formed on the non-magnetic substrate.”

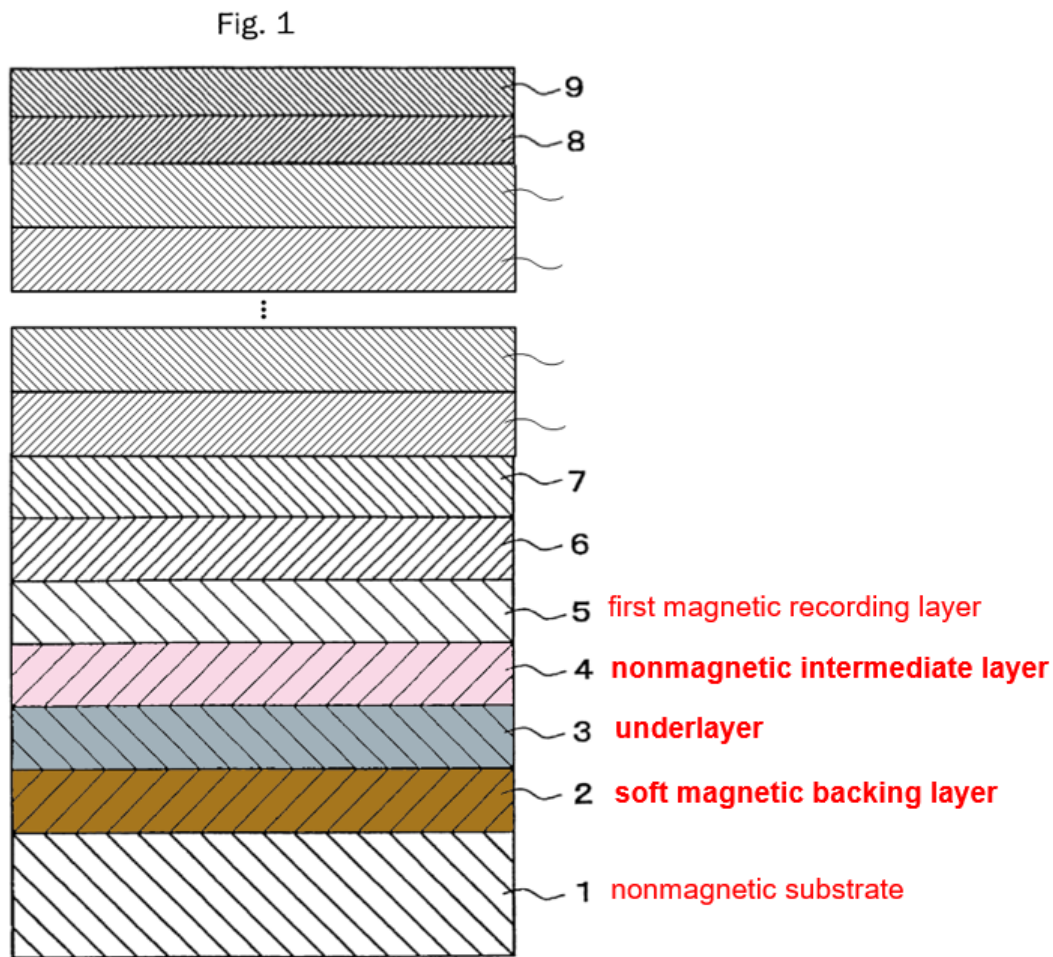
110. The '997 Patent discloses “a soft magnetic underlayer 7” and an “underlayer 11b,” as well as an interlayer 9 and a seed layer 11a in between, which are all formed on the substrate 5. Ex-1001, 4:23-30 (describing Figure 1).



Ex-1001, Fig. 1 (revised, to show nucleation host on top).

111. I note that the claims do not specify that the “underlayer” be a single layer formed from a single material between the non-magnetic substrate and the hard magnetic storage layer, and the Western Digital court’s construction for the term “underlayer” was: “**one or more layers** on which the hard magnetic storage layer is formed.” Ex-1019 (Western Digital CC Order), p.21-22.

112. Takenoiri discloses that “[o]n nonmagnetic substrate 1 sequentially formed are **soft magnetic backing layer 2, underlayer 3, nonmagnetic intermediate layer 4**, first magnetic recording layer 5...” Ex-1005, 6:1-4.



Ex-1005, Fig. 1 (tri-layer structure in modified Fig. 1).

113. Thus, in my opinion, one or more of Takenoiri’s soft magnetic backing layer 2, underlayer 3, and/or nonmagnetic intermediate layer 4 correspond to the claimed “underlayer” formed on Takenoiri’s nonmagnetic substrate 1.

114. I would like to note that while Takenoiri refers to layer 2 as soft magnetic backing layer, a POSITA would have understood it to refer to the soft underlayer (often referred to as “SUL”, as I have shown in the PMR figure in Section V.B above), which, as Takenoiri discloses, is formed to improve read/write characteristics by controlling the magnetic flux from the magnetic head used for magnetic recording. Ex-1005, 6:13-16. Also like the '997 Patent's soft magnetic underlayer 7, Takenoiri's soft magnetic backing layer 2 is (i) formed “on the nonmagnetic substrate...before deposition of other layers,” (ii) composed of materials such as “FeTaC or Sendust alloy (FeSiAl), or an amorphous cobalt alloy such as CoZrNb...,” and (iii) with a thickness “in a range of 10 nm to 500 nm.” Ex-1005, 6:16-29; Ex-1001, 4:34-40 (compare to '997 Patent's “[s]oft magnetic underlayer 7 ... on substrate 5. soft [*sic*] magnetic underlayer 7 may be made of any suitable material such as...FeTaC,...FeAlSi,...CoZrNb... Soft magnetic underlayer 7 may have a thickness in the range of about 50 nm to about 500 mm.”). Like the '997 Patent's underlayer 11b, Takenoiri's nonmagnetic intermediate layer 4 is also (i) “formed to appropriately control the crystal alignment, the grain size, and the grain boundary segregation in first magnetic recording layer 5,” (ii) composed of materials such as “ruthenium-based alloy,” and (iii) with a thickness “in the range of 1 nm to 20 nm.” Ex-1005, 6:52-65; Ex-1001, 4:51-56 (“Underlayer 11b may be formed of a suitable hep material with a lattice parameter close to the alloys of the

first layer in the magnetic layer. These alloys may be... Ru-based alloys... Underlayer 11 b may have a thickness in the range of about 1 nm to about 20 nm.”).

115. To the extent that the claimed “underlayer” requires a single layer, it is my opinion that each of Takenoiri’s soft magnetic backing layer 2, underlayer 3, and nonmagnetic intermediate layer 4 constitutes a single underlayer and Takenoiri notes that each of these layers “may be omitted.” Ex-1005, 6:16, 6:33-34, 6:55. For example, when layers 2 and 4 are omitted, Takenoiri’s underlayer 3 discloses the claimed “underlayer.” This same is true for soft magnetic backing layer 2 and nonmagnetic intermediate layer 4.

116. Therefore, in my opinion, Takenoiri discloses “**an underlayer** [e.g., one or more of Takenoiri’s soft magnetic backing layer 2, underlayer 3, and/or nonmagnetic intermediate layer 4] **formed on the non-magnetic substrate** [e.g., Takenoiri’s nonmagnetic substrate 1].”

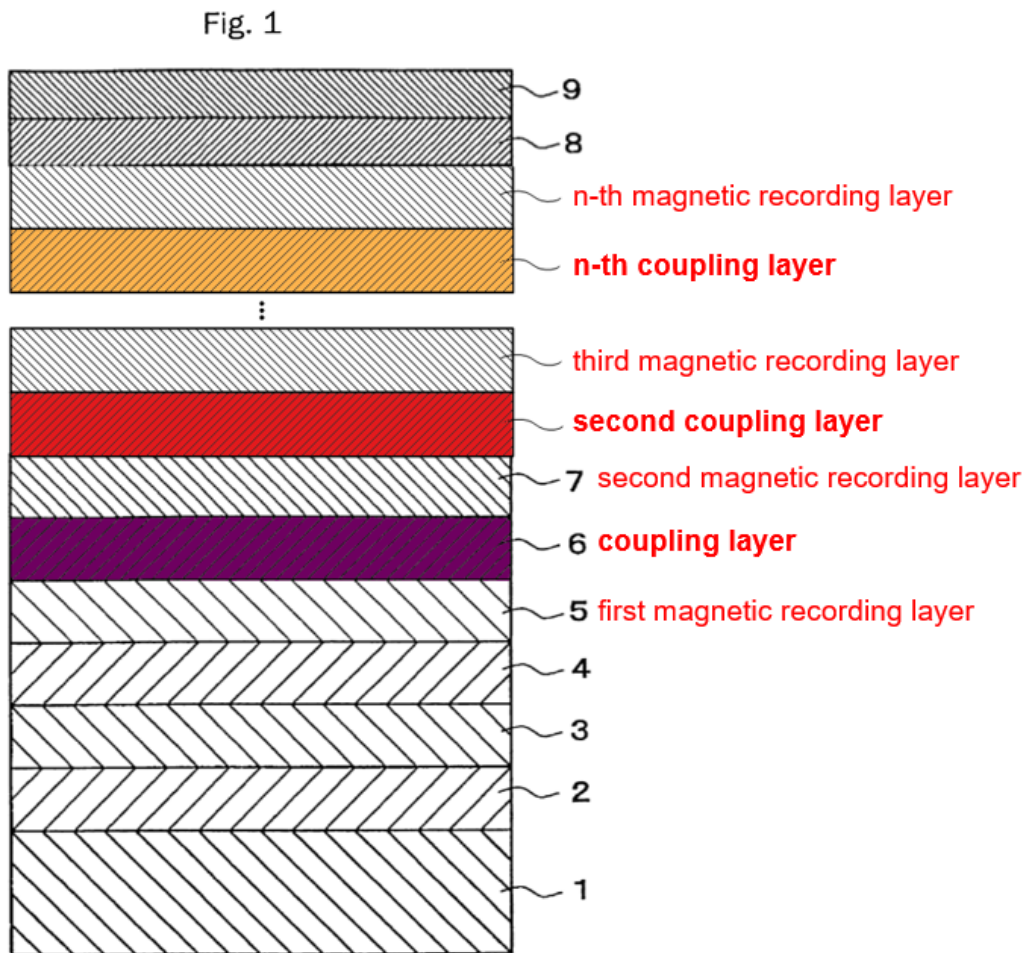
f. 1[E]

117. Limitation 1[E] requires: “an exchange coupled magnetic multilayer structure.”

118. As I explained above in Section XII.A, Takenoiri discloses a three-or-more layered structure (e.g., tri-layered structure shown in revised Figure 1 below), where every two magnetic recording layers are ferromagnetically coupled via a coupling layer. Ex-1005, 10:8-10. According to Takenoiri, such coupling layer

provides exchange coupling between two adjacent magnetic recording layers. *See, e.g., id.*, Ex-1005, 5:63-65 (“conditions of the **coupling layer** for controlling the **exchange coupling** energy between the magnetic recording layers”). In my opinion, a POSITA would have understood that ferromagnetic coupling is a type of exchange coupling. I also note that by 2005, the fact that the nature (antiferromagnetic or ferromagnetic) of the exchange coupling and its strength can be tuned by choosing different materials at adequate thickness had been well understood in the field as appreciated by Dr. Parkin of IBM in 1991. *See* Ex-1031; Ex-1036, ¶98. As Dr. Parkin pointed out, the exchange coupling can be finely tuned by selecting an interlayer, using selected materials, and selecting appropriate thickness.

119. Accordingly, Takenoiri’s coupling layer 6 and additional coupling layers added between adjacent additional magnetic layers per Takenoiri (including the second coupling layer and n-th coupling layer) are coupling layers that exchange couple the first, second, third,...and n-th magnetic recording layers within the multilayer structure.



Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1).

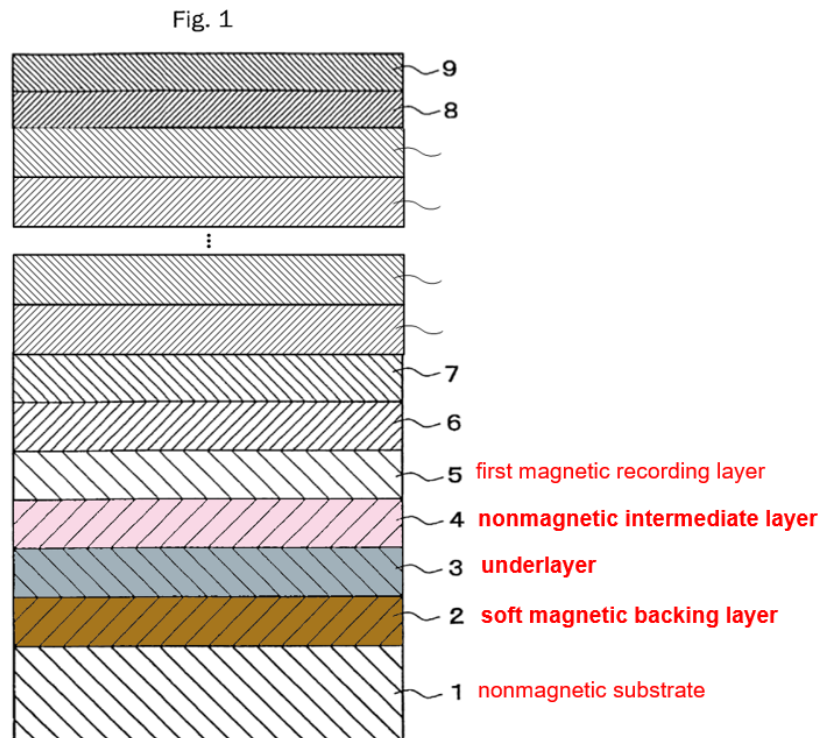
120. Moreover, as I will discuss below, Takenoiri discloses all of the elements required in the recited “exchange coupled magnetic multilayer structure,” including the recited “hard magnetic storage layer” and “nucleation host.”

121. Therefore, in my opinion, Takenoiri discloses “**an exchange coupled magnetic multilayer structure** [e.g., Takenoiri’s multilayered structure with three or more magnetic recording layers exchange coupled to one another, having the recited structures described below].”

g. 1[F]

122. Limitation 1[F] requires: “a hard magnetic storage layer, having a first coercive field $H_s > 0.5$ T, formed on the underlayer.”

123. *First*, in my opinion, Takenoiri’s tri-layer structure includes a “magnetic storage layer..., formed on the underlayer” required by this limitation. As shown below, Takenoiri discloses that “[o]n nonmagnetic substrate 1 sequentially formed are **soft magnetic backing layer 2, underlayer 3, nonmagnetic intermediate layer 4, first magnetic recording layer 5...**” Ex-1005, 6:1-4.



