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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

WESTERN DIGITAL TECHNOLOGIES, INC.,
Petitioner,

v.

GODO KAISHA IP BRIDGE 1,
Patent Owner.

Case No. IPR2024-01384

U.S. Patent No. 7,884,403

**PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 7,884,403**

TABLE OF CONTENTS

I.	INTRODUCTION.....	1
II.	BACKGROUND.....	3
	A. The District Court Litigation	3
	B. Magnetic Memory Development	4
	C. Quantum Electron Tunneling In MTJs: Barrier Heights And Fermi Levels	8
	D. Research Into Materials To Increase TMR	10
	1. Ferromagnetic Materials.....	11
	2. Barrier Layers	12
	E. Oxygen Vacancy Defects In MgO Thin Films.....	15
	F. The '403 Patent Family.....	17
	G. The Prosecution Of The '403 Patent.....	18
	H. Soukup (EX1028)	20
	I. Bowen (EX1026)	21
	J. Nagahama (EX1027)	22
	K. Sunai (EX1029/EX1030).....	24
III.	CLAIM CONSTRUCTION	26
IV.	STATEMENT OF PRECISE RELIEF REQUESTED FOR EACH CHALLENGED CLAIM (37 C.F.R. §42.104(b)(1)-(2)).....	26
	A. Grounds Presented	26
	B. The Prior Art	26

1.	March 10, 2004 Critical Date For The '403 Patent	26
2.	Prior Art Status	28
V.	LEVEL OF ORDINARY SKILL IN THE ART	29
VI.	GROUND 1: CLAIMS 1-8 ARE OBVIOUS OVER BOWEN IN VIEW OF SOUKUP (AND SUNAI)	30
A.	Obviousness Of Claim 1 Over Bowen In View Of Soukup And Alternatively Sunai	30
1.	Claim 1[preamble]: “A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:”	30
2.	Claim 1[a]: “a tunnel barrier layer;”	30
3.	Claim 1[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”	31
4.	Claim 1[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	33
5.	Claim 1[d]: “said tunnel barrier layer is formed by a single-crystalline MgO_x (001) ($0 < x < 1$) or a poly- crystalline MgO_x ($0 < x < 1$) in which (001) crystal plane is preferentially oriented, and”	34
6.	Claim 1[e]: “wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.”	37

B.	Claim 2: “The magnetoresistive device according to claim 1, wherein said ferromagnetic material comprises a single-crystalline (001) of Fe or Fe-based alloy, or a poly-crystalline of Fe or Fe-based alloy in which (001) crystal plane is preferentially oriented.”	41
C.	Claim 3: “The magnetoresistive device according to claim 1, wherein a magnetoresistance ratio of said magnetoresistive device is more than 70%.”	42
D.	Claim 4: “The magnetoresistive device according to claim 1, wherein said first ferromagnetic material layer comprises CoFeB alloy.”	43
E.	Obviousness Of Claim 5 Over Bowen In View Of Soukup And Alternatively Sunai	44
1.	Claim 5[preamble]: “A magnetoresistive device, comprising:”	44
2.	Claim 5[a]: “a first ferromagnetic material layer of a BCC structure;”	44
3.	Claim 5[b]: “a second ferromagnetic material layer of the BCC structure; and”	44
4.	Claim 5[c]: “a magnesium oxide layer located between said first ferromagnetic material layer and said second ferromagnetic material layer, wherein”	45
5.	Claim 5[d]: “said magnesium oxide is a single-crystalline (001) or a poly-crystalline crystalline in which (001) crystal plane is preferentially oriented,”	45
6.	Claim 5[e]: “wherein said magnesium oxide has oxygen vacancy defects, and”	45
7.	Claim 5[f]: “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV.”	45

F.	Obviousness Of Claim 6 Over Bowen In View Of Soukup And Sunai	45
1.	Claim 6[preamble]: “A magnetoresistive device having a magnetic tunnel junction structure comprising:”	45
2.	Claim 6[a]: “a tunnel barrier layer;”	45
3.	Claim 6[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”	45
4.	Claim 6[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	46
5.	Claim 6[d]: “said tunnel barrier layer comprises a polycrystalline MgO in which (001) crystal plane is preferentially oriented, said MgO having oxygen vacancy defects,”	46
6.	Claim 6[e]: “wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”	47
7.	Claim 6[f]: “wherein a magnetoresistance ratio of said device is more than 70%.”	47
G.	Obviousness Of Claim 7 Over Bowen In View Of Soukup And Sunai	47
1.	Claim 7[preamble]: “A magnetoresistive device having a magnetic tunnel junction structure, the magnetoresistive device comprising:”	47
2.	Claim 7[a]: “a tunnel barrier layer;”	47
3.	Claim 7[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”	47

4.	Claim 7[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	47
5.	Claim 7[d]: “said tunnel barrier layer comprises a polycrystalline magnesium oxide having oxygen vacancy defects in which (001) crystal plane is preferentially oriented,”	47
6.	Claim 7[e]: “said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”	48
7.	Claim 7[f]: “a magnetoresistance ratio of said device is more than 70%.”	48
H.	Obviousness Of Claim 8 Over Bowen In View Of Soukup And Sunai	48
1.	Claim 8[preamble]: “A memory device comprising:”	48
2.	Claim 8[a]: “a transistor; and”	49
3.	Claim 8[b]: “a magnetoresistive device comprising a tunnel barrier layer;”	52
4.	Claim 8[c]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”	52
5.	Claim 8[d]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	52
6.	Claim 8[e]: “said tunnel barrier layer is formed by a single-crystalline MgO _x (001) (0<x<1) or a polycrystalline MgO _x (0<x<1) in which (001) crystal plane is preferentially oriented, wherein”	52

7. Claim 8[f]: “a tunnel barrier height of said tunnel barrier layer is in a range of 0.2 to 0.5 eV and said magnetoresistive device is used as a load for said transistor.” 53

VII. GROUND 2: CLAIMS 1-8 ARE OBVIOUS OVER NAGAHAMA IN VIEW OF SOUKUP (AND SUNAI).....53

A. Obviousness Of Claim 1 Over Nagahama In View Of Soukup And Alternatively Sunai.....54

1. Claim 1[preamble]: “A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:” 54
2. Claim 1[a]: “a tunnel barrier layer;” 54
3. Claim 1[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and” 55
4. Claim 1[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein” 59
5. Claim 1[d]: “said tunnel barrier layer is formed by a single-crystalline MgO_x (001) ($0 < x < 1$) or a polycrystalline MgO_x ($0 < x < 1$) in which (001) crystal plane is preferentially oriented, and” 60
6. Claim 1[e]: “wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.” 62

B.	Claim 2: “The magnetoresistive device according to claim 1, wherein said ferromagnetic material comprises a single-crystalline (001) of Fe or Fe-based alloy, or a poly-crystalline of Fe or Fe-based alloy in which (001) crystal plane is preferentially oriented.”	64
C.	Claim 3: “The magnetoresistive device according to claim 1, wherein a magnetoresistance ratio of said magnetoresistive device is more than 70%.”	65
D.	Claim 4: “The magnetoresistive device according to claim 1, wherein said first ferromagnetic material layer comprises CoFeB alloy.”	66
E.	Obviousness Of Claim 5 Over Nagahama In View Of Soukup And Sunai.....	66
1.	Claim 5[preamble]: “A magnetoresistive device, comprising:”	66
2.	Claim 5[a]: “a first ferromagnetic material layer of a BCC structure;”	66
3.	Claim 5[b]: “a second ferromagnetic material layer of the BCC structure; and”	66
4.	Claim 5[c]: “a magnesium oxide layer located between said first ferromagnetic material layer and said second ferromagnetic material layer, wherein”	67
5.	Claim 5[d]: “said magnesium oxide is a single-crystalline (001) or a poly-crystalline crystalline in which (001) crystal plane is preferentially oriented,”	67
6.	Claim [5e]: “wherein said magnesium oxide has oxygen vacancy defects, and”	67
7.	Claim [5f]: “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV.”	67

F.	Obviousness Of Claim 6 Over Nagahama In View Of Soukup And Sunai.....	67
1.	Claim [6-pre]: “A magnetoresistive device having a magnetic tunnel junction structure comprising:”.....	67
2.	Claim 6[a]: “a tunnel barrier layer;”.....	67
3.	Claim 6[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”.....	67
4.	Claim 6[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	68
5.	Claim 6[d]: “said tunnel barrier layer comprises a poly- crystalline MgO in which (001) crystal plane is preferentially oriented, said MgO having oxygen vacancy defects,”	68
6.	Claim 6[e]: “wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”	68
7.	Claim 6[f]: “wherein a magnetoresistance ratio of said device is more than 70%.”.....	68
G.	Obviousness Of Claim 7 Over Nagahama In View Of Soukup And Sunai.....	68
1.	Claim 7[preamble]: “A magnetoresistive device having a magnetic tunnel junction structure, the magnetoresistive device comprising:”	68
2.	Claim 7[a]: “a tunnel barrier layer;”.....	68
3.	Claim 7[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”.....	68