Ex-1005, Fig. 1 (tri-layer structure in modified Fig. 1). Therefore, Takenoiri’s first magnetic recording layer is formed “on the underlayer” (e.g., each of Takenoiri’s

one or more of Takenoiri's soft magnetic backing layer 2, underlayer 3, and nonmagnetic intermediate layer 4) as required by this limitation.

124. *Second*, it is my opinion that Takenoiri's first magnetic recording layer 5 is "a hard magnetic storage layer... having a first coercive field $H_s > 0.5$ T."

125. While the '997 Patent appears to define "hard" as having a "coercive field $H_c > 0.5$ T" and "soft" as having a "coercive field $H_c < 0.5$ T," it also states that "[i]n some embodiments[,] these terms are defined in a relative sense," e.g., "the coercive field of (soft) nucleation host 21 can be half of the coercive field of hard magnetic storage layer 24," but "this ratio can be different." Ex-1001, 5:23-30. Thus, the '997 Patent does not define what constitutes a "hard" magnetic storage layer. Nonetheless, Takenoiri discloses "a hard magnetic storage layer" having a "first coercive field $H_s > 0.5$ T" (which I will address here below) that is higher than the nucleation host (which I will address for limitation 1[G] below).

126. Because Takenoiri's first magnetic recording layer 5, as its name suggests, is used for magnetic recording, it is my opinion that a POSITA would have understood that it also meets the Western Digital court's claim construction for the term "hard magnetic storage layer": "a magnetic layer that stores information in magnetically oriented bits." Ex-1019 (Western Digital CC Order), p.19-20.

127. In my opinion, Takenoiri's first magnetic storage layer 5 having a coercive field (H_c) greater than 0.5 T is **separately shown** in three groups of embodiments.

128. As I explained in the technical background, coercivity and coercive field are synonymous, which is denoted by H_c . Thus, while the '997 Patent claim 1 uses H_s and H_n to refer to switching of magnetic media, the coercive field, it is most often denoted by H_c , is the switching field H_s at zero magnetization state where half of the grains have reversed. In this declaration therefore, to avoid any confusion, I will use H_c to refer to H_s recited in the challenged claims.

129. Takenoiri's Example 1 and Comparative Example 1. The coercivity (H_c), i.e., coercive field, of the first magnetic recording layer 5 in Takenoiri's Example 1 is determined by looking at both Example 1 and Comparative Example 1. Because the structure in Takenoiri's Example 1 includes, among other things, a first magnetic recording layer 5, a coupling layer 6, and a second magnetic recording layer 7 (Ex-1005, 10:56-66), while the structure in Takenoiri's Comparative Example 1 is the same as Example 1 except that it includes only the first magnetic recording layer 5, with neither the coupling layer 6 nor the second magnetic recording layer 7, the coercivity (H_c) of the first magnetic recording layer 5 in Takenoiri's Example 1 and Comparative Example 1 is 6770 Oe (red). *Id.*, 11:17-21.

TABLE 1		
Item	Example 1	Comp Ex 1
H _c (Oe)	4,710	6,770
TAA [336 kfc] (mVp-p)	1.82	1.29
normalized noises [336 kfc] (μVrms/mVp-p)	19.5	22.4
S/N [336 kfc] (dB)	25.5	23.5
D ₅₀ (kfc)	371	344
decay rate of output signals [28 kfc] (%/decade)	0.67	0.25

Id., 12:30-42 (Table 1).

130. The unit conversion for coercive field is 1 Tesla (T) = 10k Oersted (Oe). Ex-1021, p.9 (“1Tesla (10,000 Oe)”). Therefore, the coercive field of the first magnetic recording layer in Takenoiri’s Example 1 (and Comparative Example 1) is 0.677 T, which is greater than 0.5 T.

131. Takenoiri’s Example 2 and Comparative Example 3. Similarly, the H_c of the first magnetic recording layer 5 in Takenoiri’s Example 2 is measured via Comparative Example 3 because the structure in Comparative Example 3 is the same as in Example 2 except that it includes only the first magnetic recording layer 5, with no coupling layer 6 or second magnetic recording layer 7. Ex-1005, 13:49-58, 14:9-13. As shown below, the H_c of the first magnetic recording layer 5 in

Takenoiri's Example 2 and Comparative Example 3 is 6990 Oe (red), which is 0.699 T, which is greater than 0.5 T.

TABLE 3		
Item	Example 2	Comp Ex 3
H _c (Oe)	5,214	6,990
O/W (dB)	46.5	16.0
normalized noises [336 kfc] (μVrms/mVp-p)	22.8	23.1
S/N [336 kfc] (dB)	24.3	22.9
D ₅₀ (kfc)	396	349
decay rate of output signals [28 kfc] (%/decade)	0.01	4.66

Id., 14:54-67 (Table 3).

132. Takenoiri's Examples 3-6 and Comparative Example 4. Similar to the above pairs of examples, the H_c of the first magnetic recording layer 5 in each of Takenoiri's Examples 3-6 is measured via Comparative Example 4, which includes only the first magnetic recording layer 5, with no coupling layer 6 or second magnetic recording layer 7. Ex-1005, 15:21-30, 16:23-27. As shown below, the H_c of the first magnetic recording layer in Examples 3-6 (whose first magnetic recording layer 5 is identical to that of Comparative Example 4 (*id.*, 15:45-16:20)), is 6449 Oe (red), which is 0.6449 T, which is greater than 0.5 T.

TABLE 4						
		Example 3	Example 4	Example 5	Example 6	Comp Ex 4
first magnetic recording layer	composition		(Co ₇₂ Cr ₁₀ Pt ₁₈) ₉₀ (SiO ₂) ₁₀			
	thickness (nm)	9.5	9.5	9.5	9.5	9.5
coupling layer	composition	Ru	Ru	Ru	Ru	none
	thickness (nm)	1.6	0.25	0.25	0.25	none
second magnetic recording layer	composition	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄	Co ₆₉ Cr ₂₂ Pt ₅ B ₄	Co ₇₆ Cr ₂₀ B ₄	none
	thickness (nm)	6.5	6.5	6.5	6.5	none
	H _c (Oe)	5,016	5,119	4,490	4,176	6,449
	O/W (dB)	38.1	37.4	45.6	46.2	24.7

Id., 16:50-67 (Table 4).

133. Thus, as I have explained above, in each of Takenoiri's Examples 1-6, the first magnetic recording layer 5 has a coercive field greater than 0.5 T. Because Takenoiri's tri-layer structure includes the same first magnetic recording layer 5, Takenoiri's tri-layer structure therefore includes a hard magnetic storage layer having a coercive field greater than 0.5 T.

134. Therefore, in my opinion, Takenoiri discloses "a **hard magnetic storage layer** [e.g., Takenoiri's first magnetic recording layer 5], **having a first coercive field $H_c > 0.5$ T** [e.g., in each of Takenoiri's Examples 1-6, the coercive field of the first magnetic recording layer 5 is 0.677 T, 0.699 T, or 0.6449 T, respectively, which are all greater than 0.5 T], **formed on the underlayer** [e.g.,

one or more of Takenoiri's soft magnetic backing layer 2, underlayer 3, and/or nonmagnetic intermediate layer 4].”

135. To the extent that the recited “first coercive field” refers to the coercive field of the hard magnetic storage layer with the nucleation host, it is my opinion that Takenoiri also discloses or at least renders obvious this limitation. For example, as I show below, Takenoiri discloses in Examples 2-4 that the coercive field of the entire structure is 0.5214 T, 0.5016 T, and 0.5119 T, respectively. Because the completion of magnetic reversal of an entire composite magnetic recording medium structure depends on the completion of magnetic reversal of the hardest layer within the stack (e.g., Takenoiri's first magnetic recording layer 5, *see* my discussion below in Section XII.B.1.k for limitation 1[J]), a POSITA would have understood that for Takenoiri's multilayer structure, the coercive field of the first magnetic recording layer 5 in the stack of layers) in Examples 2-4 is at least 0.5214 T, 0.5016 T, and 0.5119 T, respectively, which are all greater than 0.5 T.

TABLE 3

Item	Example 2	Comp Ex 3
Hc (Oe)	5,214	6,990
O/W (dB)	46.5	16.0
normalized noises [336 kfc] ($\mu\text{Vrms/mVp-p}$)	22.8	23.1
S/N [336 kfc] (dB)	24.3	22.9
D ₅₀ (kfc)	396	349
decay rate of output signals [28 kfc] (%/decade)	0.01	4.66

Ex-1005, Table 3.

TABLE 4

		Example 3	Example 4	Example 5	Example 6	Comp Ex 4
first magnetic recording layer	composition	$(\text{Co}_{72}\text{Cr}_{10}\text{Pt}_{18})_{90}(\text{SiO}_2)_{10}$				
	thickness (nm)	9.5	9.5	9.5	9.5	9.5
coupling layer	composition	Ru	Ru	Ru	Ru	none
	thickness (nm)	1.6	0.25	0.25	0.25	none
second magnetic recording layer	composition	$\text{Co}_{61}\text{Cr}_{22}\text{Pt}_{13}\text{B}_4$	$\text{Co}_{61}\text{Cr}_{22}\text{Pt}_{13}\text{B}_4$	$\text{Co}_{69}\text{Cr}_{22}\text{Pt}_5\text{B}_4$	$\text{Co}_{76}\text{Cr}_{20}\text{B}_4$	none
	thickness (nm)	6.5	6.5	6.5	6.5	none
	Hc (Oe)	5,016	5,119	4,490	4,176	6,449
	O/W (dB)	38.1	37.4	45.6	46.2	24.7

Id., Table 4.

136. I note that Comparing Examples 3 and 4 in Table 4 below, it is apparent that changing the interlayer thickness yield a change in exchange

coupling and results in a corresponding change of the coercivity of the entire structure, as well as the corresponding change in overwrite (O/W), which represents recordability or writability.

TABLE 4

		Example 3	Example 4	Example 5	Example 6	Comp Ex 4
first magnetic recording layer	composition		(Co ₇₂ Cr ₁₀ Pt ₁₈) ₉₀ (SiO ₂) ₁₀			
	thickness (nm)	9.5	9.5	9.5	9.5	9.5
coupling layer	composition	Ru	Ru	Ru	Ru	none
	thickness (nm)	1.6	0.25	0.25	0.25	none
second magnetic recording layer	composition	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄	Co ₆₉ Cr ₂₂ Pt ₅ B ₄	Co ₇₆ Cr ₂₀ B ₄	none
	thickness (nm)	6.5	6.5	6.5	6.5	none
	Hc (Oe)	5,016	5,119	4,490	4,176	6,449
	O/W (dB)	38.1	37.4	45.6	46.2	24.7

Ex-1005, Table 4.

137. As I detailed in Section XII.B.1.h (limitation 1[G]), *infra*, Takenoiri teaches introducing softer layer(s) to make switching easier, e.g., by initiating reversal through the layer stack. *See, e.g.*, Ex-1005, 10:7-18. This allows Takenoiri to maintain thermal stability by keeping the first magnetic recording layer with high coercivity/anisotropy. *Id.* As I also explained in in Section XII.B.1.h, Takenoiri's tri-layer structure introduces a third magnetic recording layer softer than the second magnetic recording layer 7, which makes switching

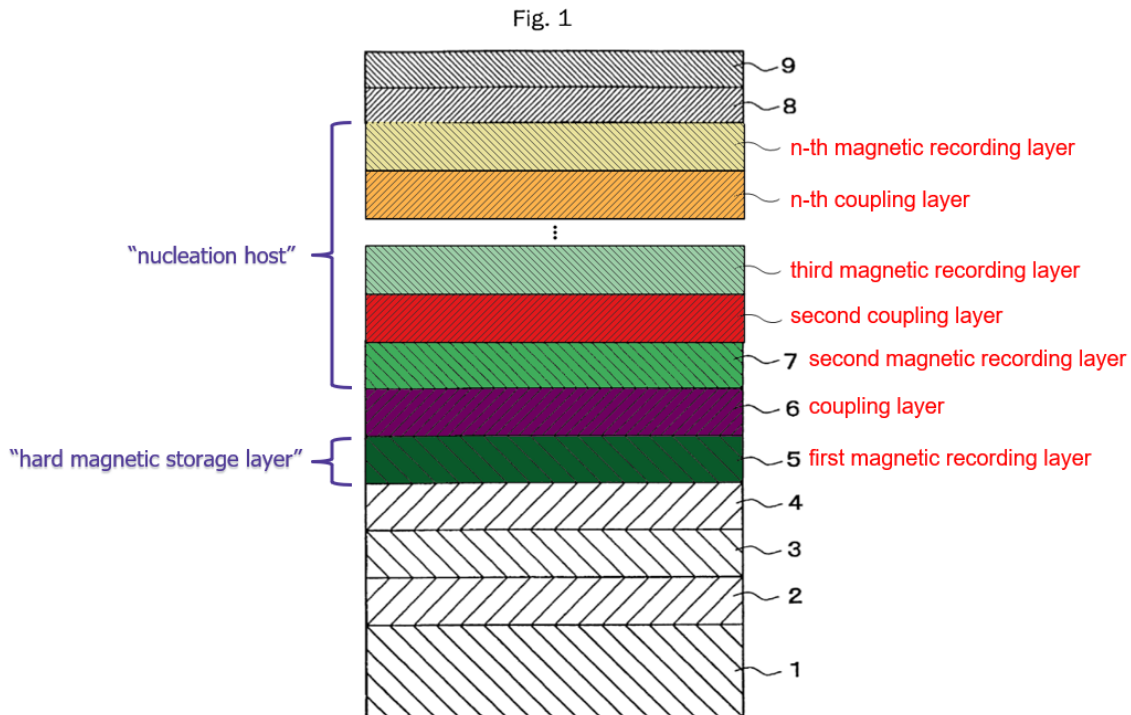
even easier than the bi-layer structure. In other words, a POSITA would have understood that with the additional even softer third magnetic recording layer, even if the coercivity of the first magnetic recording layer 5 is increased, Takenoiri's tri-layer structure is still able to maintain the same level of overall coercivity (thereby writeability). Therefore, in view of the additional third magnetic recording layer, a POSITA looking to further improve the thermal stability of Takenoiri's tri-layer structure while maintaining its writeability would have been motivated to further increase the coercivity/anisotropy of the first magnetic recording layer 5, such that the overall coercivity of the tri-layer structure maintains at the same level as the bi-layer structure, and would have had reasonable expectation of success as Takenoiri expressly teaches tuning H_c via layer thickness and composition. Ex-1005, 9:23-29; *see also id.*, 9:63-67. Thus, for Takenoiri's tri-layer structures built by introducing a third magnetic recording layer into Takenoiri's bi-layer structure in Examples 2-4, a POSITA would have found it obvious to increase the coercivity of the first magnetic recording layer 5 from the bi-layer structure such that the coercivity of the entire stack, which is also the coercivity of the first magnetic recording layer with the second and third magnetic recording layers (i.e., Takenoiri's "nucleation host," *see* Section XII.B.1.h (limitation 1[G])) maintains the same as that of the bi-layer structure, i.e., 0.5214 T, 0.5016 T, and 0.5119 T, respectively, which are all greater than 0.5 T as required by this limitation.

h. 1[G]

138. Limitation 1[G] requires: “a nucleation host, having a second coercive field H_n without the hard magnetic storage layer, lower than the first coercive field, $H_n < H_s$.”

139. Before diving into the details of Takenoiri’s teachings, I would like to provide a preview of my opinions for this limitation. In my opinion, Takenoiri teaches a multilayer magnetic recording structure comprising multiple ferromagnetically exchange-coupled magnetic recording layers with anisotropy perpendicular to the medium plane. While its Figures and Examples focus primarily on bi-layer embodiments, Takenoiri explicitly extends the same principles to tri-layer (or greater) structures. *See* Ex-1005, 10:7-10. Specifically, it discloses that magnetization reversal occurs sequentially through each layer, enabling a reduction in switching field without sacrificing thermal stability. As I will show below, in this design, in addition to the first magnetic recording layer, the system includes multiple additional magnetic recording layers (second, third, fourth,...n-th magnetic recording layers). These additional magnetic recording layers are the claimed nucleation host. And as I will also show below, these additional magnetic recording layers have a coercivity lower than that of the first magnetic recording layer (i.e., the claimed hard magnetic storage layer). The additional magnetic recording layers are softer than the first magnetic recording layer 5 to which they are coupled and

facilitate in its switching. In my opinion, these layers therefore constitute the recited “nucleation host,” consistent with Western Digital court’s construction of this term. *See, infra*, Section XII.B.1.k (limitation 1[J]).



Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1). Now I will offer my analysis in detail.

140. In my opinion, a POSITA would have found it obvious that Takenoiri’s “nucleation host” (at least second and third magnetic recording layers) has a coercive field lower than that of the first magnetic recording layer 5 for at least the following reasons.

141. Takenoiri's Examples 1–6 demonstrate that adding a second magnetic recording layer with lower coercivity (H_{c2}) to the first layer (H_{c1}) reduces the overall coercivity (H_{c1+2}).

142. Takenoiri's Example 1 and Comparative Example 1. For example, in Example 1, adding the second magnetic recording layer and a coupling layer drops H_c from 6770 Oe (Comparative Example 1) to 4710 Oe—a 30% reduction. Ex-1005, 11:16-20, Table 1. Specifically, as I discussed above for limitation 1[F], the structure disclosed in Takenoiri's Example 1 and Comparative Example 1 are identical, except that Example 1 includes the first magnetic recording layer 5, the coupling layer 6, and the second magnetic recording layer 7, while Comparative Example 1 includes the first magnetic recording layer 5 and not the coupling layer 6 and the second magnetic recording layer 7. Ex-1005, 10:56-66, 11:17-21. As shown in Table 1 below, the H_c of Example 1 is 4710 Oe and Comparative Example 1 6770 Oe.

Second magnetic recording layer 7
+
Coupling layer 6
+
First magnet recording layer 5

First magnet recording layer 5

TABLE 1

Item	Example 1	Comp Ex 1
H _c (Oe)	4,710	6,770
TAA [336 kfc] (mVp-p)	1.82	1.29
normalized noises [336 kfc] (μVrms/mVp-p)	19.5	22.4
S/N [336 kfc] (dB)	25.5	23.5
D ₅₀ (kfc)	371	344
decay rate of output signals [28 kfc] (%/decade)	0.67	0.25

Id., 12:30-42 (Table 1). In other words, in Example 1, the H_c of the combination of the first magnetic recording layer 5, the coupling layer 6, and the second magnetic recording layer 7 (H_{c1+2}) is 4710 Oe. In Comparative Example 1, H_{c1} of only the first magnetic recording layer is 6770 Oe. By introducing the second magnetic recording layer 7 (as well as the coupling layer 6) on top of the first magnetic recording layer 5, “the H_c in Example 1 was reduced by 2,000 Oe (about 30%) as compared with Comparative Example 1,” which only has the first magnetic recording layer 5. *Id.*, 11:64-66.

143. Because in Example 1, H_{c1} is 6770 Oe and H_{c1+2} is 4710 Oe (which is lower than H_{c1}), a POSITA would have understood that H_{c2} is lower than H_{c1} (6770 Oe) because in order to reduce H_c of the entire structure such that the magnetization

reverses at magnetic field lower than H_{c1} (i.e., to make H_{c1+2} lower than H_{c1}), the newly introduced layer, i.e., the second magnetic recording layer 7, must reverse its magnetization at a magnetic field lower than H_{c1} , resulting in H_{c2} being lower than H_{c1} . In fact, a POSITA would have understood that H_{c2} is lower than H_{c1+2} (4710 Oe), because otherwise, the value of H_{c1+2} would have to be above 4710 Oe.

144. The same effect appears in Examples 2–6, with H_c consistently reduced compared to their respective controls. Ex-1005, 12:46-16:49, Tables 3-4.

145. Takenoiri's Example 2 and Comparative Example 3. As also discussed above, the structure disclosed in Takenoiri's Example 2 and Comparative Example 3 are identical, except that Comparative Example 3 includes only the first magnetic recording layer 5. Ex-1005, 13:49-58, 14:9-13. As shown in Table 3 below, the coercive field H_c of Example 1 is 5214 Oe and Comparative Example 1 6990 Oe.

Second magnetic recording layer 7
+
Coupling layer 6
+
First magnet recording layer 5

First magnet recording layer 5

TABLE 3

Item	Example 2	Comp Ex 3
H _c (Oe)	5,214	6,990
O/W (dB)	46.5	16.0
normalized noises [336 kfc] (μVrms/mVp-p)	22.8	23.1
S/N [336 kfc] (dB)	24.3	22.9
D ₅₀ (kfc)	396	349
decay rate of output signals [28 kfc] (%/decade)	0.01	4.66

Id., 14:54-67 (Table 3). In other words, in Example 12, H_{c1} is 6990 Oe, and the H_{c1+2} is 5214 Oe. Again, by introducing the second magnetic recording layer 7 (as well as the coupling layer 6) on top of the first magnetic recording layer 5, “Example 2 reduced the H_c by about 1,800 Oe (about 25%) as compared with Comparative Example 3,” which only has the first magnetic recording layer 5. *Id.*, 14:28-30.

146. Because in Example 2, H_{c1} is 6990 Oe and H_{c1+2} is 5214 Oe (which is lower than H_{c1}), a POSITA would have understood that H_{c2} is lower than H_{c1} (6990 Oe) for the same reasons explained above with respect to Example 1. In fact, a POSITA would have understood that H_{c2} is lower than H_{c1+2} (5214 Oe).

147. Takenoiri's Examples 3–6 and Comparative Example 4. As I have discussed above, the structure disclosed in each of Takenoiri's Examples 3–6 is identical to that in Comparative Example 3, except that each of Takenoiri's Examples 3–6 includes the first magnetic recording layer 5, the coupling layer 6, and the second magnetic recording layer 7 (with different thickness for the coupling layer 6 and different composition for the second magnetic layer 7), while Comparative Example 4 includes only the first magnetic recording layer 5. Ex-1005, 15:21-30, 15:45-16:20, 16:23-27. As shown in Table 3 below, the coercive field H_c of Examples 3-6 is 5016 Oe, 5119 Oe, 4490 Oe, and 4176 Oe, respectively, and the coercive field H_c of Comparative Example 4 is 6449 Oe.

Second magnetic recording layer 7
+
Coupling layer 6
+
First magnet recording layer 5

First magnet recording layer 5

TABLE 4

		Example 3	Example 4	Example 5	Example 6	Comp Ex 4
first magnetic recording layer	composition		(Co ₇₂ Cr ₁₀ Pt ₁₈) ₉₀ (SiO ₂) ₁₀			
	thickness (nm)	9.5	9.5	9.5	9.5	9.5
coupling layer	composition	Ru	Ru	Ru	Ru	none
	thickness (nm)	1.6	0.25	0.25	0.25	none
second magnetic recording layer	composition	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄	Co ₆₉ Cr ₂₂ Pt ₅ B ₄	Co ₇₆ Cr ₂₀ B ₄	none
	thickness (nm)	6.5	6.5	6.5	6.5	none
	H_c (Oe)	5,016	5,119	4,490	4,176	6,449
	O/W (dB)	38.1	37.4	45.6	46.2	24.7

Id., 16:50-67 (Table 4).

148. Because in Examples 3–6, H_{c1} is 6449 Oe and H_{c1+2} is 5016 Oe, 5119 Oe, 4490 Oe, and 4176 Oe, respectively (each of which is lower than H_{c1}), a POSITA would have understood that H_{c2} in each of Examples 3–6 is lower than H_{c1} (6449 Oe) for the same reasons explained above with respect to Example 1. In fact, a POSITA would have understood that in each of Examples 3–6, H_{c2} is lower than H_{c1+2} in each of Examples 3-6 respectively.

149. In summary, Takenoiri teaches in each of its Examples 1–6 that H_{c2} is lower than both H_{c1} and H_{c1+2} .

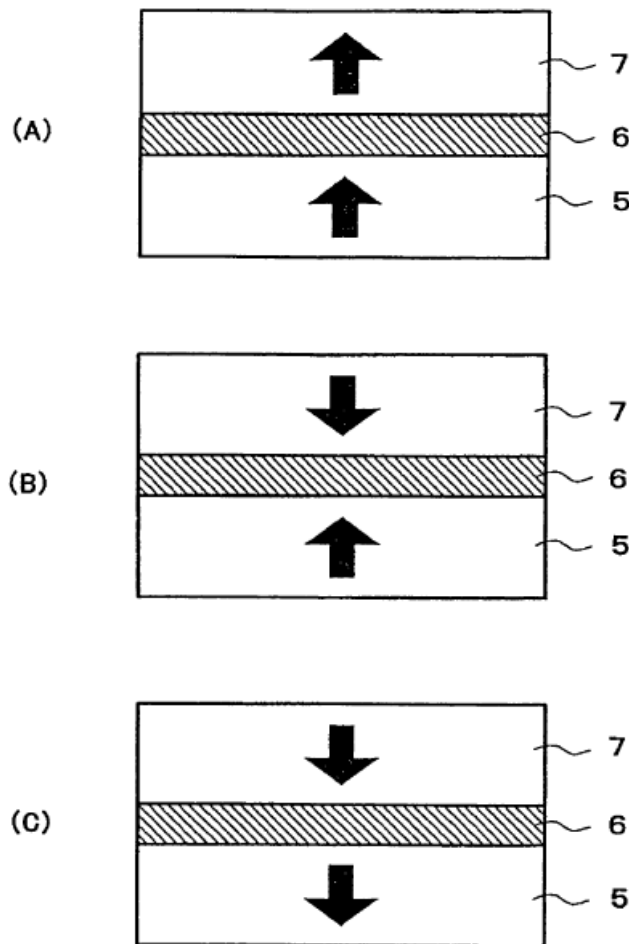
150. Given that $H_{c2} < H_{c1}$, it is my opinion that a POSITA would be motivated to continue this trend in a tri-layer (or more) structure by setting the coercivity of the third magnetic recording layer $H_{c3} < H_{c2}$ in order to accomplish Takenoiri's stated goal of reducing switching fields while maintaining thermal stability.

151. According to Takenoiri, “each magnetic layer **reverses magnetization individually.**” Ex-1005, 5:12-13; *see also id.*, 7:33-35 (“[T]he thermal stability is improved and simultaneously the switching field is reduced by **individually reversing the magnetization.**”); 9:25-28 (“switching field can be effectively decreased without impairing thermal stability **by reversing the magnetization first in the second magnetic recording layer...**”). In particular, for a bi-layer structure “in which first magnetic recording layer 5 and second magnetic recording layer 7 ferromagnetically couple through coupling layer 6,” Takenoiri discloses that “the

magnetization reversal first arises in the second magnetic recording layer.” *Id.*, 5:18-

19. As illustrated in Takenoiri’s Figure 4 below, starting with state (A), when an external magnetic field is applied, magnetic reversal in the second magnetic recording layer 7 occurs first, as shown in state (B). *Id.*, 5:26-40. Further increasing the external magnetic field will eventually cause the first magnetic recording layer 5 to also reverse, as shown in state (C). *Id.*

Fig. 4



Ex. 1005, Fig. 4. Takenoiri further explains the effect of individual magnetization reversal:

At the moment of the magnetization reversal in the first magnetic recording layer, the second magnetic recording layer has already reversed the magnetization thereof. So, the magnetization reversal in the first magnetic recording layer is easy owing to the effect of the magnetic field of the second magnetic recording layer.

Ex. 1005, 5:41-46.

152. While Takenoiri's Figures 1 and 4, as well as Examples 1-6, concern bi-layer structures, Takenoiri explicitly states that the same individual magnetization reversal principle applies to a structure having three or more magnetic recording layers. *See* Ex-1005, 10:14-18 ("**By individually reversing** the magnetization of each **magnetic recording layer as in this measure**, the structure **having three or more magnetic recording layers** still produces the effect of **improving thermal stability** and the effect of **reducing switching field** at the same time."). Thus, it is my opinion that a POSITA would have been motivated to set H_{c3} lower than H_{c2} , to continue to **reduce the switching field** for the tri-layer structure as taught by Takenoiri.

153. As I have explained above, in Takenoiri's bi-layer structures, when an external magnetic field is applied, the layer further away from the substrate (i.e., the

second magnetic recording layer 7) reverses magnetization first, and the layer closer to the substrate (i.e., the first magnetic recording layer 5) reverses magnetization last. *See* Ex-1005, Fig. 4. Thus, it is my opinion that a POSITA implementing Takenoiri's tri-layer structure would have been motivated to continue such reversal sequence by configuring the third magnetic recording layer such that the third magnetic recording layer reverses magnetization first, the second magnetic recording layer 7 follows, and the first magnetic recording layer 5 reverses last, and such reversal sequence requires H_{c3} being lower than H_{c2} .

154. Doing so would further reduce the overall coercivity (H_{c1+2+3}), enhancing writability as Takenoiri intended. Alternatively, the overall coercivity (H_{c1+2+3}) can be maintained while increasing the coercivity of the first layer (H_{c1}) to improve the thermal stability of the recording layer. Therefore, it is axiomatic that when $H_{c3} < H_{c2} < H_{c1}$, the coercivity of the combined second and third magnetic recording layers (H_{c2+3}) is lower than H_{c1} .