4.	Claim 7[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	69
5.	Claim 7[d]: “said tunnel barrier layer comprises a polycrystalline magnesium oxide having oxygen vacancy defects in which (001) crystal plane is preferentially oriented,”	69
6.	Claim 7[e]: “said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”	69
7.	Claim 7[f]: “a magnetoresistance ratio of said device is more than 70%.”	69
H.	Obviousness Of Claim 8 Over Nagahama In View Of Soukup And Sunai.....	69
1.	Claim 8[preamble]: “A memory device comprising:”	69
2.	Claim 8[a]: “a transistor; and”	70
3.	Claim 8[b]: “a magnetoresistive device comprising a tunnel barrier layer;”	70
4.	Claim 8[c]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”	70
5.	Claim 8[d]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”	71
6.	Claim 8[e]: “said tunnel barrier layer is formed by a single-crystalline MgOx (001) (0<x<1) or a polycrystalline MgOx (0<x<1) in which (001) crystal plane is preferentially oriented, wherein”	71

7.	Claim 8[f]: “a tunnel barrier height of said tunnel barrier layer is in a range of 0.2 to 0.5 eV and said magnetoresistive device is used as a load for said transistor.”	71
VIII.	SECONDARY CONSIDERATIONS	71
IX.	DISCRETIONARY DENIAL IS UNWARRANTED HERE.....	71
A.	<i>Fintiv</i> Is No Roadblock To Institution	72
B.	Discretionary Denial Under 35 U.S.C. §325(d) Is Unwarranted.....	73
X.	CONCLUSION	76
XI.	GROUND FOR STANDING.....	76
XII.	MANDATORY NOTICES.....	76
A.	Real Party-In-Interest (37 C.F.R. §42.8(b)(1)).....	76
B.	Related Matters (37 C.F.R. §42.8(b)(2)).....	76
C.	Lead and Backup Counsel (37 C.F.R. §42.8(b)(3))	77
D.	Service Information (37 C.F.R. §42.8(b)(4))	77

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<i>Apple v. Fintiv,</i> IPR2020-00019, 2020 WL 2126495 (P.T.A.B. Mar. 20, 2020)	72
<i>BMW of N. Am. v. Stragent,</i> IPR2021-00419, 2021 WL 3039219 (P.T.A.B. July 19, 2021)	73, 74
<i>Cellco P’ship v. Huawei,</i> IPR2020-01117, 2021 WL 389532 (P.T.A.B. Feb. 3, 2021)	74
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<i>Persion Pharms. v. Alvogen Malta Operations,</i> 945 F.3d 1184 (Fed. Cir. 2019)	43

Western Digital v. Godo Kaisha IP Bridge
IPR Petition – U.S. Patent No. 7,884,403

Precision Planting v. Maschio Gaspardo,
IPR2024-00008, 2024 WL 1283507 (P.T.A.B. Mar. 26, 2024).....72

Spectrum Sols. v. Longhorn Vaccines,
IPR2021-00847, Paper 13 (P.T.A.B. Nov. 12, 2021) 40

Vivid Techs. v. Am. Sci. & Eng’g,
200 F.3d 795 (Fed. Cir. 1999) 26

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35 U.S.C. § 102 26, 27, 28

35 U.S.C. § 325 73

MPEP § 2139.01 27

MPEP § 2151 27

TABLE OF EXHIBITS

Exhibit No.	Description
1001	U.S. Patent No. 7,884,403 (“’403 Patent”)
1002	File History for U.S. Patent No. 7,884,403
1003	U.S. Patent No. 8,319,263 (“’263 Patent”)
1004	File History for U.S. Patent No. 8,319,263
1005	U.S. Patent No. 8,405,134 (“’134 Patent”)
1006	File History for U.S. Patent No. 8,405,134
1007	U.S. Patent No. 9,123,463 (“’463 Patent”)
1008	File History for U.S. Patent No. 9,123,463
1009	U.S. Patent No. 9,608,198 (“’198 Patent”)
1010	File History for U.S. Patent No. 9,608,198
1011	U.S. Patent No. 10,367,138 (“’138 Patent”)
1012	File History for U.S. Patent No. 10,367,138
1013	U.S. Patent No. 10,680,167 (“’167 Patent”)
1014	File History for U.S. Patent No. 10,680,167
1015	U.S. Patent No. 11,737,372 (“’372 Patent”)
1016	File History for U.S. Patent No. 11,737,372
1017	U.S. Patent No. 11,968,909 (“’909 Patent”)
1018	File History for U.S. Patent No. 11,968,909
1019	Patent Family Tree
1020	Japanese Patent No. JP2004071186
1021	English Translation of Japanese Patent No. JP2004071186, from ’372 Patent File History (EX1015)
1022	Japanese Patent Application No. JP2004313350
1023	Certified English Translation (with Translator Declaration) of Japanese Patent Application No. JP2004313350
1024	Declaration of Jeffrey Bokor, Ph.D.

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1026	Bowen et al., <i>Large magnetoresistance in Fe/MgO/FeCo(001) epitaxial tunnel junctions on GaAs(001)</i> , 79 Appl. Phys. Letters 1655-1657 (2001) (“Bowen”)
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Western Digital v. Godo Kaisha IP Bridge
IPR Petition – U.S. Patent No. 7,884,403

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1063	Complaint, <i>Godo Kaisha IP Bridge 1 v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024) (without exhibits)
1064	Claim Chart for ’403 Patent, Exhibit D to Complaint, <i>Godo Kaisha IP Bridge 1 v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)

Western Digital v. Godo Kaisha IP Bridge
IPR Petition – U.S. Patent No. 7,884,403

Exhibit No.	Description
1065	Claim Chart for '263 Patent, Exhibit E to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
1066	Claim Chart for '372 Patent, Exhibit F to Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
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1068	Amended Claim Chart for '403 Patent, Exhibit AA to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1069	Amended Claim Chart for '263 Patent, Exhibit BB to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1070	Amended Claim Chart for '372 Patent, Exhibit CC to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1071	Claim Chart for '909 Patent, Exhibit DD to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1072	Claim Chart for '138 Patent, Exhibit EE to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1073	Claim Chart for '198 Patent, Exhibit FF to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1074	Claim Chart for '463 Patent, Exhibit GG to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1075	Claim Chart for '167 Patent, Exhibit HH to First Amended Complaint, <i>Godo Kaisha IP Bridge I v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)

Western Digital v. Godo Kaisha IP Bridge
IPR Petition – U.S. Patent No. 7,884,403

Exhibit No.	Description
1076	Claim Chart for '134 Patent, Exhibit II to First Amended Complaint, <i>Godo Kaisha IP Bridge 1 v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. July 8, 2024)
1077	Docket <i>Godo Kaisha IP Bridge 1 v. Western Digital Corporation</i> , Case No. 24-cv-00342-RGA (D. Del. Mar. 15, 2024)
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1079	Microsoft Computer Dictionary (5th ed. 2002) (excerpts)

LIST OF CHALLENGED CLAIMS

1[pre] A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:

1[a] a tunnel barrier layer;

1[b] a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and

1[c] a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein

1[d] said tunnel barrier layer is formed by a single-crystalline MgO_x ($0 < x < 1$) or a poly-crystalline MgO_x ($0 < x < 1$) in which (001) crystal plane is preferentially oriented, and

1[e] wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.

2. The magnetoresistive device according to claim 1, wherein said ferromagnetic material comprises a single-crystalline (001) of Fe or Fe-based alloy, or a poly-crystalline of Fe or Fe-based alloy in which (001) crystal plane is preferentially oriented.

3. The magnetoresistive device according to claim 1, wherein a magnetoresistance ratio of said magnetoresistive device is more than 70%.

4. The magnetoresistive device according to claim 1, wherein said first ferromagnetic material layer comprises CoFeB alloy.

5[pre] A magnetoresistive device, comprising:

5[a] a first ferromagnetic material layer of a BCC structure;

5[b] a second ferromagnetic material layer of the BCC structure; and

5[c] a magnesium oxide layer located between said first ferromagnetic material layer and said second ferromagnetic material layer, wherein

5[d] said magnesium oxide is a single-crystalline (001) or a poly-crystalline crystalline in which (001) crystal plane is preferentially oriented,

5[e] wherein said magnesium oxide has oxygen vacancy defects, and

5[f] wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV.