155. In my opinion, at a minimum, a POSITA would have been motivated to set H_{c3} lower than H_{c1+2} to maintain or reduce the overall coercivity (H_{c1+2+3}) as compared to a bi-layer structure, because as Takenoiri teaches with its bi-layer structures, introducing a "softer" layer with coercivity lower (H_{c2}) than the existing structure reduces the overall coercivity (H_{c1+2}).

156. Specifically, Takenoiri “achieves improved recordability without deteriorating thermal stability by reducing the switching field.” Ex-1005, Abstract. According to Takenoiri, recordability refers to “easiness with which a magnetic recording medium is recorded” and “the reduction of H_c ... improve[s] the recordability.” *Id.*, 1:65-67, 12:1-3; *see also id.*, 18:13-15 (“[T]he H_c is also decreased, demonstrating the effect to improve the recordability”).

157. I note that although coercive field H_c and switching field are generally different parameters, they are intimately related as coercivity can be considered as the average switching field of the media. As I explained in the technical background section above, a POSITA would have understood that coercive field H_c refers to the average field to switch magnetic grain stack of the media and switching field refers to the field to switch the magnetization of a particular grain stack, both determine writability, or “recordability” as discussed in Takenoiri. This is consistent with the agreed-upon claim construction of the term “coercive field” in the Western Digital case: “plain meaning – a property of magnetic materials that provides a measure of the ability of a ferromagnetic material to withstand an external magnetic field without becoming demagnetized.” Ex-1019 (Western Digital CC Order), p.7. In Takenoiri, improved recordability is achieved by “reducing the switching field” and “reduction of H_c .” Ex-1005, Abstract, 12:1-3. Therefore, Takenoiri uses coercive field and switching field interchangeably. Takenoiri “achieves improved

recordability without deteriorating thermal stability” (Ex-1005, Abstract) because H_{c1} can be maintained relatively high while H_c of the entire structure is reduced by introducing additional magnetic recording layers with lower H_c values. Therefore, for purposes of this declaration, I also treat these two terms synonymously.

158. Going back to Takenoiri’s disclosure, as demonstrated by each of Takenoiri’s Examples 1–6 discussed above, introducing a softer magnetic recording layer (i.e., second magnetic recording layer 7) with an H_c lower than that of the underlying structure (i.e., the structure with only first magnetic recording layer 5) reduces the overall coercivity for the structure—provided that the introduced softer layer and the existing magnetic recording layer is appropriately exchange coupled. This layered configuration, where the softer layer is exchange-coupled to the harder layer, enables the use of a high-anisotropy magnetic recording layer while reducing the switching field required for writing, thereby “improv[ing] the recordability of a magnetic recording medium without impairing thermal stability.” Ex-1005, 12:20-24; *see also id.*, 14:44-48 (“As described above, the structure of two magnetic layers that are ferromagnetically coupled according to the invention has demonstrated the simultaneous improvements in the recordability of a magnetic recording medium and the thermal stability.”); 17:13-17 (“As is apparent by comparing Comparative Example 4 with Examples 3 through 6, the ferromagnetically-coupled double-layer magnetic layer of the invention decreases H_c , improves O/W, and remarkably

reduces the decay rate of signals. In other words, recordability and thermal stability of a medium have been remarkably improved.”). Therefore, in my opinion, a POSITA implementing Takenoiri’s multilayered structure that includes three or more magnetic recording layers—by adding a third magnetic recording layer on top of the existing bi-layer structure—would have been naturally motivated to design the third magnetic recording layer with a coercivity (H_{c3}) lower than that of the underlying bi-layer (H_{c1+2}), assuming appropriate exchange coupling with the underlying bi-layer. This is because introducing the softer third magnetic recording layer with H_{c3} lower than that of the underlying bi-layer structure (H_{c1+2}) further reduces the overall coercivity for the resulting tri-layer structure (H_{c1+2+3}) to be lower than H_{c1+2} , thereby further improving the structure’s recordability compared to the original bi-layer configuration.

159. Moreover, as there are only three configurations for H_{c3} relative to H_{c1+2} (greater than, equal to, or less than), in my opinion, a POSITA would have been motivated to try (i.e., it would have been **obvious to try**) the third option, as it aligns with Takenoiri’s goal of reducing switching fields. When $H_{c3} < H_{c1+2} < H_{c1}$, since $H_{c2} < H_{c1}$ (as I have explained above), it follows that $H_{c2+3} < H_{c1}$.

160. In my opinion, a POSITA would have had reasonable expectation of success in setting H_{c3} lower than H_{c1+2} and/or H_{c2} , both of which results in H_{c2+3} lower than H_{c1} , as I have explained above. Since $H_{c2+3} < H_{c1}$, a POSITA would have

understood that H_{c1+2+3} is also power than H_{c1} , especially to achieve the references stated purpose of sequential switching.

161. For example, Takenoiri teaches how to tune H_c via layer thickness, composition, and grain isolation. Specifically, Takenoiri teaches that “the **thicknesses and materials** of the first and the second magnetic recording layers are determined so as to satisfy the inequality... because the switching field can be effectively decreased without impairing thermal stability...” Ex-1005, 9:23-29; *see also id.*, 9:63-67 (“The magnetic recording layer more preferably contains at least one element selected from Ta, B, Nb, and N. This composition promotes reduction of noise of the medium and more effectively decreases the switching field of the magnetic recording layer.”); Examples 1-6 (with varying material composition and thickness for the first and second magnetic recording layers). Because Takenoiri teaches that its magnetic recording layers may have “a granular structure composed of a matrix of a nonmagnetic oxide or a nonmagnetic nitride and magnetic crystal grains dispersed in the matrix” (Ex-1005, 3:33-37), it is my opinion that a POSITA would have known that H_c could also be adjusted by controlling the grain size, grain distribution, and grain isolation via oxide. Ex-1032, Fig. 1. In my opinion, a POSITA would have known how to implement these adjustments using conventional techniques with a reasonable expectation of success. For example, grain size of a magnetic material can be controlled through various processing techniques,

including adjusting alloy composition, controlling deposition parameters, and post-processing thermal treatments. Grain size distribution can be adjusted by adding specific elements to the magnetic alloy, which helps control grain growth and isolation. Sputtering and deposition parameters, such as substrate temperature, and post-deposition thermal processing, were both well-known techniques to control grain size distribution and grain isolation.

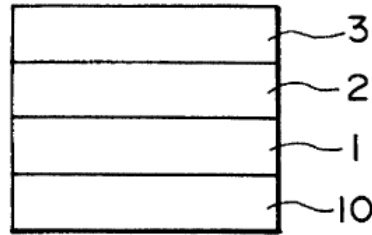
162. Moreover, this configuration of $H_{c3} < H_{c2} < H_{c1}$ is not novel. U.S. Pat. No. 5,536,570 (“Osato,” Ex. 1016), for example, discloses a magneto-optical recording medium with exactly that gradient:

That is, the present invention is a magneto-optical recording medium comprising a first magnetic layer [1] having a curie point T_1 and a coercive force H_1 , a second magnetic layer [2] having a curie point T_2 and a coercive force H_2 , and a third magnetic layer [3] having a curie point T_3 and a coercive force H_3 , where said first, second and third magnetic layers being successively laminated on a substrate. Further, said first magnetic layer, said second magnetic layer and said third magnetic layer each being vertically magnetized film composed chiefly of an amorphous alloy of rare earth elements and transition metal elements, and satisfying the following conditions:

$$H_1 > H_2 > H_3,$$

$$T1 > T2 > T3.$$

Ex. 1016, 2:24-39.



F I G. 1A

Ex. 1016, Fig. 1A; *see also id.*, Fig. 1B (showing similar structure with additional layers, such as coupling layers).

163. Osato's medium and Takenoiri's structure both use vertically magnetized tri-layer systems to improve magnetic recordability via a coercivity gradient. It is my opinion that a POSITA would have had every reason to expect success in applying the same H_c gradient to Takenoiri's media. Li also provides an exemplary stack of three magnetic recording layers with coercivity/anisotropy gradient, also resulting in the sequential switching as taught by Takenoiri. *See, e.g.*, Ex-1022, 5:20-25 ("Preferably, each of the magnetic grains comprises a plurality of overlying sub-layers of magnetic material, each of the sub-layers of magnetic material having a different perpendicular magnetic anisotropy which progressively decreases from a sub-layer at the first end to a sub-layer at the second end of each of

the magnetic grains.”); *see also id.*, 6:49-55 (“In accordance with embodiments of the present invention, application of an external magnetic field to the recording layer induces a progressive reversal process of an initial magnetization direction of each of the plurality of columnar-shaped magnetic grains which originates at one of the ends, progresses toward the other end, and results in reversal of the initial magnetization direction to yield a final magnetization direction.”). In my opinion, a POSITA would have been motivated by both the Osato and Li references to implement a coercivity gradient in Takenoiri’s tri-layer structure such that $H_{c3} < H_{c2} < H_{c1}$ and would have had a reasonable expectation of success in doing so. Osato discloses a tri-layer magnetic structure with a coercivity gradient at room temperature, while Li describes a similar gradient, albeit in the reverse direction, in the context of PMR. Together, these references confirm that coercivity (and thus anisotropy) grading across magnetic layers was known in the art and technically achievable. A POSITA would have understood from these teachings not only the motivation to apply a gradient in Takenoiri’s structure but also that such a configuration could be practically implemented with predictable results.

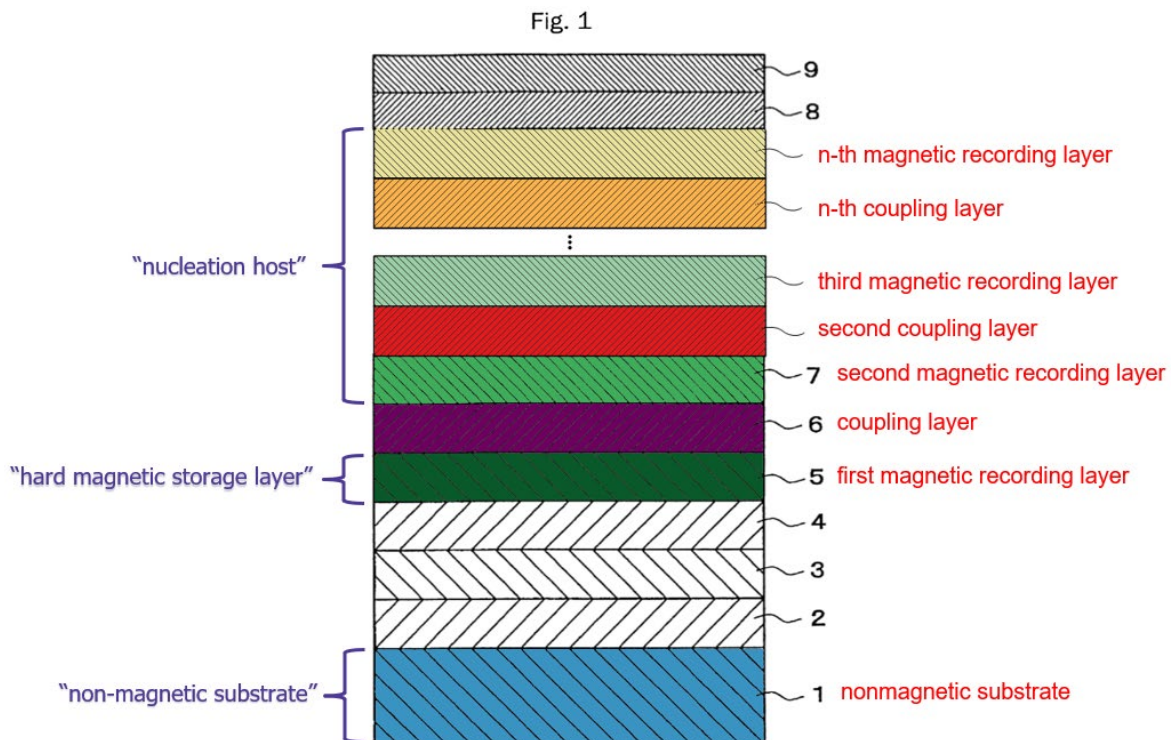
164. Therefore, in my opinion, Takenoiri renders obvious “**a nucleation host** [e.g., at least Takenoiri’s second magnetic recording layer 7, the third magnetic recording layer, and the coupling layer in between, as part of Takenoiri’s tri-layer structure], **having a second coercive field H_n without the hard magnetic storage**

layer [e.g., the coercive field H_c of Takenoiri's "nucleation host," i.e., H_{c2+3}], **lower than the first coercive field, $H_n < H_s$** [e.g., both H_{c2+3} and H_{c1+2+3} being lower than H_c of Takenoiri's first magnetic recording layer 5, i.e., H_{c1}]."

i. 1[H]

165. Limitation 1[H] requires: "said nucleation host is formed on the hard magnetic storage layer such that the hard magnetic storage layer is between the nucleation host and the non-magnetic substrate."

166. As I have explained for limitation 1[G] in Section XII.B.1.h above, Takenoiri's tri-layer structure discloses the claimed "nucleation host." As shown below, Takenoiri's "hard magnetic storage layer" is between its "nucleation host" and the non-magnetic substrate.



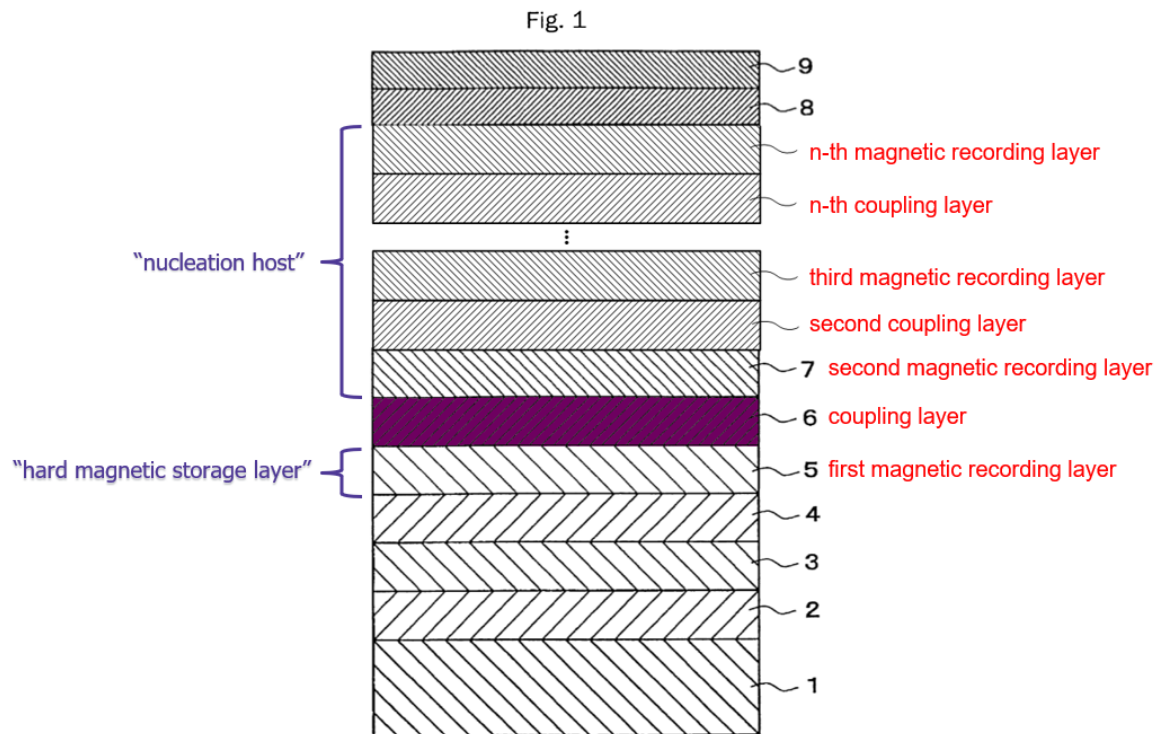
Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1).

167. Therefore, in my opinion, Takenoiri discloses that “**said nucleation host** [e.g., at least Takenoiri’s second magnetic recording layer 7, the third magnetic recording layer, and the coupling layer in between, as part of Takenoiri’s tri-layer structure] **is formed on the hard magnetic storage layer** [e.g., Takenoiri’s first magnetic recording layer 5] **such that the hard magnetic storage layer is between the nucleation host and the non-magnetic substrate** [e.g., Takenoiri’s nonmagnetic substrate 1].”

j. 1[I]

168. Limitation 1[I] requires: “[said nucleation host] is exchange coupled to the hard magnetic storage layer.”

169. As I have explained in Section XII.A above, Takenoiri discloses a tri-layer structure. *See* revised Figure 1 reproduced below.



Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1).

170. As shown in the figure above, “[t]he first magnetic recording layer [5] and the second magnetic recording layer [7] are ferromagnetically coupled through the coupling layer [6 (purple)].” *Id.*, 3:5-7; *see also id.*, 3:21-23 (“Advantageously, an **exchange coupling energy** per unit area between the first magnetic recording layer and the second magnetic recording layer is at least 5×10^{-3} erg/cm².”). Because the second magnetic recording layer 7 is part of Takenoiri’s “nucleation host,” Takenoiri’s “nucleation host” is therefore exchange coupled to the first magnetic recording layer 5.

171. Therefore, in my opinion, Takenoiri discloses “[said nucleation host] is **exchange coupled to the hard magnetic storage layer** [e.g., Takenoiri’s

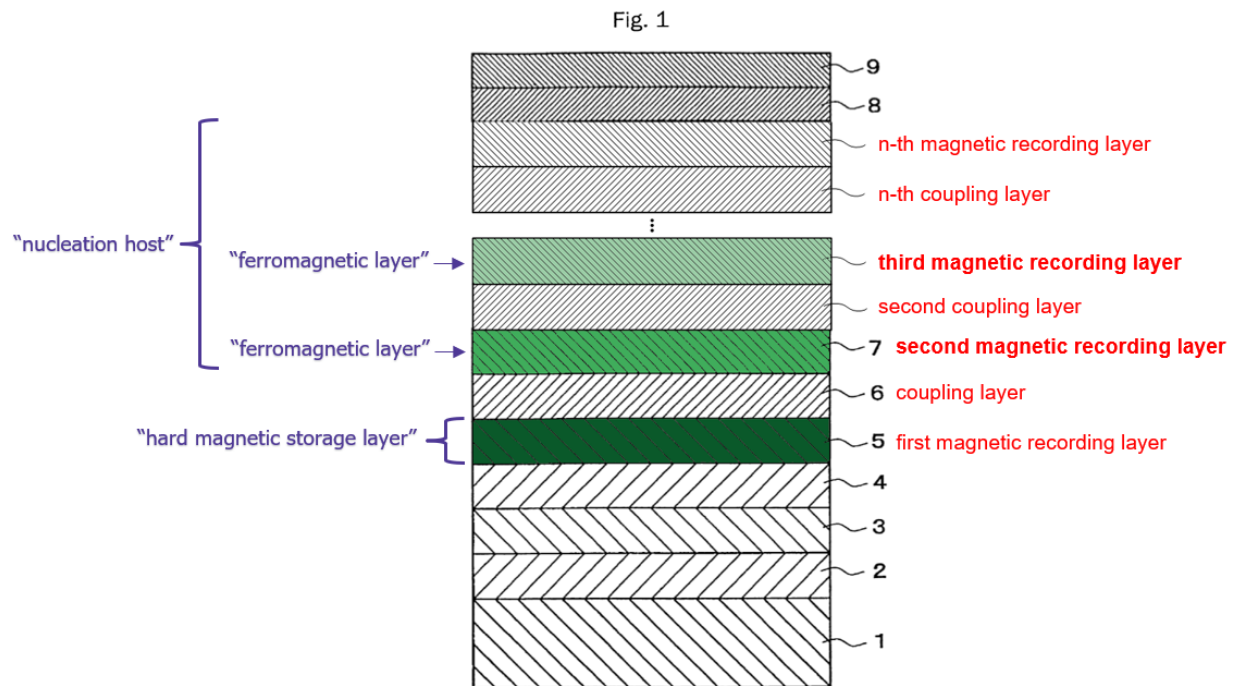
“nucleation host” is exchange coupled to the first magnetic recording layer 5 because the second magnetic recording layer 7 as part of Takenoiri’s “nucleation host” is exchange coupled to the first magnetic recording layer 5].”

k. 1[J]

172. Limitation 1[J] requires: “[said nucleation host] comprises ferromagnetic layers with increasing anisotropy constant K from layer to layer.

173. In my opinion, Takenoiri’s tri-layer magnetic recording architecture satisfies the structural and material requirements of the claimed “nucleation host,” including the presence of ferromagnetic layers with the claimed anisotropy gradient. Takenoiri expressly extends the described bi-layer switching and anisotropy principles to three or more magnetic recording layers. As shown below, Takenoiri’s second and third magnetic recording layers form the “nucleation host.” Takenoiri further teaches and suggests that these layers are made of ferromagnetic alloys and that their anisotropy constants (K_u values) are tuned to enable top-down sequential switching. Ex-1005, 10:7-18. It is my opinion that a POSITA would have recognized from Takenoiri’s teachings, and known design principles in the art, that configuring the second magnetic recording layer with anisotropy higher than that of the third magnetic recording layer, i.e., $K_{u2} > K_{u3}$, not only preserves this switching behavior but also improves writability and thermal stability, as I will discuss in detail below.

174. **Ferromagnetic layers.** It is my opinion that Takenoiri's "nucleation host" includes at least two ferromagnetic layers. As shown in Takenoiri's tri-layer structure, Takenoiri's "nucleation host" as part of its tri-layer structure includes at least two magnetic recording layers: the second magnetic recording layer 7 (green) and the third magnetic recording layer (light green).



Ex-1005, Fig. 1 (tri-layer structure in modified Fig. 1).

175. Takenoiri discloses that the second magnetic recording layer 7 can employ "the same material and structure as in first magnetic recording layer 5" (Ex-1005, 9:13-15), which "is preferably composed of a **ferromagnetic alloy** containing at least cobalt and platinum." *Id.*, 6:66-67. Therefore, Takenoiri's second magnetic recording layer 7 is a ferromagnetic layer.

176. It is my opinion that a POSITA would have found it obvious to use the same or a similar material as in the first and second magnetic recording layers. This is true for at least three reasons. First, the third magnetic recording layer participates in the same sequential magnetization reversal process as the first and second layers, as described in Takenoiri (Ex-1005) at 10:14–18. Second, the third layer is exchange-coupled to the second layer beneath it, just as the second layer is exchange-coupled to the first. *Id.*, 10:8–10 (“The magnetic recording layers can be constructed with three or more layers. The ferromagnetic coupling is provided between every two magnetic recording layers through a coupling layer.”). Third, all three layers must satisfy the same functional requirement involving the $K_u \cdot T$ relationship. *Id.*, 10:10-14 (“The order of magnitude of the product $K_u T$ of a uniaxial anisotropy constant and a thickness of each magnetic recording layer are determined in accordance with the order of magnitude of the anisotropy magnetic field H_k of the magnetic recording layer.”); *see also* Takenoiri’s Examples 1-6 (showing that similar materials are used for the first and second magnetic recording layers) though different compositions for achieving different anisotropy field H_k . Takenoiri uses similar material with different compositions to meet this requirement in the first and second magnetic recording layers, and in my opinion, a POSITA would have applied the same approach to the third magnetic recording layer. Moreover, because Takenoiri’s magnetic layers are exchange coupled (*id.*,

10:7-10), a POSITA would have understood that the main ferromagnetic element(s) in the magnetic alloy materials used for these magnetic layers need to be of similar though different compositions to ensure appropriate coupling. Thus, it is my opinion that a POSITA would have found it obvious that the third magnetic recording layer is also composed of “ferromagnetic alloy” and therefore is also a ferromagnetic layer.

177. Moreover, I would like to note that all magnetic recording layers in a PMR HDD must be ferromagnetic. Ferromagnetic materials are those in which magnetic moments of atoms spontaneously align in the same direction, even without an external magnetic field, due to strong exchange interactions. This alignment produces a net magnetization, making ferromagnetic materials capable of retaining magnetic information and thus suitable for data storage. Key properties include remanence and coercivity. In a perpendicular magnetic recording (PMR) hard disk drive (HDD), all magnetic recording layers involved in storing or propagating bits—including the hard magnetic storage layer and any soft or graded layers that assist in switching—must be ferromagnetic. This is because non-ferromagnetic materials cannot hold a remanent magnetization and therefore cannot contribute to stable data storage or controlled switching. Layers such as nonmagnetic spacers, seed layers, or interlayers may exist in the stack, but they serve structural or coupling roles—not directly for recording.

178. Therefore, in my opinion, Takenoiri discloses, or at least suggests, “[said nucleation host] **comprises ferromagnetic layers** [e.g., at least Takenoiri’s second magnetic recording layer 7 and third magnetic recording layer as part of its tri-layer structure].”

179. **Anisotropy Constants.** In my opinion, a POSITA would have found it obvious to configure Takenoiri’s “nucleation host” such that the anisotropy constant of Takenoiri’s second magnetic recording layer 7 (hereinafter Ku_2) is greater than that of the third magnetic recording layer (hereinafter Ku_3), for at least the following reasons.

180. *First*, Takenoiri discloses that for a bi-layer structure, if $Hk_1 > Hk_2$, then $Ku_1 T_1 > Ku_2 T_2$, where “ Hk_1 , Ku_1 , and T_1 are an anisotropy magnetic field, a uniaxial anisotropy constant, and a thickness of the first magnetic recording layer, respectively, and Hk_2 , Ku_2 , and T_2 are an anisotropy magnetic field, a uniaxial anisotropy constant, and a thickness of the second magnetic recording layer, respectively.” Ex-1005, claim 1. I have summarized the parameters in Takenoiri’s Examples 1–6 in the table below. As shown in the table, for each of Takenoiri’s Examples 1–6, $Hk_1 > Hk_2$ and $Ku_1 T_1 > Ku_2 T_2$. In particular, in each of Examples 1–6, $Ku_1 > Ku_2$.

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
second magnetic recording layer 7	Composition	(Co ₇₂ Cr ₁₆ Pt ₁₂) ₉₀ -(SiO ₂) ₁₀	Co ₇₀ Cr ₂₀ Pt ₁₀	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄		Co ₆₉ Cr ₂₂ Pt ₅ B ₄	Co ₇₆ Cr ₂₀ B ₄
	thickness T ₂	6	6	6.5	6.5	6.5	6.5
	Ku ₂	2.5	2	1.85	1.85	1.51	1.31
	Hk ₂	13.2	11.1	13.2	13.2	10.1	8.17
coupling layer 6	Composition	Ru	Cobalt	Ru			
	Thickness	0.2	0.3	1.6	0.25	0.25	0.25
first magnetic recording layer 5	Composition	(Co ₇₄ Cr ₁₂ Pt ₁₄) ₉₀ -(SiO ₂) ₁₀	(Co ₇₂ Cr ₁₀ Pt ₁₈) ₉₀ -(SiO ₂) ₁₀				
	thickness T ₁	10	10	9.5	9.5	9.5	9.5
	Ku ₁	4.2	5	5.05	5.05	5.05	5.05
	Hk ₁	18.7	20	20	20	20	20

181. As disclosed in Takenoiri, the unit for thickness T₁ and T₂ is nm and the unit for Hk₁ and Hk₂ is kOe. *See, e.g.*, Ex-1005, 10:56-66, 11:31-36. While the unit for Ku₁ and Ku₂ in Takenoiri is 10⁻⁶ erg/cm³ (*id.*, 11:31-33), a POSITA would have understood that this is a typographical error because it was well known that the Ku values of CoCrPt-based materials, as used for Takenoiri's Examples 1-6, are in the 10⁶ erg/cm³ range. *See* Ex-1028, Figures 3, 4, 7; Ex-1036, ¶90. Regardless, this typographical error does not affect my analysis because Takenoiri discloses the correct relative values of Ku and KuT.

182. Thus, in my opinion, if a third magnetic layer is added (per Takenoiri's tri-layer (or more) structure described above), it would have been obvious to a POSITA that Ku₂>Ku₃, following the same Ku trend described in each of Examples 1-6 to preserve the switching behavior, e.g., sequential magnetization switching from top to bottom. *See, e.g.*, Ex-1005, 9:25-29 ("This is because the switching field can be effectively decreased without impairing thermal stability by reversing the magnetization first in the second magnetic recording layer in the case

$H_{k1} > H_{k2}$, for example.”). In other words, a POSITA would have understood that extending the Ku scheme between two magnetic layers to a third magnetic layer naturally suggests the same directional Ku gradient, so that sequential magnetization switching from top to bottom (as illustrated in Examples 1-6) can be more easily achieved in Takenoiri’s tri-layer structure (as I will explain below), thereby “still produc[ing] the effect of improving thermal stability and the effect of reducing switching field at the same time.” *Id.*, 10:14-18.