6[pre] A magnetoresistive device having a magnetic tunnel junction structure comprising:

6[a] a tunnel barrier layer;

6[b] a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and

6[c] a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein

6[d] said tunnel barrier layer comprises a poly-crystalline MgO in which (001) crystal plane is preferentially oriented, said MgO having oxygen vacancy defects,

6[e] wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and

6[f] wherein a magnetoresistance ratio of said device is more than 70%.

7[pre] A magnetoresistive device having a magnetic tunnel junction structure, the magnetoresistive device comprising:

7[a] a tunnel barrier layer;

7[b] a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and

7[c] a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein

7[d] said tunnel barrier layer comprises a poly-crystalline magnesium oxide having oxygen vacancy defects in which (001) crystal plane is preferentially oriented,

7[e] said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and

7[f] a magnetoresistance ratio of said device is more than 70%.

8[pre] A memory device comprising:

8[a] a transistor; and

8[b] a magnetoresistive device comprising a tunnel barrier layer;

8[c] a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and

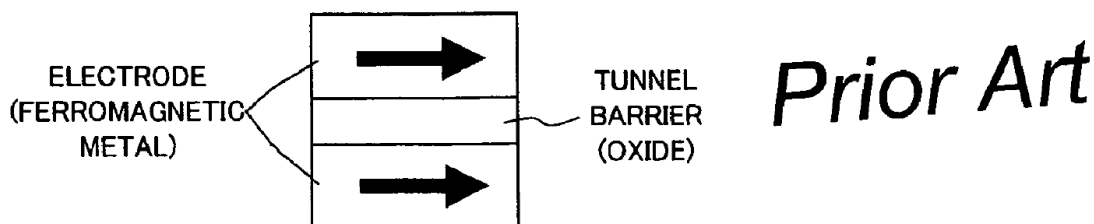
8[d] a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein

8[e] said tunnel barrier layer is formed by a single-crystalline MgO_x (001) ($0 < x < 1$) or a poly-crystalline MgO_x ($0 < x < 1$) in which (001) crystal plane is preferentially oriented, wherein

8[f] a tunnel barrier height of said tunnel barrier layer is in a range of 0.2 to 0.5 eV and said magnetoresistive device is used as a load for said transistor.

I. INTRODUCTION

This IPR concerns the storage elements underlying magnetoresistive random-access memory (MRAM). MRAM is a niche memory device: a non-volatile random-access memory that stores data in magnetic storage elements called magnetic tunnel junctions (MTJs, shown below), comprising two ferromagnetic electrodes separated by a thin insulating layer:



Patent Owner IP Bridge claims Shinji Yuasa invented magnesium oxide MTJs used in MRAM as claimed in the '403 Patent at issue here. But “[n]onvolatile MRAM is not really new.” EX1057 at xiv. Dr. Yuasa himself acknowledged that “[r]esearch and development of MRAM devices, which are fast and non-volatile memory devices, are being extensively carried out” before he filed his patent. EX1001 at 1:17-20. The '403 Patent instead purports to claim as its own decades of research by the brightest minds in quantum mechanics and device fabrication.

In the 1930s, researchers discovered a surprising phenomenon unexplained by classical physics: current flowing through a thin insulator sandwiched between two electrodes. EX1031 at 1793 n.2. Simmons’ influential 1963 paper quantified the

“tunnel effect” and provided a formula for quantifying the “barrier height,” or the energy required for electrons to tunnel across the insulating barrier. EX1031 at Abstract.

When inventor Yuasa applied for the '403 Patent claiming an MgO MTJ with a low barrier height, the Examiner required what he believed was a critical limitation for patentability: specifying a low “tunnel barrier height in a specified eV range.” EX1002 at 235. The '403 Patent was duly amended to require a “tunnel barrier height... in a range of 0.2 to 0.5 eV,” EX1002 at 254-57; EX1001 at 9:26-10:55, and the Examiner allowed the claims, EX1002 at 268. But MgO barriers with a barrier height in the 0.2 to 0.5 eV range were not inventive, and are inherent, according to the '403 Patent itself. EX1001 at 6:52-56; *e.g.*, EX1028 at Abstract (observing 0.33 eV barrier height for MgO). What the Examiner apparently did not know was that researchers had been studying tunneling in MgO barriers for decades and had already found MgO barrier heights in this range. *Id.*

The same is true of the “larger” tunnel magnetoresistance ratio (TMR) that applicant touted to the Examiner. *E.g.*, EX1002 at 168; EX1001 at 9:48-53. A high TMR has clear advantages: it allows lower voltages (and smaller currents) to determine the MTJ's resistance (*i.e.*, read the memory cell) and lowers power consumption, opening the door to smaller, denser MRAMs. Researchers had been studying how to obtain higher TMRs in MTJs for decades when two 2001 studies

calculating TMRs of >1000% for MTJs with MgO barriers set off a scientific gold rush, spawning extensive research into these devices. EX1044; EX1046.

This Petition presents two grounds showing all claims of the '403 Patent were obvious:

- Bowen (Ground 1): A 2001 paper by Bowen et al. in *Applied Physics Letters* (EX1026) builds high-quality FeCo/MgO/Fe MTJs to achieve a high TMR. Bowen observed the presence of defects in the MgO barrier led to increased tunneling, suggesting a low barrier height, previously observed by Soukup.
- Nagahama (Ground 2): A 2002 European patent application publication also naming Dr. Yuasa and collaborators (EX1027) disclosed nearly every aspect of an MgO MTJ he later sought to claim in the '403 Patent, including a TMR of more than 90%, rendering the claims obvious over Nagahama coupled with Soukup's observations about the barrier height.

In short, Dr. Yuasa's effort to individually stake a claim to the territory of MgO MTJs should be rejected, and his claims revoked.

II. BACKGROUND

A. The District Court Litigation

A few years ago, Patent Owner IP Bridge bought Dr. Yuasa's patents on MgO-based MTJs, including the '403 Patent challenged here. EX1063 ¶¶3, 10. In March, IP Bridge filed suit in the District of Delaware against Western Digital, asserting that

essentially its entire hard drive product line infringed the '403 Patent and two related patents. *Id.* ¶¶28-30, 33-35. It filed a similar suit against Seagate. *Infra* §XII.B.

IP Bridge touted Dr. Yuasa's "pioneering contribution to the MgO-based MTJs" and explained that his patents "are directed to a MTJ structure comprising a thin insulating layer (a tunnel barrier layer) sandwiched between two ferromagnetic metal electrodes." EX1063 ¶¶12, 14. The Complaint says Dr. Yuasa's three-layer MTJ structure (right) obtained "the highest MR ratios." *Id.* ¶18 (reproducing EX1001, Fig. 1(B)).

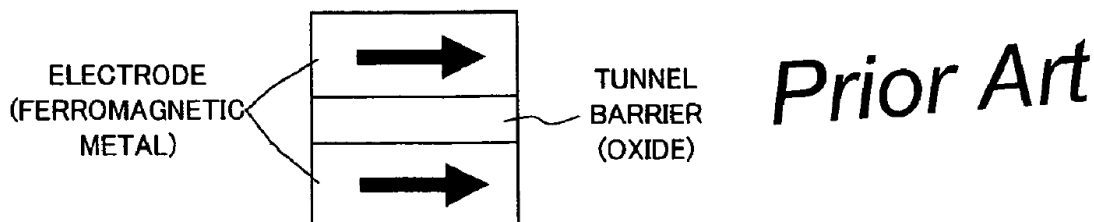


Almost nothing has happened in the Delaware litigation. EX1077. Confronted with a motion to dismiss its original complaint, IP Bridge filed a First Amended Complaint asserting six more related patents. EX1067 ¶2; EX1019. Western Digital filed another motion to dismiss and also moved to transfer the case to California. As of the filing of this Petition, both motions remain pending. EX1077.

B. Magnetic Memory Development

Conventional semiconductor-based memories like DRAM and EEPROM store data as electrical charges. EX1024 ¶30. Magnetic memory operates differently. As shown below, the simplest structure for magnetic memory

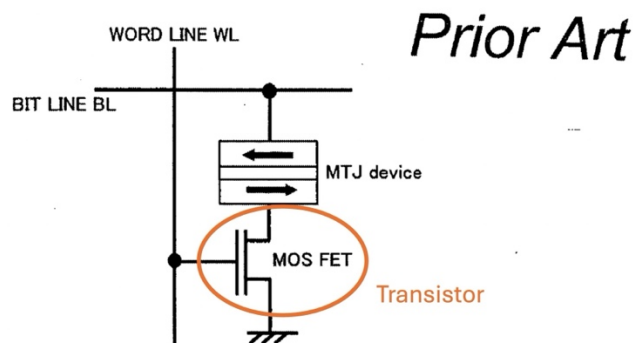
conventionally is a magnetic tunnel junction (MTJ) with two ferromagnetic layers separated by a thin oxide layer:



EX1001 at Fig. 8(A); *see also id.* at Fig. 8(B), 1:21-46; EX1027 at Fig. 3; EX1030 at Fig. 1; EX1024 ¶¶31-35.