183. *Second*, it is my opinion that it would have been obvious to a POSITA to configure K_{u3} such that $K_{u2} > K_{u3}$ because only three configurations could exist: (i) $K_{u3} > K_{u2}$; (ii) $K_{u3} = K_{u2}$; or (iii) $K_{u3} < K_{u2}$. Of these, a POSITA would have been motivated to try (i.e., **obvious to try**) all three configurations, but in particular a POSITA would have been motivated to try configuration (iii) because, as explained above, it aligns with Takenoiri’s established gradient of decreasing anisotropy and supports sequential switching from top to bottom, which is also a known strategy for reducing coercivity while maintaining thermal stability.

184. In my opinion, same is true for configuring H_{k3} , as a POSITA would have been motivated to configure H_{k3} such that $H_{k2} > H_{k3}$ because that is one of the only three available configurations: (i) $H_{k3} > H_{k2}$; (ii) $H_{k3} = H_{k2}$; or (iii) $H_{k3} < H_{k2}$, and a POSITA have been motivated to try configuration (iii) as it continues the established Hk gradient and facilitates sequential magnetization switching from top

to bottom (since lower H_k contributes to lower H_c). When $H_{k2} > H_{k3}$, and given Takenoiri's equation " $H_k = 2 Ku/Ms$ " (Ex-1005, 8:15), it is my opinion that a POSITA would have been motivated to set $Ku_2 > Ku_3$ so that $H_{k2} > H_{k3}$ can be more easily achieved.

185. *Third*, it is my opinion that a POSITA would have been motivated to configure Ku_3 such that $Ku_2 > Ku_3$ because a lower Ku_3 makes Takenoiri's top-to-bottom sequential switching easier to achieve. In Takenoiri, for the second magnetic layer 7 to reverse before the first magnetic recording layer 5, $H_{k1} > H_{k2}$ and $Ku_1 T_1 > Ku_2 T_2$ must be satisfied. Extending this to a tri-layer structure, it is my opinion that a POSITA would have recognized that $H_{k2} > H_{k3}$ and $Ku_2 T_2 > Ku_3 T_3$ must also hold. *See* Ex-1005, 10:10-14 ("The order of magnitude of the product KuT of a uniaxial anisotropy constant and a thickness of each magnetic recording layer are determined in accordance with the order of magnitude of the anisotropy magnetic field H_k of the magnetic recording layer."). Lowering Ku_3 helps meet both conditions. Lower Ku_3 obviously contributes to lower $Ku_3 T_3$. Moreover, under Takenoiri's equation " $H_k = 2 Ku/Ms$," lower Ku_3 also reduces H_{k3} , which in turn contributes to lower H_c , making sequential switching more attainable.

186. *Fourth*, it is my opinion that a POSITA would have been motivated to configure Ku_3 such that $Ku_2 > Ku_3$ because a lower Ku_3 also helps reduce the overall coercivity (H_c) of the structure. Although Takenoiri imposes specific relationships

between H_{k1} , H_{k2} , K_{u1} , K_{u2} , T_1 , and T_2 , these relationships ultimately aim to “contribute to the reduction of the H_c .” Ex-1005, 14:30-34; *see also id.*, 10:14-18 (“By individually reversing the magnetization of each magnetic recording layer as in this measure, the structure having three or more magnetic recording layers still produces the effect of improving thermal stability and the **effect of reducing switching field** at the same time.”). As I have explained for limitation 1[G] in Section XII.B.1.h above, a POSITA would have been motivated to configure $H_{c3} < H_{c2}$ to further reduce the overall coercivity. I must note that it was well known that lower K_u leads to lower H_c or switching field, as acknowledged by Dr. Suess himself. Ex-1011, p.1 (“According to the Stoner–Wohlfarth theory (SW) an increase of anisotropy...results in an unfavorable increase of coercivity $\mu_0 H_c$.”); Ex-1036, ¶70; *see also* Ex-1006, 2:2-3 (“increasing K_u also increases the switching field”). The ’997 Patent itself also acknowledges this: “[I]ncreasing the anisotropy K ... results in an unfavorable increase of the coercivity H_c .” Ex-1001, 1:22-26. Therefore, it is my opinion that to achieve $H_{c3} < H_{c2}$, a POSITA would have been motivated to configure $K_{u3} < K_{u2}$.

187. *Finally*, it is my opinion that a POSITA would have had **reasonable expectation of success** in configuring K_{u3} lower than K_{u2} . For example, as I show in the table below, Takenoiri has provided exemplary magnetic recording layers with various K_u values in Examples 1-6. Takenoiri provided not only the material

compositions, but also the deposition conditions for each of these layers. *See* Ex-1005, 10:56-66, 13:49-58, 15:21-30. Although these layers are used as the first and second magnetic recording layers, it is my opinion that a POSITA would not have had any difficulty in using one of these layers with relatively lower Ku value as the third magnetic recording layer. As one example, a POSITA would have had reasonable expectation of success in depositing a magnetic layer having the same composition and Ku value as the second magnetic layer 7 in Example 5 (red) as the additional third magnetic recording layer to the structure in Example 1.

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6
second magnetic recording layer 7	Composition	(Co ₇₂ Cr ₁₆ Pt ₁₂) ₉₀ -(SiO ₂) ₁₀	Co ₇₀ Cr ₂₀ Pt ₁₀	Co ₆₁ Cr ₂₂ Pt ₁₃ B ₄		Co ₆₉ Cr ₂₂ Pt ₅ B ₄	Co ₇₆ Cr ₂₀ B ₄
	thickness T ₂	6	6	6.5	6.5	6.5	6.5
	Ku ₂	2.5	2	1.85	1.85	1.51	1.31
	Hk ₂	13.2	11.1	13.2	13.2	10.1	8.17
coupling layer 6	Composition	Ru	Cobalt	Ru			
	Thickness	0.2	0.3	1.6	0.25	0.25	0.25
first magnetic recording layer 5	Composition	(Co ₇₄ Cr ₁₂ Pt ₁₄) ₉₀ -(SiO ₂) ₁₀	(Co ₇₂ Cr ₁₀ Pt ₁₈) ₉₀ -(SiO ₂) ₁₀				
	thickness T ₁	10	10	9.5	9.5	9.5	9.5
	Ku ₁	4.2	5	5.05	5.05	5.05	5.05
	Hk ₁	18.7	20	20	20	20	20

188. Moreover, Takenoiri teaches specific “favorable compositions of the magnetic recording layer exhibiting lower Hk,” and therefore lower Ku. Ex-1005, 10:1-6. Takenoiri further teaches that lower platinum content contributes to lower Hk value, and therefore lower Ku. *Id.*, 9:49-54 (“Specifically, the platinum content can be reduced in the magnetic recording layer that exhibits lowest Hk value, which is the magnetic recording layer that starts to reverse magnetization first among the magnetic recording layers. It is yet possible for this magnetic recording

layer not to contain platinum at all.”). In fact, K_u adjustment was well known and widely implemented. In addition to reducing platinum content as explicitly taught by Takenoiri, increasing Cr content and incorporating elements such as Ta, B, Nb, and N (which are implied by Takenoiri) are also common ways to reduce K_u value. *See, e.g.*, Ex-1005, 9:57-67; *see also* Ex-1022, 10:58-61 (“Tailoring of the magnetic anisotropies, i.e., the perpendicular magnetic anisotropy fields H_k , of each of the sub-layers is accomplished, in known fashion, as by appropriate selection of the magnetic alloys and their processing conditions...”). Therefore, it is my opinion that a POSITA would have had **reasonable expectation of success** in configuring K_{u3} lower than K_{u2} in Takenoiri’s tri-layer structure.

189. Because Takenoiri’s K_{u2} is greater than K_{u3} , the anisotropy constant increases from the third magnetic recording layer to the second magnetic recording layer. This is consistent with the court’s construction of the term “nucleation host... comprises ferromagnetic layers with increasing anisotropy constant K from layer to layer” in the Western Digital case: “nucleation host includes two or more ferromagnetic layers which have anisotropy constants K , and the value of the anisotropy constant K for the layers increase as the layers get closer to the hard magnetic storage layer, such that the nucleation host has an overall increase in anisotropy toward the hard magnetic storage layer.” Ex-1019 (Western Digital CC Order), p.9-14.

190. Therefore, in my opinion, Takenoiri renders obvious that “[said nucleation host] **comprises ferromagnetic layers** [e.g., at least Takenoiri’s second magnetic recording layer 7 and third magnetic recording layer as part of its tri-layer structure] **with increasing anisotropy constant K from layer to layer** [e.g., Takenoiri’s anisotropy constant of the second magnetic recording layer 7 (K_{u2}) being greater than the anisotropy constant K of the third magnetic recording layer (K_{u3})].”

191. I would like to note that because the second and third magnetic recording layers in Takenoiri’s tri-layer structure are ferromagnetic layers and are expected to switch magnetization earlier than the first magnetic recording layer, thereby facilitating the switching of the first magnetic storage layer 5, Takenoiri’s second and third magnetic recording layers, as well as the coupling layer in between, corresponds to the claimed “nucleation host,” which is consistent with the court’s construction in the Western Digital case: “a structure that includes ferromagnetic layers that assist in switching the hard magnetic storage layer, and optional coupling layers.” Ex-1019 (Western Digital CC Order), p.17-18.

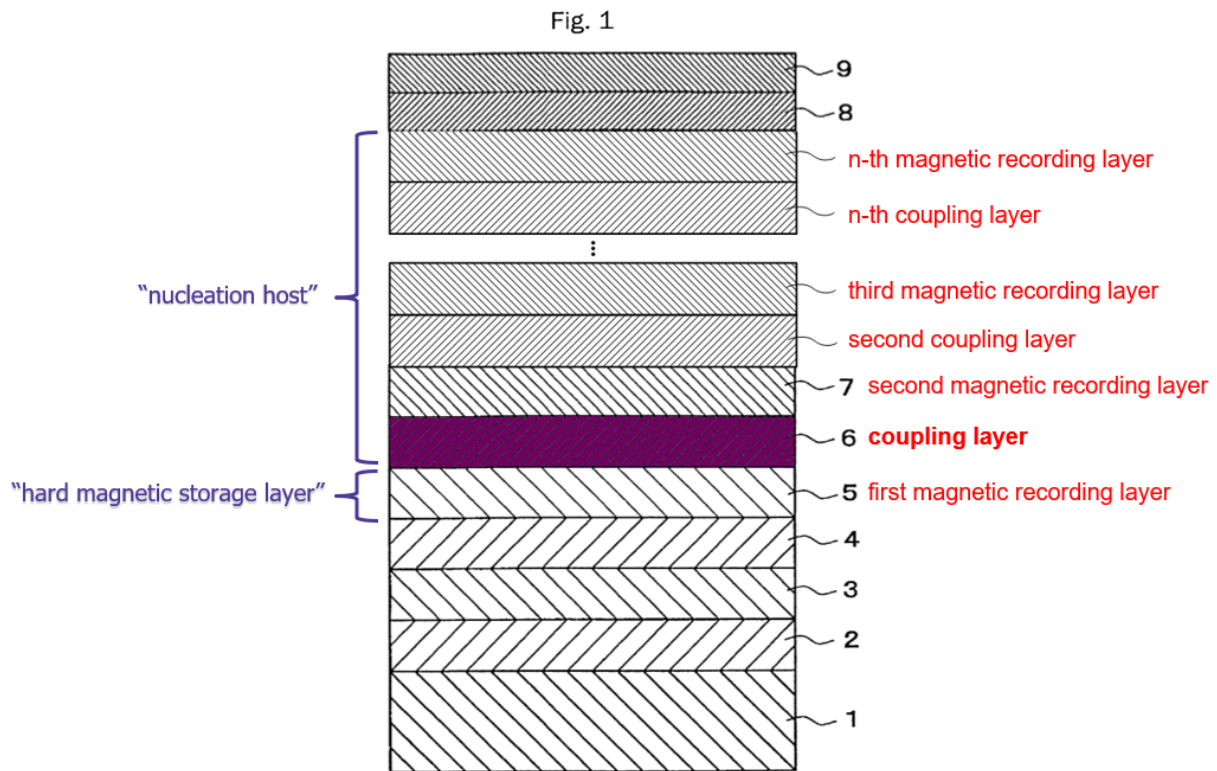
192. In summary, each of the limitations in claim 1 is disclosed by or at least obvious over Takenoiri. As I will explain below, other claims of the ’997 Patent were also disclosed by Takenoiri alone and/or in view of other prior art.

2. Claim 2

193. Claim 2 depends from claim 1. As I explained above, all the limitations of claim 1 are rendered obvious by Takenoiri. Claim 2 further recites “**wherein: the nucleation host and the hard magnetic storage layer are in direct contact,**” which, in my opinion, is disclosed, or at least rendered obvious, by Takenoiri.

194. Claim 1 of the '997 Patent states that the nucleation host “comprises ferromagnetic layers,” which does not limit the nucleation host to only ferromagnetic layers. Therefore, it is my opinion that for the embodiment claimed in claim 3, Takenoiri’s coupling layer 6 can be considered part of the nucleation host formed on the hard magnetic storage layer. This is further confirmed by PO’s own proposed claim construction of “nucleation host” in the Western Digital case (which was also adopted by the court): “a structure that includes ferromagnetic layers that assist in switching the hard magnetic storage layer, and **optional coupling layers.**” Ex-1019 (Western Digital CC Order), p.17-18.

195. Therefore, for the embodiment claimed in claim 3, as shown below, Takenoiri’s “nucleation host” includes the coupling layer 6 (purple), so Takenoiri’s “nucleation host” (including the coupling layer 6) and its first magnetic recording layer 5 (i.e., the claimed “hard magnetic storage layer”) are in direct contact.



Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1).

196. As such, it is my opinion that claim 2 is obvious over Takenoiri.

197. To the extent PO attempts to argue that the coupling layer 6 cannot be considered part of Takenoiri's "nucleation host," it is my opinion that a POSITA would have found it obvious to omit that layer from Takenoiri's tri-layer structure, placing the first and second magnetic recording layers in direct contact and resulting in direct contact between Takenoiri's "nucleation host" and "hard magnetic storage layer."

198. Although Takenoiri states that a coupling layer is necessary, it does so only "from the viewpoint of leading to an appropriate coupling energy between the

magnetic recording layers while retaining the ferromagnetic coupling” to achieve simultaneous improvement of thermal stability and reduction in the switching field. Ex-1005, 7:30-35. In my opinion, this language reflects a desire to improve the device’s performance, not a structural requirement, and confirms that Takenoiri describes a magnetic recording medium that could exist without the coupling layer 6.

199. Moreover, it is my opinion that a POSITA seeking to implement or evaluate Takenoiri’s teachings would have been motivated to fabricate and compare versions of Takenoiri’s multilayer structure with and without the coupling layer 6 to assess its impact. Since omitting the coupling layer 6 would lead to the even stronger coupling between the two adjacent ferromagnetic layers (layer 5 and layer 7), a POSITA seeking stronger coupling (and thereby further reduction in the structure’s coercivity) would have been motivated to omit the coupling layer 6. It is my opinion that whether to test the efficacy of Takenoiri’s invention or in applications where thermal stability or switching field is less critical, omitting the coupling layer 6 would also have simplified fabrication, and a POSITA would have had a reasonable expectation of success. In fact, Takenoiri teaches that there existed magnetic recording media having three magnetic recording layers in direct contact. Ex-1005, 2:3-14 (citing JP 2003-157516); Ex-1027 (“Hikosaka,” US equivalent of JP 2003-157516), ¶¶ 44, 102, Figs. 3 and 8; *see also* Ex-1022, 7:1-13 (“tailoring of the local

exchange coupling strength between adjacent sub-layers to achieve a desired coupling strength is accomplished by...forming the adjacent sub-layers positioned in direct contact...”).

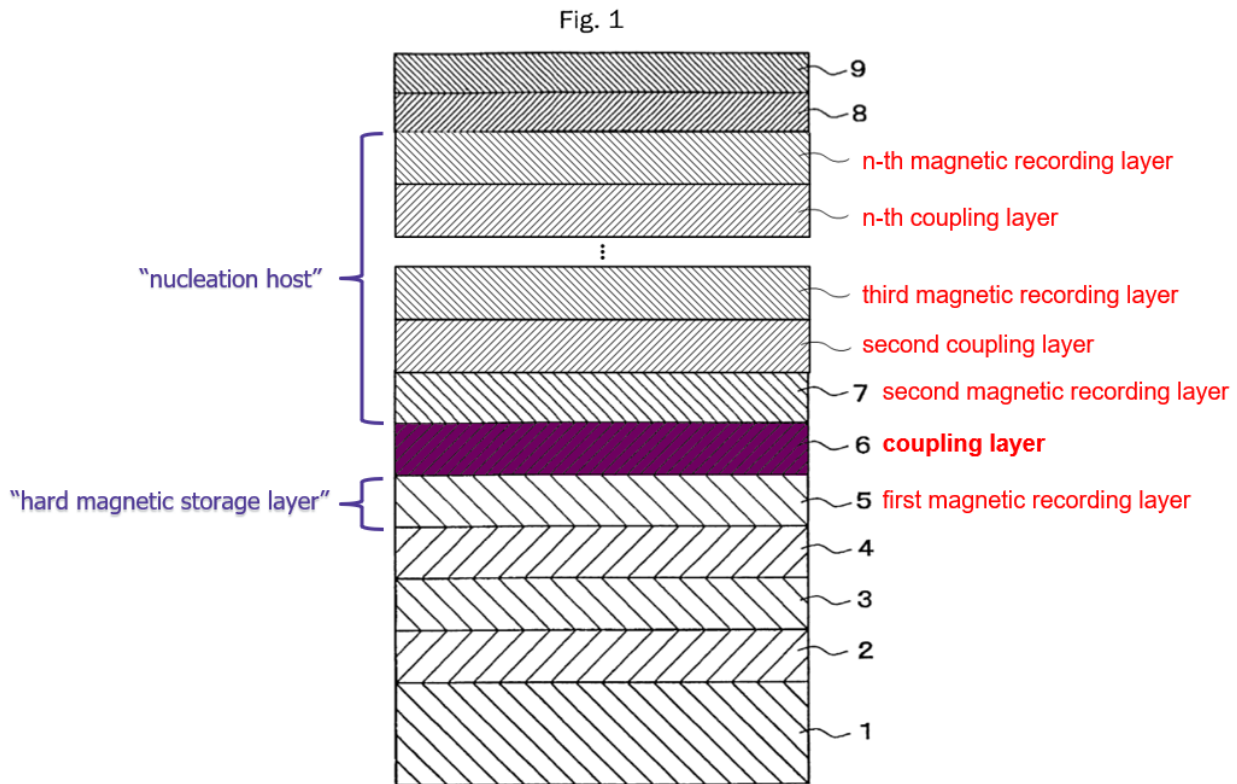
3. Claim 5

200. Claim 5 depends from claim 1. As I explained above, all the limitations of claim 1 are rendered obvious by Takenoiri. Claim 5 further recites “**wherein: a coupling layer is disposed between the nucleation host and the hard magnetic storage layer,**” which, in my opinion, is disclosed by Takenoiri.

201. As I discussed for claim 2 above, claim 1’s nucleation host must include the ferromagnetic layers, and may (or may not) include other layers, such as coupling layers.

202. Here, the embodiment claimed in Claim 5 requires “**a coupling layer [] disposed between the nucleation host and the hard magnetic storage layer.**” In my opinion, this claimed embodiment is also disclosed by Takenoiri.

203. As shown in revised Figure 1 below, Takenoiri discloses a coupling layer 6 (purple) between second magnetic recording layer 7 and the first magnetic recording layer 5.



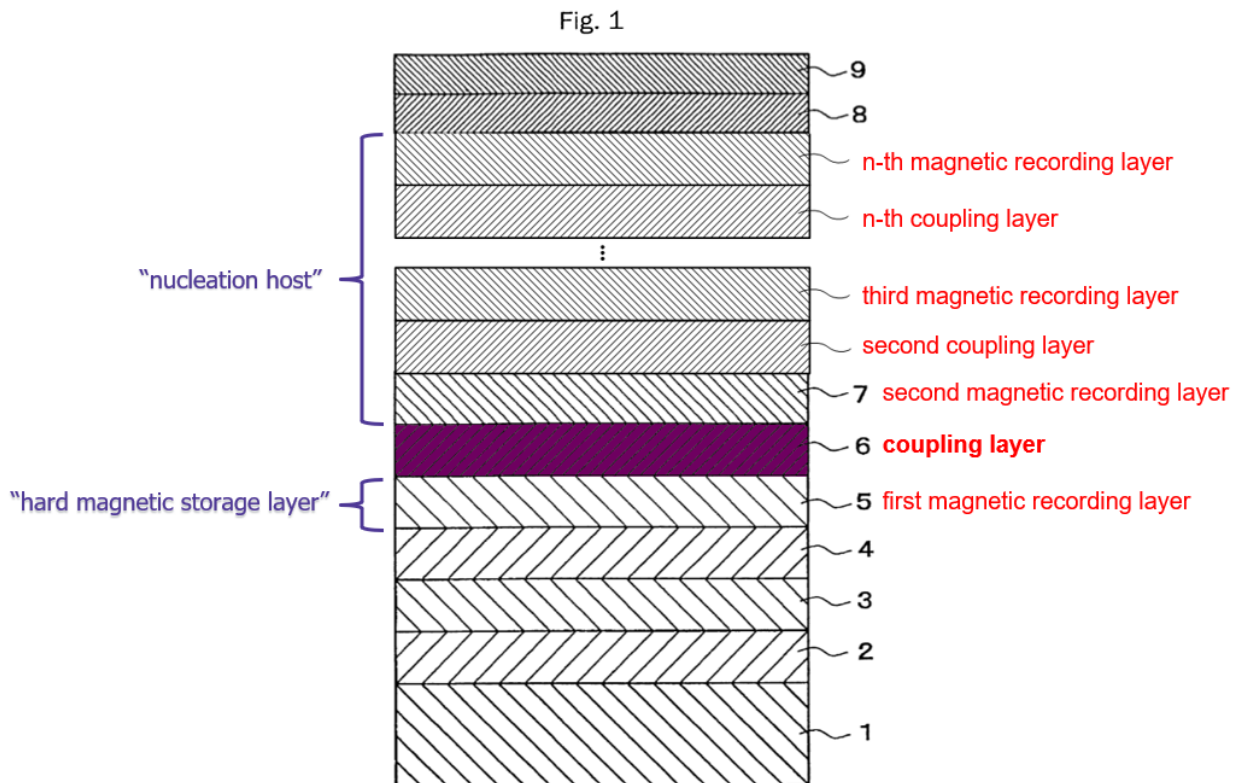
Ex. 1005, Fig. 1 (tri-layer structure in modified Fig. 1). For the embodiment claimed in claim 2, as shown in figure above, Takenoiri's "nucleation host" includes the second and third magnetic recording layers but does not include the coupling layer 6. For this claimed embodiment, Takenoiri's coupling layer 6 is the coupling layer added in claim 5.

204. Therefore, in my opinion, Takenoiri discloses that **"a coupling layer** [e.g., Takenoiri's coupling layer 6] **is disposed between the nucleation host** [e.g., Takenoiri's "nucleation host" including the second magnetic recording layer 7 at the bottom] **and the hard magnetic storage layer** [e.g., the first magnetic recording layer 5]."

4. Claim 6

205. Claim 6 depends from claim 1. As I explained above, all the limitations of claim 1 are rendered obvious by Takenoiri. Claim 6 further recites “**wherein: the nucleation host is separated from the hard magnetic storage layer by a layer of thickness less than 5 nm,**” which, in my opinion, is disclosed by Takenoiri.

206. As shown below, Takenoiri’s “nucleation host” is separated from the first magnetic recording layer 5 by a coupling layer 6 (purple).



Ex-1005, Fig. 1 (tri-layer structure in modified Fig. 1).

207. Takenoiri further discloses that “[t]he thickness of coupling layer 6 is preferably at most 2 nm,” and “more preferably 0.3 nm or smaller.” Ex-1005, 8:60-63.

208. Therefore, in my opinion, Takenoiri discloses that “**the nucleation host** [e.g., Takenoiri’s “nucleation host” including the second magnetic recording layer 7 at the bottom] **is separated from the hard magnetic storage layer** [e.g., Takenoiri’s first magnetic recording layer 5] **by a layer of thickness less than 5 nm** [e.g., Takenoiri’s coupling layer 6 having a thickness of at most 2 nm, and preferably 0.3 nm or smaller].”

5. Claim 7

209. In my opinion, claim 7 of the ’997 Patent is unpatentable because it is obvious over Takenoiri. Claim 7 of the ’997 Patent recites the following. I address each of these limitations in my analysis below.

7[P]: A magnetic recording medium, comprising:

1[A]: an essentially non-magnetic substrate;

1[B]: an underlayer formed on the non-magnetic substrate; and

1[C]: an exchange coupled magnetic multilayer structure, including

1[D]: a hard magnetic storage layer, having a first coercive field $H_s > 0.5$ T, formed on the underlayer; and

1[E]: a nucleation host, having a second coercive field H_n without the hard magnetic storage layer, lower than the first coercive field, $H_n < H_s$, wherein

1[F]: said nucleation host is formed on the hard magnetic storage layer such that the hard magnetic storage layer is between the nucleation host and the non-magnetic substrate,

1[G]: [said nucleation host] is exchange coupled to the hard magnetic storage layer, and

1[H]: [said nucleation host] comprises ferromagnetic layers with increasing anisotropy constant K from layer to layer, wherein

1[I]: at least two of the ferromagnetic layers are coupled with a thin exchange coupling layer.

a. 7[P]

210. Preamble 7[P] recites “[a] magnetic recording medium,” which is substantially the same as limitation 1[B] but does not require “a disk.” To the extent it is limiting, it is my opinion that 7[P] is disclosed for the same reasons. *See* Section XII.B.1.c.

b. 7[A]

211. 7[A] recites “an essentially non-magnetic substrate,” which is identical to limitation 1[C]. Therefore, in my opinion, 7[A] is disclosed for the same reasons. *See* Section XII.B.1.d.

c. 7[B]

212. 7[B] recites “an underlayer formed on the non-magnetic substrate,” which is identical to limitation 1[D]. Therefore, in my opinion, 7[B] is disclosed for the same reasons. *See* Section XII.B.1.e.

d. 7[C]

213. 7[C] recites “an exchange coupled magnetic multilayer structure,” which is identical to limitation 1[E]. Therefore, in my opinion, 7[C] is disclosed for the same reasons. *See* Section XII.B.1.f.

e. 7[D]

214. 7[D] recites “a hard magnetic storage layer, having a first coercive field $H_s > 0.5$ T, formed on the underlayer,” which is identical to limitation 1[F]. Therefore, in my opinion, 7[D] is disclosed for the same reasons. *See* Section XII.B.1.g.

f. 7[E]

215. 7[E] recites “a nucleation host, having a second coercive field H_n without the hard magnetic storage layer, lower than the first coercive field, $H_n < H_s$,” which is identical to limitation 1[G]. Therefore, in my opinion, 7[E] is disclosed for the same reasons. *See* Section XII.B.1.h.

g. 7[F]

216. 7[F] recites “said nucleation host is formed on the hard magnetic storage layer such that the hard magnetic storage layer is between the nucleation host and the non-magnetic substrate,” which is identical to limitation 1[H]. Therefore, in my opinion, 7[F] is disclosed for the same reasons. *See* Section XII.B.1.i.

h. 7[G]

217. 7[G] recites “[said nucleation host] is exchange coupled to the hard magnetic storage layer,” which is identical to limitation 1[I]. Therefore, in my opinion, 7[G] is disclosed for the same reasons. *See* Section XII.B.1.j.

i. 7[H]

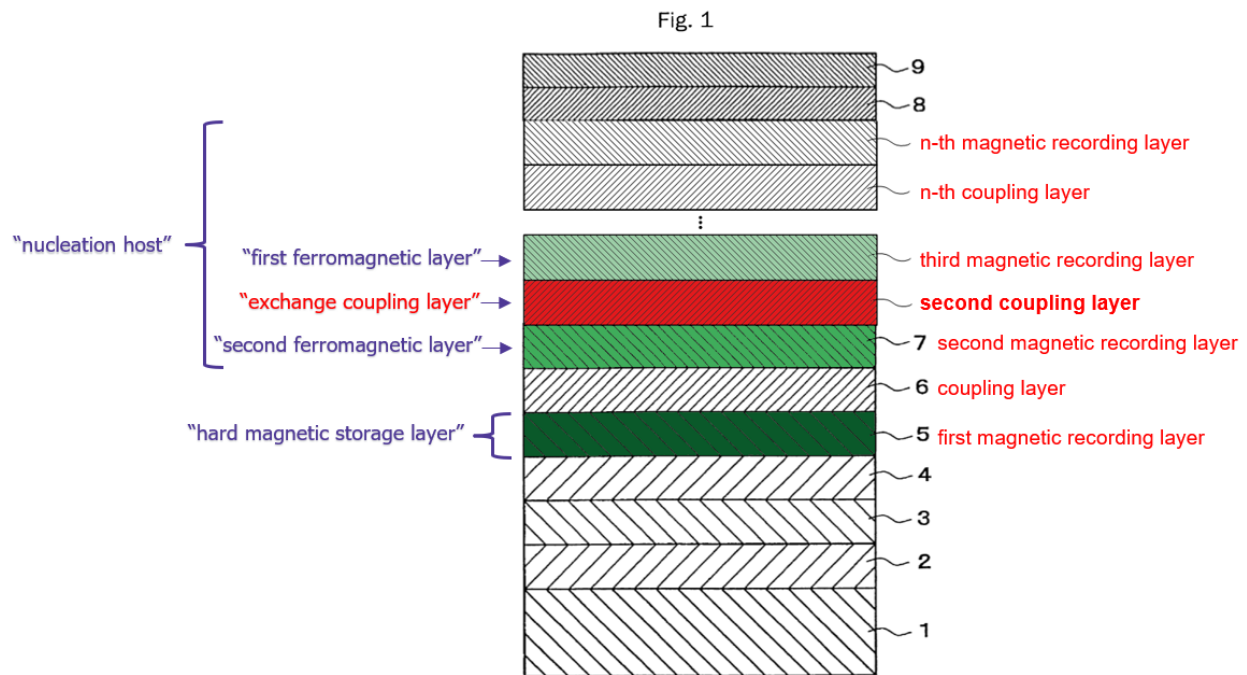
218. 7[H] recites “[said nucleation host] comprises ferromagnetic layers with increasing anisotropy constant K from layer to layer,” which is identical to limitation 1[J]. Therefore, in my opinion, 7[H] is disclosed for the same reasons. *See* Section XII.B.1.k.

j. 7[I]

219. 7[I] recites “wherein at least two of the ferromagnetic layers are coupled with a thin exchange coupling layer,” which, in my opinion, is disclosed by Takenoiri.