MRAM stores bits in MTJs, with a transistor typically controlling access to individual MTJs, as shown below.

FIG. 9 (B)



EX1001 at Fig. 9(B) (annotated); EX1030 ¶¶37-40, Figs. 4-5; EX1039 at 2816, 2818 (MRAM cell “transistors provide bit selection for reading individual bits.”); EX1049 at Abstract (explaining that “[t]he simplest architecture of MRAM cell is a

combination of MTJ... as a data storage part and MOS transistor as a data selection part”), Fig. 2 (showing “MRAM cell with a MTJ and a transistor”); EX1024 ¶30.

One MTJ electrode has a fixed polarity, while the other electrode’s magnetization can be changed by an external electric field. EX1030 ¶19. To read the bit, typically the MRAM runs a small current through the electrodes and tunnel barrier and reads the resistance of

the MTJ. *Id.*; EX1001 at 1:31-46.

As shown at right, if the MTJ has

low resistance, this indicates the

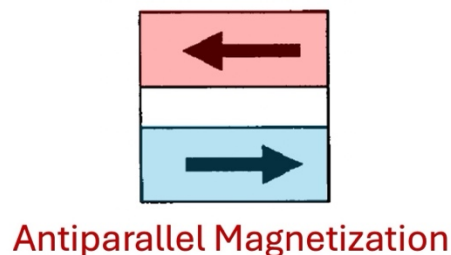
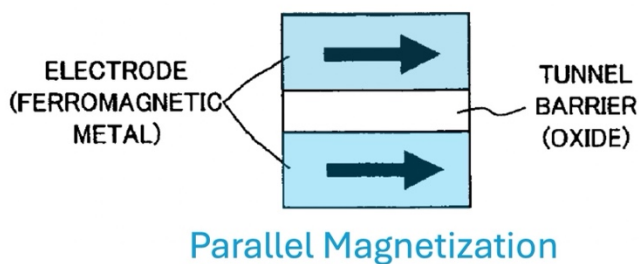
electrodes have **parallel**

magnetization; high resistance

indicates **antiparallel**

magnetization. EX1001 at 1:31-

41, Figs. 8(A)-8(B) (excerpted, annotated).



Researchers were particularly interested in optimizing MTJs to improve MRAM performance. EX1026 at 1655; EX1045 at 1; EX1024 ¶31. An “important parameter” was the **tunnel magnetoresistance ratio (TMR)**, measuring the tunneling resistance across the MTJ. EX1055 at 2269. In 1973, the “pioneering work of Jullière” (EX1033), EX1057 at 9, discovered tunneling magnetoresistance in an MTJ at a low temperature (4.2 K, -452°F), EX1033 at 225. Mathematically,

the TMR for an MTJ is equal to the difference in the resistance between the antiparallel (R_{ap}) and parallel states (R_p), divided by the parallel state resistance:

$$TMR = \frac{\Delta R}{R_p} = \frac{R_{ap} - R_p}{R_p}$$

EX1035 at 3273; EX1027 ¶2; EX1001 at 4:43-51; EX1024 ¶37. Thus, high anti-parallel resistance R_{ap} compared to lower parallel resistance R_p results in high TMR.

Id.

Higher TMRs long promised improved performance for MRAM. EX1049 at 186; EX1001 at 2:18-35; EX1024 ¶¶36-44. High TMR allowed lower voltages (and smaller currents) to determine the MTJ's resistance (*i.e.*, read the memory cell) and lowered power consumption. EX1055 at 2269; EX1024 ¶¶41-43. High TMR also improved the signal-to-noise ratio; made sensing the correct state more accurate; and paved the way for smaller, denser MRAMs. EX1055 at 2269; EX1049 at 194-95; EX1024 ¶¶41-44.

Two decades after Jullière, Miyazaki and Moodera separately measured TMR above 10%, demonstrating the tunneling effect at room temperature. EX1034 at Abstract (reporting TMR of “18% at 300 K”); EX1035 at Abstract (TMR of 11.8% at 295 K). “Since 1995, extensive experimental effort has been made on MTJs with amorphous AlO barriers and ferromagnetic electrode[s]....” EX1057 at 43. The

patent itself acknowledges that then-current MTJ devices exhibited TMRs of “approximately 70%.” EX1001 at 4:66-5:2.

In 2001, separate research teams led by Butler (EX1044) and Mathon (EX1046) calculated that MTJs with a crystalline MgO barrier layer would achieve TMRs of over 1000%. EX1053 at 8041, 8043 nn.9-10 (citing EX1044, EX1046). Butler’s and Mathon’s publications spurred a scientific gold rush, with researchers publishing an explosion of research into MgO MTJs. As one researcher put it: “TMR[] in magnetic tunnel junctions (MTJs) is widely studied nowadays due to the large-scale potential applications of MTJs” in MRAM and data storage. EX1052 at 4507.

C. Quantum Electron Tunneling In MTJs: Barrier Heights And Fermi Levels

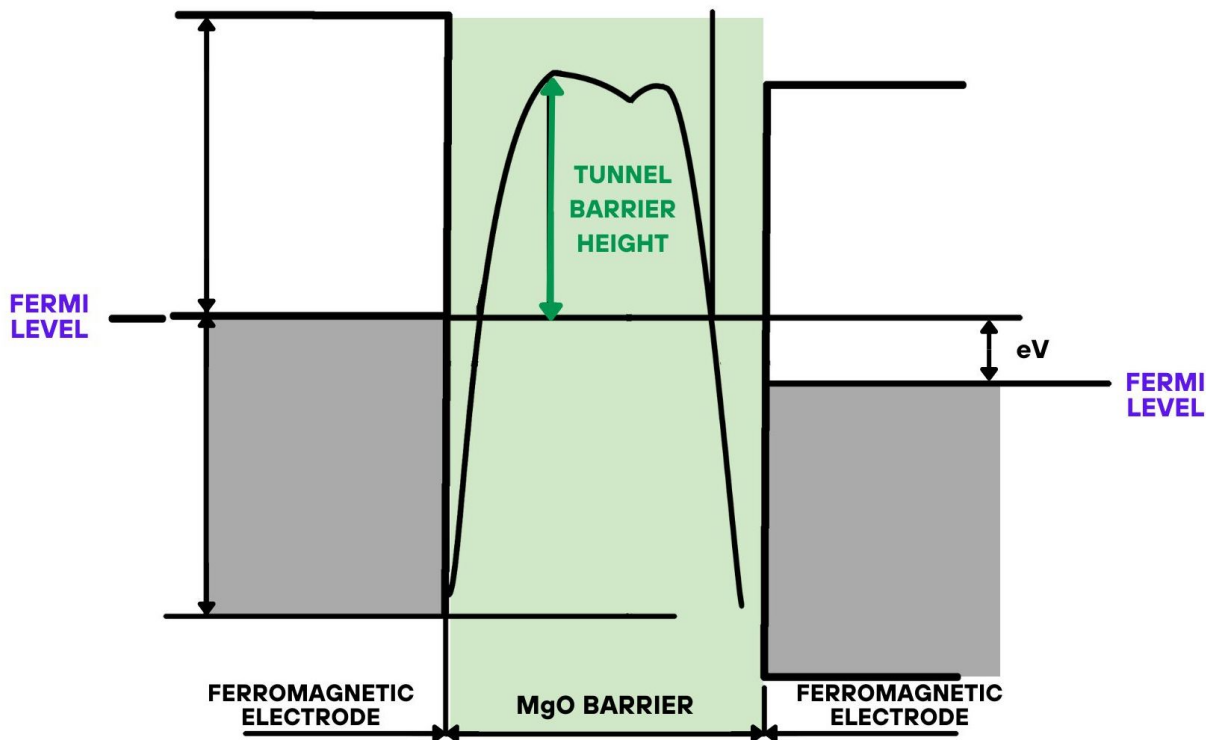
MTJ behavior is explained by quantum mechanics. EX1024 ¶¶45-49. Current typically flows through conductors and is inhibited by insulators. EX1024 ¶45. But in the 1930s, researchers discovered that current (electrons) could flow between two electrodes separated by a very thin insulating layer (or barrier). EX1031 at 1793 n.2 (citing Sommerfeld and Bethe (1933)).

Simmons published an influential 1963 paper describing the “tunnel effect” of electrons across the barrier using quantum mechanics and providing a

mathematical formula to estimate the barrier height, which is explained below.

EX1031 at Abstract, 1797 (Eq. (25)).

The **Fermi level** (E_F) corresponds to this highest energy level occupied by electrons at 0 K. EX1024 ¶46. Electrons that lie close to the Fermi level participate in tunneling. *Id.*; EX1052 at 4508; EX1031 at 1802.



As shown above, tunneling can occur across a barrier (**green**) separating two ferromagnetic electrodes (**gray**). EX1031 at 1794, Fig. 1. At equilibrium, the Fermi levels (E_F) of the two electrodes align, so there is no net current flow (i.e., the same number of electrons tunnel in both directions across the barrier). EX1031 at 1796

(equilibrium “[w]hen V is zero”). If a bias voltage is applied to the junction, the Fermi level of the collector electrode (right) lowers by an amount (eV) compared to the injector electrode (left), allowing the electrons to tunnel across the barrier from the injector to empty states above the Fermi level in the collector. EX1031 at 1796, Figs. 1, 3.

In an MTJ, the **tunnel barrier height** represents the difference between the bottom of the conduction band of the tunnel barrier layer and the **Fermi level** of electrons in the conductor. EX1031 at Fig. 1; EX1047 at 509; EX1001 at 3:38-41; EX1024 ¶48. Simmons’ 1963 paper provided a widely used formula for calculating the tunnel barrier height.¹ EX1031 at 1797 (Eq. (25)); EX1026 at 1656; EX1035 at 3274; EX1001 at 7:3-8; EX1024 ¶49.

D. Research Into Materials To Increase TMR

It was known that “the tunnel characteristics are an intrinsic function of the thermal properties of the *insulator*, as well as of the electrodes.” EX1031 at 1802

¹ Simmons’ formula for the low-voltage range is:

$$J = [3(2m\phi)^{\frac{1}{2}}/2s](e/h)^2 V \times \exp[-(4\pi s/h)(2m\phi_0)^{\frac{1}{2}}].$$

EX1031 at 1797 (Eq. (25)). Researchers later corrected Simmons’ formula to remove an erroneous factor of 3/2:

$$J_c = \frac{(2m\phi_0)^{\frac{1}{2}}}{s} \left(\frac{e}{h}\right)^2 V \exp\left[-\frac{4\pi s}{h}(2m\phi_0)^{\frac{1}{2}}\right].$$

EX1059 at 1 (Eq. (1)).

(emphasis in original); *see also* EX1050 at 2427. To improve tunneling and TMR, researchers studied different materials for the ferromagnetic electrodes and barrier layer. *E.g.*, EX1055 at 2269; EX1024 ¶¶50-72.

1. Ferromagnetic Materials

Well-known ferromagnetic materials such as Fe, Ni, Co, and their alloys typically have crystalline structures. EX1030 ¶33 (“ferromagnetic materials” include “Fe, Co, Ni, and alloys containing them”); EX1024 ¶54; *id.* ¶¶55-62. Alignment between the crystal of the electrodes and the barrier layer facilitates electron tunneling, reducing the barrier height and increasing TMR. EX1024 ¶56; EX1044 at 1; EX1046 at 1.

Researchers also found that alloys of iron (Fe) and cobalt (Co) improved TMR. EX1050 at 2428 (Yuasa 2002 study on FeCo electrodes); EX1026 at 1655 (depositing Fe₅₀Co₅₀ electrode layers); EX1052 at 4507 (using Fe and Co layers to try to achieve the calculated high TMRs); EX1024 ¶58.

By the early 2000s, researchers investigated using CoFeB alloys to improve TMR in magnetic memory. EX1030 ¶¶25-29; EX1055 at 2269-70 (“benefit of using CoFeB is multifold” including “a higher TMR value”); EX1056 ¶39 (ferromagnetic layer “comprised of a CoFeB alloy... exhibits a larger TMR ratio”). Introducing boron (B) to form a CoFeB electrode resulted in an initially “amorphous structure,” EX1055 at Abstract, where “crystallization is inhibited,” EX1030 ¶¶24-25, 30;

EX1024 ¶¶61-62. As a result, a “CoFeB/MgO/CoFeB MTJ can theoretically be grown on all kinds of underlayers.” EX1057 at 47. Without B, CoFe films had to be deposited as thicker or discontinuous films, decreasing TMR. EX1030 ¶27; EX1024 ¶¶59-60.

2. Barrier Layers

Initially, there was significant interest in aluminum oxide (Al_2O_3) barrier layers. EX1024 ¶¶63-65; EX1052 at 4507; EX1044 at 1. But Al_2O_3 was amorphous and lacked an ordered crystalline lattice structure or symmetry with the electrodes. EX1044 at 1; EX1045 at 1; EX1001 at 5:6-14 (contrasting crystalline MgO and amorphous Al_2O_3 barriers). This “lattice disorder” resulted in incoherent tunneling with the electrons prone to scattering. EX1045 at 1. By the early 2000s, MTJs with Al_2O_3 barriers conventionally had TMRs “at approximately 70%.” EX1001 at 2:29-31, 4:66-5:2; EX1063 ¶18; EX1055 at 2270 (“TMR value of 70.4%”).

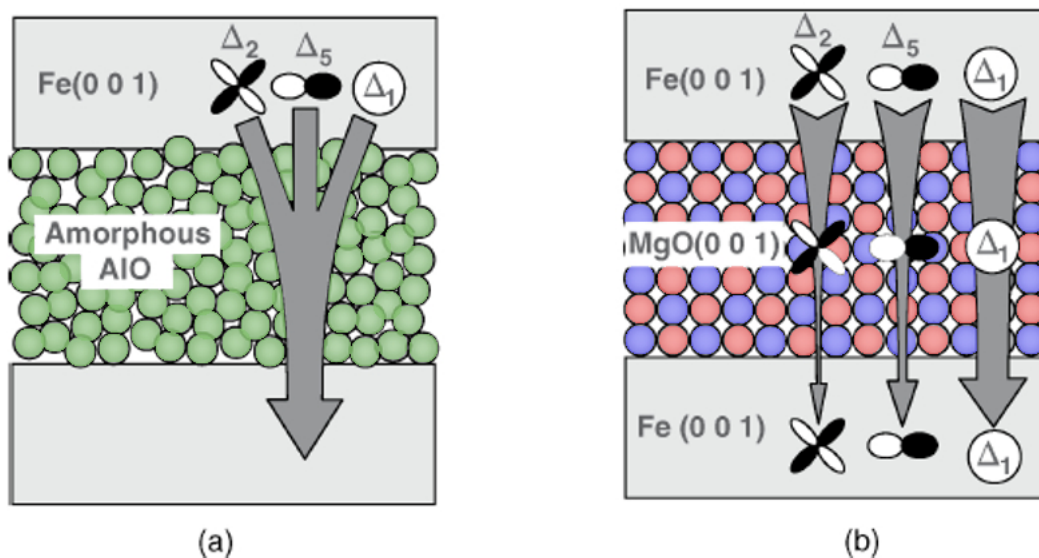
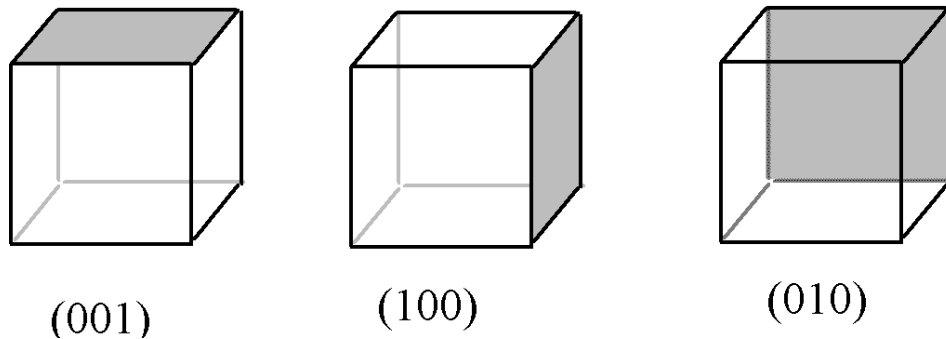


Figure 2.19 Schematic of electron tunneling through (a) an amorphous AlO barrier and (b) a crystalline MgO(0 0 1) barrier.

EX1057 at 44, Fig. 2.19 (annotated).

Thin film magnesium oxide (MgO) barriers had been studied for years. EX1028 at 3229; EX1038 at Abstract; EX1024 ¶¶66-72. MgO was known to have a low barrier height because of its ordered crystalline structure. EX1028 at Abstract (MgO: 0.33 eV barrier height).

Single-crystalline MgO barriers grow in a cubic crystalline lattice like table salt. EX1001 at 4:21-22; EX1040 at 2839. Its symmetric structure results in the (001), (100), and (010) crystalline planes being the same:



EX1001 at 4:21-23; EX1024 ¶¶66-67.