220. As I have explained in Section XII.B.1.f (limitation 1[E]) above, Takenoiri’s tri-layer structure is “an exchange coupled magnetic multiplayer

structure.” In particular, as shown below, the second magnetic recording layer 7 and the third magnetic recording layer are exchange coupled via an exchange coupling layer (red).



Ex-1005, Fig. 1 (tri-layer structure in modified Fig. 1).

221. Takenoiri’s coupling layer 6 is used to “appropriately control the exchange coupling energy between the first magnetic recording layer and the second magnetic recording layer.” Ex-1005, 3:24-32. Because Takenoiri’s bi-layer structure and tri-layer structure employs the same sequential switching mechanism (*id.*, 10:7-18), in my opinion, a POSITA would have understood that the function and structure (such as thickness) of the second coupling layer in Takenoiri’s tri-layer structure would have been similar to those for the coupling layer 6.

222. Although the '997 Patent does not define what constitute a “thin” exchange coupling layer, because Takenoiri’s coupling layer 6 “is more preferably 0.3 nm or smaller,” the second coupling layer will also be within the same or similar range, which, in my opinion, is “thin” compared to other layers within the tri-layer structure (such as 500 nm for the soft magnetic backing layer 2 and 30 nm for the first magnetic recording layer 5). Ex-1005, 6:22-25, 7:23-24. According to Takenoiri, thin exchange coupling layers are preferred because otherwise, the “coupling energy that is too small, and the effect of thermal stability improvement cannot be obtained.” *Id.*, 8:54-56. This is consistent with the court’s claim construction of the term “a thin exchange coupling layer”: “a layer that is sufficiently thin to alter but not prevent exchange coupling between adjacent ferromagnetic layers.” Ex-1019 (Western Digital CC Order), p.23-25.

C. **My Opinions as to Claims 4 and 9 based on Takenoiri in view of Li**

1. **Claim 4**

223. Claim 4 depends from claim 1. As I explained above, all the limitations of claim 1 are rendered obvious by Takenoiri. Claim 4 further recites “**wherein: the nucleation host comprises grains with an average diameter greater than 2 nm and less than 10 nm,**” which, in my opinion, is disclosed by Takenoiri in view of Li.

224. Takenoiri discloses that “the second magnetic recording layer has a granular structure that is composed of a matrix of a nonmagnetic oxide or a nonmagnetic nitride and **magnetic crystal grains** dispersed in the matrix.” Ex-1005, claim 5. Using of the same CoCr-based magnetic materials with a similar H_k value and a similar thickness as taught in Takenoiri, Li teaches “a grain size from about 4 to about 10 nm.” *Compare* Ex-1022, 12:6-7, 11:58-65 (“a first sub-layer at the first end of each of the magnetic grains is comprised of **CoCrX₁** first magnetic material, where X₁ is at least one element selected from the group consisting of **Ta, Pt, B, V, C, Nd, Cu, Zr, Fe, P, O, Si, and Ni, with...a relatively high perpendicular anisotropy field H_k from about 8,000 to about 20,000 Oe, a thickness δ_1 from about 6 to about 25 nm**”) *and* Ex-1005, 7:5-9 (“First magnetic recording layer 5 can be composed of an alloy material such as CoPt, **CoCrPt, CoCrPtB, or CoCrPtTa...**”), 11:35-36 (“**Anisotropy magnetic fields H_{k1} and H_{k2} were 18.7 kOe and 13.2 kOe, respectively.**”); 7:23-24 (“**The thickness of the first magnetic recording layer is preferably at most 30 nm, more preferably at most 15 nm...**”).

225. As I will explain in Section XII.C.3 below, a POSITA would have been motivated to implement Takenoiri’s grains in the second magnetic recording layer using the dimension taught by Li, i.e., with grain size from about 4 to 10 nm, in its

second magnetic recording layer, which is part of Takenoiri's "nucleation host" as explained in Section XII.B.1.h (limitation 1[G]).

226. Moreover, Takenoiri discloses in Examples 1–6 that the second magnetic recording layer (layer 7) has a thickness of 6 or 6.5 nm and a granular structure composed of magnetic particles dispersed in a non-magnetic oxide matrix (Ex-1005, 3:33–37). Although Takenoiri does not directly specify grain diameter, a POSITA would understand that in CoCr-based perpendicular granular media, the grain diameter is typically on the same nanometer scale as the layer thickness because the film consists of columnar grains that extend through the layer thickness. Accordingly, in my opinion, a POSITA would expect Takenoiri's magnetic grains to have diameters on the order of several nanometers, for example about 6 nm, which falls between 2 and 10 nm as recited in the claim.

227. In my opinion, Li's grain size is the recited grain diameter because like the '997 patent, Li's grains are "columnar-shaped" and Li's "grain size" refers to the "width[] (as measured in a horizontal direction)" of a grain. *Id.*, 13:3-7, 2:20-24; *see also id.*, 10:62-11:2 ("cross-sectional dimensions of the underlying grains (i.e., grain sizes)"). It is my opinion that a POSITA would have understood that because the grains all having a grain diameter between 4 to 10 nm, the average diameter of these grains must also be between 4 to 10 nm.

228. Therefore, Takenoiri in view of Li renders obvious that “**the nucleation host** [e.g., Takenoiri’s “nucleation host” including its second magnetic recording layer 7] **comprises grains with an average diameter greater than 2 nm and less than 10 nm** [e.g., Takenoiri’s magnetic crystal grains with diameters between 4 to 10 nm as taught by Li].”

2. Claim 9

229. Claim 9 depends from claim 7. As I explained above, all the limitations of claim 7 are rendered obvious by Takenoiri. Claim 9 further recites “**wherein: the nucleation host comprises grains with an average diameter greater than 2 nm and less than 10 nm,**” which is identical to the additional limited recited in claim 4. Therefore, in my opinion, claim 9 is disclosed by Takenoiri in view of Li for the same reasons. *See* Section XII.C.1.

3. Motivations to Combine Takenoiri with Li

230. In my opinion, both Takenoiri and Li are analogous art to the ’997 Patent because they are in the same field of endeavor, e.g., perpendicular magnetic recording media. Ex-1001, Abstract (“The invention proposes a recording media that overcomes the writeability problem of perpendicular recording media.”); Ex-1005, Title (“Perpendicular Magnetic Recording Medium”); Ex-1022, Title (“Perpendicular Magnetic Recording Media with Magnetic Anisotropy/Coercivity Gradient and Local Exchange Coupling”). In particular, each of Takenoiri, Li, and

the '997 Patent is directed to **granular** magnetic recording media with **anisotropy/coercivity gradient**. Ex-1001, claim 1, 5:41-43; Ex-1005, claim 1, Abstract; Ex-1022, claim 1 (“each of said sub-layers of magnetic material in each columnar-shaped magnetic anisotropy field Hk that progressively decreases from a sub-layer at said first end to a sub-layer at said second end of each of said magnetic grains”), 1:9-12. The '997 Patent, Takenoiri, and Li are all in Cooperative Patent Classification (CPC) class G11B 5/66. Both references and the '997 Patent achieve improved recordability without sacrificing thermal stability by introducing a “softer” magnetic layer. *See, e.g.*, Ex-1005, 5:56-59; 5:41-46; Ex-1022, 13:4-13 (“a main recording layer comprised of columnar-shaped magnetic grains with specifically designed gradients of magnetic anisotropy field (Hk)...which provide good writability and signal-to-noise ratio (SNR)...without significant sacrifice in thermal stability of the media.”); Ex-1001, 2:49-61. At a minimum, it is my opinion that both Takenoiri and Li are reasonably pertinent to at least the problem identified in the '997 Patent of how to “overcome the writability problem of extremely hard magnetic storage layers” without impairing “thermal stability.” *See, e.g.*, Ex-1001, 3:64-67; Ex-1005, 2:54-57; Ex-1022, 13:4-13.

231. In my opinion, a POSITA would have been motivated to incorporate the grain size range disclosed in Li into Takenoiri's magnetic recording layers. Both references aim to optimize the microstructure of perpendicular magnetic recording

layers to improve performance parameters such as writability, thermal stability, and signal-to-noise ratio. More specifically, both Takenoiri and Li disclose using granular perpendicular magnetic recording layers having magnetic anisotropy gradient to enable a progressive reversal process. Ex-1005, 7:5-9, 10:7-18; Ex-1022, 1:9-12, 5:4-16. These performance parameters ultimately enable higher areal data density. Ex-1005, 2:57-62; Ex-1022, 4:38-40.

232. Takenoiri discloses that both “the first magnetic recording layer and the second magnetic recording layer ha[ve] a granular structure that is composed of a matrix of a nonmagnetic oxide or a nonmagnetic nitride and magnetic crystal grains dispersed in the matrix.” Ex-1005, claim 5. Takenoiri also discloses using underlayer 3 and nonmagnetic intermediate layer 4 to control the grain size of the first magnetic recording layer. *Id.*, 6:29-32 (“Underlayer 3 is preferably formed to control the crystalline orientation and the grain size of the layer formed on the underlayer: nonmagnetic intermediate layer 4 or first magnetic recording layer 5.”); 6:52-55 (“Nonmagnetic intermediate layer 4 is formed to appropriately control the crystal alignment, the grain size, and the grain boundary segregation in first magnetic recording layer 5.”).

233. While Takenoiri recognizes the importance of grain size, it does not provide a numerical reference for a desired grain size. Li does so. Using of the same CoCr-based magnetic materials with similar H_k value and thickness as taught in

Takenoiri, Li teaches “a grain size from about 4 to about 10 nm.” Ex-1022, 12:6-7, 11:58-65; Ex-1005, 7:5-9, 11:35-36, 7:23-24. With such grain size, Li enables “ultra-high recording densities (i.e., $>\sim 250$ Gbits/in²) and high data recording rates (i.e., $>\sim 2,000$ Mbits/sec)...” Ex-1022, 8:45-54. Therefore, in my opinion, a POSITA implementing Takenoiri’s structure, with the understanding that Takenoiri aims for “high density recording” (Ex-1005, 7:25-26), would have been motivated to look to other references like Li that describe grain size, to design and/or fabricate the first magnetic recording layer 5 with a grain size from about 4 to 10 nm, as taught by Li. Because Takenoiri teaches using “the same material and structure” for both the first and second magnetic recording layers (*id.*, 9:13-15), and because Li teaches multiple sub-layers having matching grain size (Ex-1022, 5:46-54), it is my opinion that a POSITA would have found it obvious to design and/or fabricate Takenoiri’s second magnetic recording layer 7 also with a grain size from about 4 to 10 nm, as taught by Li. In fact, Dr. Suess, the inventor of the ’997 acknowledged that “[i]n order to achieve an areal density of 10 Tbit/in² in perpendicular recording, grains with diameters of about 3 nm are required.” Ex-1008, Abstract; Ex-1036, ¶66. Therefore, a POSITA looking to achieve high areal density for Takenoiri’s magnetic recording medium would have been motivated to set the grain size to be at least within the 4 to 10 nm range as taught by Li.

234. While Li's embodiments focus more on a stack of magnetic layers with anisotropy decreasing toward the substrate and Takenoiri's stack of layers have anisotropy increasing toward the substrate, this does not affect my analysis here because the grain size is not dependent on layer order (e.g., whether with decreasing anisotropy taught in Li or increasing anisotropy taught in Takenoiri). The grain size for a magnetic recording medium is mostly determined based on the desired areal density of the magnetic recording medium, as Dr. Suess himself acknowledges. Ex-1008, Abstract. The '997 Patent further confirms this because it discusses the grain diameter, which is not dependent on whether the nucleation host is on top of or below the hard magnetic storage layer. Ex-1001, 7:66-67, 9:4, 9:61, 5:13-16.

235. In my opinion, a POSITA would have had **reasonable expectation of success** in implementing Takenoiri's magnetic recording layers with the grain size (i.e., from about 4 to 10 nm) disclosed in Li. For example, Takenoiri teaches controlling grain size of a magnetic recording layer using the layer beneath it. Ex-1005, 6:29-32; 6:52-55. Moreover, using the same CoCr-based magnetic materials as taught in Takenoiri, Li teaches "fabricat[ing] granular media with ultra-small grain sizes via reactive oxidation/sputtering processing," which was "known in the art" and was already used by Takenoiri for fabricating magnetic recording layers. Ex-1022, 11:51-54, 11:2-5; Ex-1005, 11:6-8. Therefore, in my opinion, adopting

about 4 to 10 nm in grain size would have been a routine implementation of and obvious microstructural refinement to Takenoiri's design.

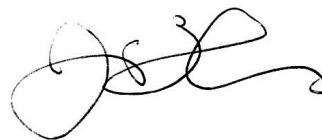
XIII. CONCLUDING STATEMENTS

236. In my opinion, claims 1-2 and 5-7 of the '997 Patent are obvious over Takenoiri alone. As such, in my opinion, these claims should be found unpatentable.

237. In my opinion, claims 4 and 9 of the '997 Patent are obvious over Takenoiri in view of Li. As such, in my opinion, these claims should be found unpatentable.

238. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the results of these proceedings.

Date: October 8, 2025



Jian-Gang Zhu, Ph.D.