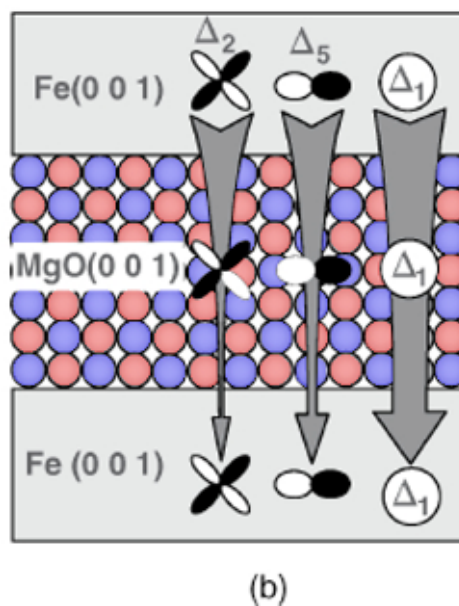
In 2001, Butler and Mathon separately “calculated [the] optimistic TMR ratio is in excess of 1000% for an MgO barrier.” EX1046 at Abstract; *see also* EX1044 at Fig. 16; EX1024 ¶68. Butler pointed out that tunneling across an MgO barrier was facilitated by the “symmetry” between the electrodes and barrier material, which “are crucial to determining the tunneling conductance.” EX1044 at 1. Mathon cited the tight symmetry between the crystal structures of a thin MgO barrier and Fe electrodes in an MTJ, with “only a small lattice mismatch of about 3.5%.” EX1046 at 1. This symmetry permitted high TMRs because “[t]he tunneling resistance for the parallel” electrons was “estimated to be 100 times smaller than that for the antiparallel” electrons “due to the absence of scattering in the barrier.” EX1045 at 1; EX1044 at 1 (different tunneling mechanisms facilitated parallel electron tunneling compared to antiparallel); EX1024 ¶69.

Butler's and Mathon's breakthroughs generated considerable excitement for MgO thin-film MTJs. EX1053 at 8041, 8043 nn.9-10 (citing Butler and Mathon); EX1045 at 1, 8 n.3 (citing Butler).

E. Oxygen Vacancy Defects In MgO Thin Films

“One of the most important defects in oxides, if not the most important, is the oxygen vacancy.” EX1042 at 162; EX1024 ¶¶73-82. A metal oxide's properties “are directly or indirectly connected to the presence of defects and in particular of point defects.” EX1042 at 161. “Oxygen vacancies are naturally present in every oxide....” EX1042 at 162.

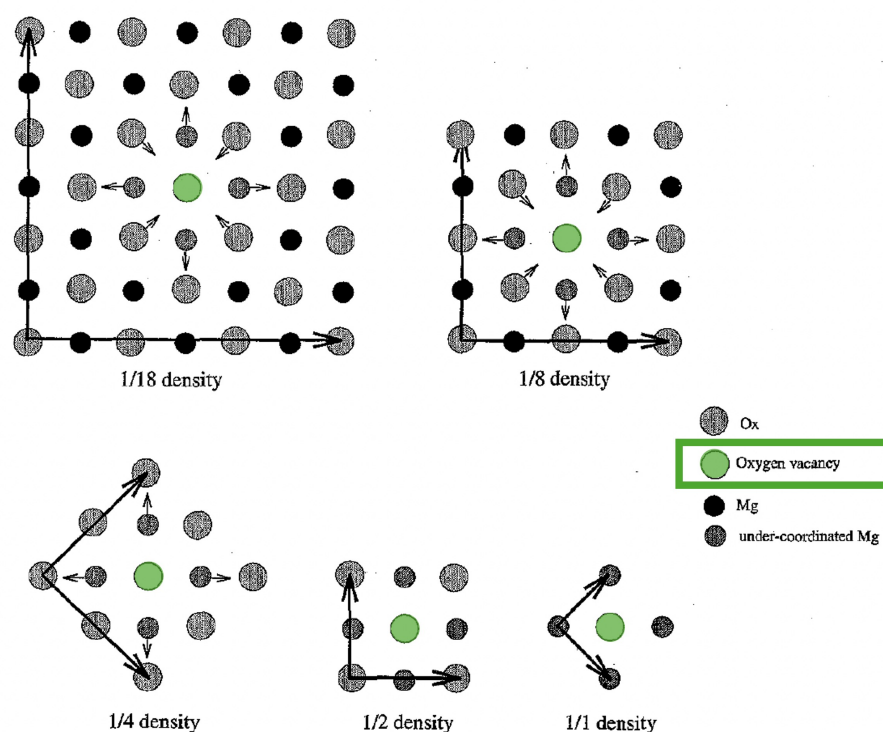
The idealized MgO structure is stoichiometric with a 1:1 ratio of Mg (blue) and O atoms (red) in its cubic crystalline structure. EX1042 at 162; EX1001 at 6:10-13; EX1057 at 44, Fig. 2.19 (excerpted, annotated). One way to quantify the level of oxygen vacancies in MgO crystal is by describing a sub-stoichiometric composition



of MgO_x , where $x < 1$ ($x=1$ in an idealized, perfectly stoichiometric crystal). EX1041 at 132 (“understoichiometric MgO_x ($x < 1$)”); EX1001 at 6:50-51 (“[T]here is the possibility that there are oxygen vacancy defects such as MgO_x ($0.9 < x < 1$).”), 6:65-

67; EX1002 at 168 (Applicant: “ MgO_x ($0 < x < 1$)” and “ x is $0 < x < 1$. (Namely, if this is represented as ‘MgO crystals,’ the crystals have oxygen vacancy defects.)”); EX1024 ¶¶74-75.

As shown below, oxygen vacancy defects (shown in green) result in a non-stoichiometric MgO crystalline structure:



EX1037 at 3, Fig. 1 (annotated); *see also* EX1001 at 6:10-13 (contrasting using “a source with oxygen vacancy defects” instead of “the MgO of the stoichiometric composition (the ratio of Mg to O is 1:1)”).

Researchers understood that oxygen vacancy defects lowered the barrier height of the MgO thin film. Soukup experimentally observed a 0.33 eV barrier

height of an MgO thin film, noting that increased oxygen vacancy defects lowered the barrier height of MgO. EX1028 at Abstract, 3232; EX1024 ¶¶77. Bowen also observed a lower barrier height of his MgO thin film and hypothesized that it may have resulted from “the presence of stoichiometric and/or thickness inhomogeneities in the insulating film.” EX1026 at 1656; *see also* EX1062 at 17:37-39 (“The exact composition of the MgO layer may differ from the stoichiometric composition.”).

F. The '403 Patent Family

The '403 Patent teaches an MTJ with a single-crystalline or polycrystalline MgO barrier layer sandwiched between two Fe electrodes. EX1001 at Fig. 1(B) (excerpted at right), 1:21-29, 5:18-24; EX1024 ¶¶83-86.

The patent purports to claim this MTJ device, specifying that the tunnel barrier layer is “MgO_x (001) (0<x<1)” and the “tunnel barrier height” is “in a range

of 0.2 to 0.5 eV.” *E.g.*, EX1001 at 9:26-42 (Claim 1). The patent repeatedly refers to the “the height of the tunnel barrier” as “the discontinuous value.” EX1001 at 3:37-41; *id.* at 2:59-63.

The patent explains that in fabricating the MgO layer, “separation of oxygen from MgO during the deposition of MgO” suggests “there is the possibility that there

FIG. 1 (B)



are oxygen vacancy defects such as MgO_x ($0.9 < x < 1$).” EX1001 at 6:44-51. It continues:

When there are oxygen vacancy defects, the potential barrier height of the MgO tunnel barrier is thought to decrease (such as in the range of 0.10 to 0.85 eV; more specifically, 0.2 to 0.5 eV), which is thought to result in an increase in the tunneling current.

EX1001 at 6:52-56.

Other claims further recite “a magnetoresistance ratio of... more than 70%” and a “first ferromagnetic material layer comprises CoFeB alloy [sic].” *E.g.*, EX1001 at 9:48-53 (Claims 3-4).

G. The Prosecution Of The '403 Patent

The '403 Patent originated as PCT application no. PCT/JP2005/004720, filed on March 10, 2005. EX1001 at 1, [22], [86]. The application was transmitted to the U.S. Patent Office on September 8, 2006. *Id.* at 1, [86]. It claims priority to two Japanese priority patent applications, filed on March 12, 2004 and October 28, 2004, respectively. *Id.* at 1, [30]. The October 2004 application included a new Figure 11 and related disclosure of a CoFeB electrode not included in the March 2004 application. *Compare* EX1020-EX1021, *with* EX1022-EX1023.

Prosecution began with three preliminary amendments spanning 119 proposed claims. EX1002 at 44-54 (9/8/2006 amendment), 155-69 (1/10/2008 amendment), 185-97 (11/7/2008 amendment).

The applicant stated that the “Present Invention [is] [t]he magnetoresistive device (i.e., a magnetic tunnel junction device (‘MTJ device’)... [that] delivers the following performance”: “a larger MR ratio (i.e., TMR ratio)” and a barrier height of “0.2 to 0.5 eV.” EX1002 at 168.

The first office action issued a restriction requirement, EX1002 at 199-202, and applicant responded by electing the “magnetoresistive device with a second ferromagnetic layer” species, *id.* at 201, 219.

Among other items, in a second office action the Examiner rejected the claims for “omitting” critical limitations: a low “tunnel barrier height in a specified eV range” and the “ferromagnetic material layers having a BCC structure.” EX1002 at 235. He objected to Figures 8-9 because they “should be designated by a legend such as --Prior Art-- because only that which is old is illustrated.” EX1002 at 233, 235. The applicant amended the claims and replaced the figures (shown below):

FIG. 8 (A)

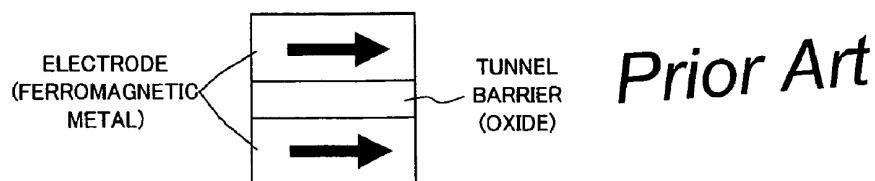
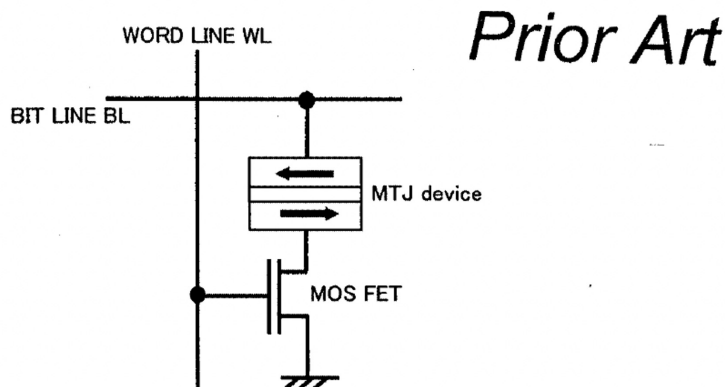


FIG. 9 (B)



EX1002 at 251-62; *see also* EX1001 at Figs. 8(A), 9(B).

Figure 8(A) shows a “Prior Art” MTJ device. EX1001 at 1:22-29; EX1024 ¶111. “Prior Art” Figure 9(B) depicts an MRAM memory cell, comprising an MTJ device connected to a MOSFET transistor at the intersection of a word line (WL) and a bit line (BL). EX1001 at 1:47-2:7.

The Examiner then allowed the claims. EX1002 at 268. After an RCE for consideration of additional information disclosure statements, EX1002 at 314-18, the patent ultimately issued, EX1002 at 334.

H. Soukup (EX1028)

Inspired by Simmons, University of Minnesota researchers R.J. Soukup and D.E. Speliotis published their results on MgO thin films in a 1970 paper. Soukup prepared samples of “Au-MgO-Au thin-film” devices. EX1028 at Abstract, 3229-30. He observed a tunnel barrier height of 0.33 eV for their MgO barrier. EX1028

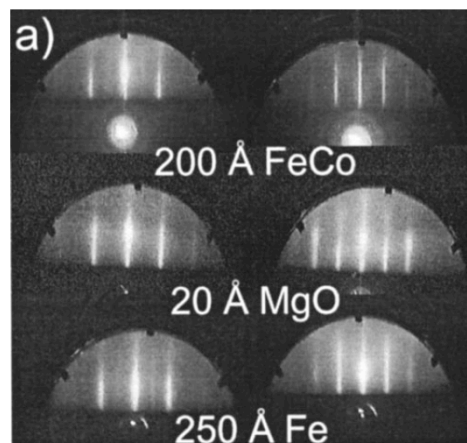
at Abstract, 3232, Table I; EX1024 ¶¶96-98. Soukup is not cited on the face of the '403 Patent. *See* EX1001 at 1-2.

Soukup also explained the relationship between oxygen vacancy defects and barrier height of the MgO barrier. EX1028 at 3232 (Soukup performed experiments “[i]n order to determine the effect of nonstoichiometry on the device characteristics.”); EX1024 ¶98. He found results showing “that admitting oxygen gas during deposition of the MgO film increases the stoichiometry of the film as seen by an increased barrier height.” EX1028 at 3232. Because more stoichiometric MgO films have fewer oxygen vacancy defects, Soukup showed that increasing stoichiometry (reducing oxygen vacancy defects) increased the barrier height. EX1028 at 3232; EX1024 ¶98; *supra* §II.E. In other words, higher oxygen vacancy defects lowered the barrier height. *See id.*

I. Bowen (EX1026)

Also following Simmons’ trail, in 2001 a consortium of European researchers led by M. Bowen published their findings on “Fe/MgO/FeCo(001)” MTJs in *Applied Physics Letters*. EX1026 at 1655, 1657 n.13 (citing Simmons (1963)); EX1024 ¶¶90-91. Bowen is listed on the face of the '403 Patent. EX1001 at 2.

Using Butler's and Mathon's calculations showing giant TMR for MgO thin films as a starting point, Bowen grew "FeCo/MgO/Fe epitaxial structures" (shown at right) with "increasingly thin MgO layers" to study their TMR. EX1026 at 1655, 1657 nn.5-6, Fig. 1 (excerpted). Using "good crystal quality MgO films with sharp interfaces," Bowen's tunneling experiments resulted in TMR measurements of 60%. *Id.* at Abstract, 1655-56. Bowen also noted the likely "presence of stoichiometric and/or thickness inhomogeneities" in the MgO barrier. *Id.* at 1656.



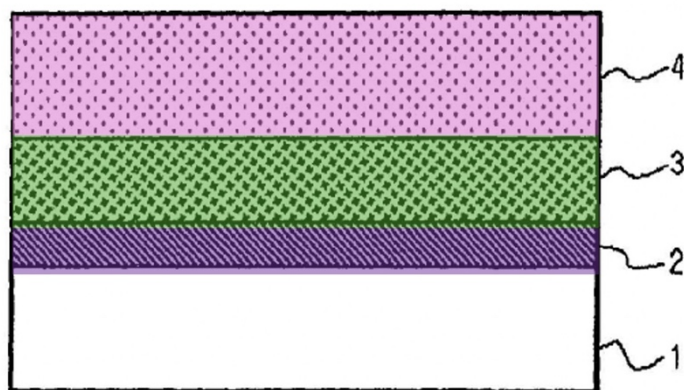
Bowen stated his intent "to confirm the predicted relative increase of the TMR" by Butler in "future experiments." EX1026 at 1657.

J. Nagahama (EX1027)

Meanwhile, named inventor Dr. Yuasa and his colleagues Taro Nagahama and Yoshishige Suzuki were working at the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan. EX1027 at 1. In a 2002 patent application by Nagahama et al., the researchers disclosed an MTJ with an MgO barrier. EX1027 ¶¶73; EX1024 ¶¶92-95. The '403 Patent lists Nagahama. *See* EX1001 at 2.

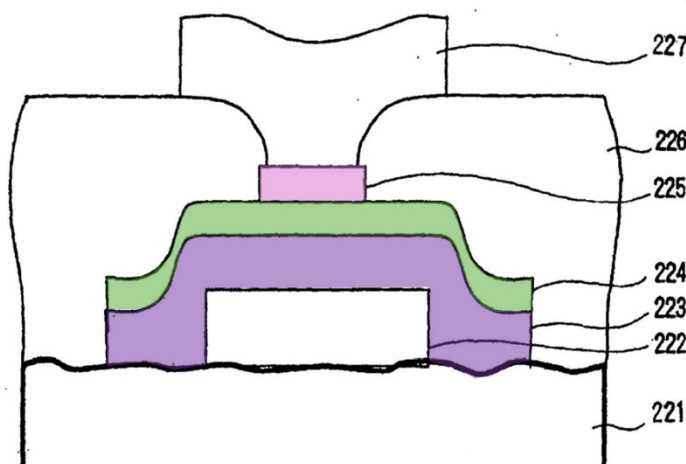
As shown at right,
Nagahama generally disclosed
an MTJ structure with a
ferromagnetic electrode 4
[pink], insulating layer 3
[green], and another ultrathin
ferromagnetic layer 2 [purple]

FIG. 3



on a substrate underlayer 1 [white]. EX1027 at Abstract, Fig. 3 (excerpted, annotated).

FIG. 17



Nagahama also specified a
polycrystalline MgO thin-film
MTJ (at left) with “a (001)-
highly-oriented lower
ferromagnetic electrode layer
[purple], a (001)-highly-oriented
MgO barrier layer [green], and a
(001)-highly-oriented upper

ferromagnetic electrode layer [pink].” EX1027 ¶¶73, 75-76, Fig. 17 (annotated).

The ferromagnetic electrodes used a bcc lattice. *Id.* ¶18 (item [20]). Nagahama taught that its MgO MTJ obtained better results than Bowen (EX1026), EX1027 ¶14,

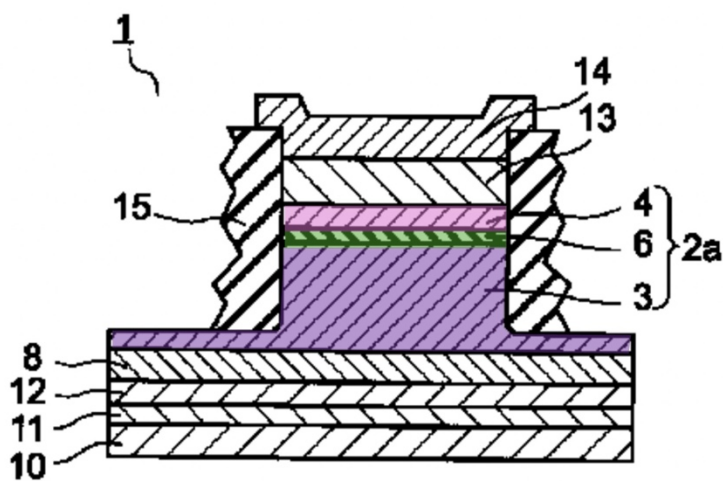
touting “a larger tunnel magnetoresistive effect of more than 90%,” *id.* ¶74. The application described the “Industrial Applicability” of their invention to “a magnetic sensor of a pickup head of a hard disk drive or a ferromagnetic random access memory.” *Id.* ¶82.

K. Sunai (EX1029/EX1030)

Japanese Patent Application Publication No. JP2002204004A to Sunai et al. was filed by Toshiba in 2000. EX1029 at 1, [22]. EX1030 is a certified English translation of Sunai. *See* 37 C.F.R. §42.63(b). Sunai described an MTJ for a “magnetic memory” device (including MRAM) that was capable of “maintain[ing] a sufficiently high magnetoresistance ratio.” EX1030 at Abstract, ¶4; EX1024 ¶¶99-104. The ’403 Patent lists Sunai. *See* EX1001 at 2.

Sunai taught a conventional 3-layer MTJ (shown at right) with “a first ferromagnetic layer 3” [purple], “a second ferromagnetic layer 4” [pink], and “a first tunnel barrier layer 6 [green]” between the ferromagnetic layers. EX1030 at Abstract, Fig. 1 (annotated), ¶1.

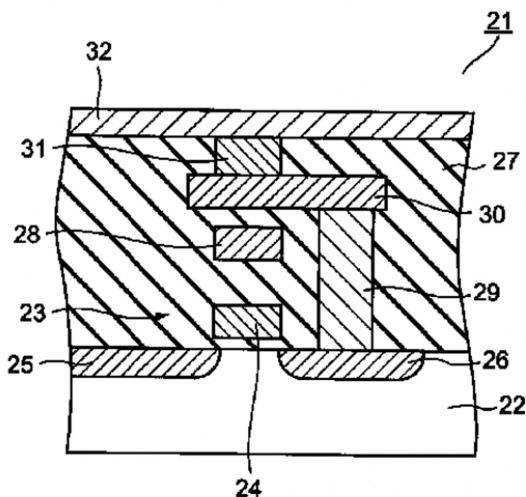
[Figure 1]



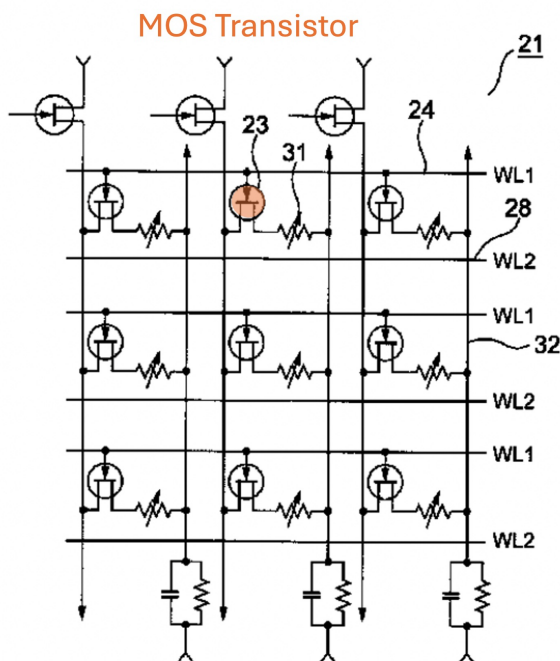
It taught that its MTJ included a CoFeB ferromagnetic layer. EX1030 at Abstract, ¶¶11, 24 (“[T]he composition of the ferromagnetic layer 4 is represented by the general formula $(\text{CoFe})_{100-x}\text{Y}_x$ ” where “Y is at least one element selected from the group consisting of B” and other elements.); EX1024 ¶103.

Sunai’s MTJ was a memory element in an MRAM:

[Figure 4]



[Figure 5]



EX1030 ¶¶37-40, Figs. 4-5 (Fig. 5 annotated); EX1024 ¶104. Sunai’s Figures 4-5 show a “cross-sectional view” of an MRAM and the “equivalent circuit diagram of the MRAM,” respectively. EX1030 ¶38. A transistor (**orange**) and MTJ (Sunai’s “TMR 31”) together form the memory cell in the array. EX1030 ¶42; EX1024 ¶104.

III. CLAIM CONSTRUCTION

Petitioner submits the claim terms should be given their plain and ordinary meaning and no claim construction is necessary to find the claims unpatentable, *see Vivid Techs. v. Am. Sci. & Eng'g*, 200 F.3d 795, 803 (Fed. Cir. 1999), and reserves the right to propose constructions in response to Patent Owner's arguments. EX1024 ¶¶87-88.

IV. STATEMENT OF PRECISE RELIEF REQUESTED FOR EACH CHALLENGED CLAIM (37 C.F.R. §42.104(b)(1)-(2))

A. Grounds Presented

Petitioner requests review and cancellation of Claims 1-8 of the '403 Patent based on the following grounds:

Ground 1: Claims 1-2 and 5 are obvious over Bowen in view of Soukup (and alternatively further in view of Sunai). Claims 3-4 and 6-8 are obvious over Bowen in view of Soukup and Sunai.

Ground 2: Claims 1-3 and 5-8 are obvious over Nagahama in view of Soukup (and alternatively further in view of Sunai). Claim 4 is obvious over Nagahama in view of Soukup and Sunai.

B. The Prior Art

1. March 10, 2004 Critical Date For The '403 Patent

The '403 Patent is a pre-AIA patent. Under pre-AIA §102(b), a person is not entitled to a patent if

the invention was patented or described in a printed publication in this or a foreign country... more than one year prior to the date of the application for patent in the United States.

35 U.S.C. §102(b) (pre-AIA).

Under Section 102(b), the effective filing date is the international filing date, not the filing date of any foreign priority documents. *See, e.g.*, MPEP §2139.01 (“[T]he effective filing date of the claimed invention is the actual filing date of the U.S. application” and “the actual U.S. filing date of an application that entered the national stage under 35 U.S.C. 371 is the international filing date.”); *id.* (“The effective filing date for claims subject to pre-AIA 35 U.S.C. 102 is not the filing date of the foreign priority document....”).

“Under pre-AIA 35 U.S.C. 102(b), the one-year [bar] is measured from the filing date of the earliest application filed in the United States (directly or through the PCT) and not from the dates of earlier filed foreign patent applications.” MPEP §2151. Because the international filing date of the ’403 Patent is the March 10, 2005 PCT filing date, EX1001 at [22], the critical date here is March 10, 2004, *Group One v. Hallmark Cards*, 254 F.3d 1041, 1044-45 (Fed. Cir. 2001) (“[T]he United States filing date, for §102(b) purposes, of a patent application filed under the PCT in which the United States is designated, is the date of the PCT

application—in this case, November 12, 1992. Thus, the ‘critical date’ is November 12, 1991.”).

2. Prior Art Status

Bowen, Nagahama, Soukup, and Sunai are all prior art under at least pre-AIA 35 U.S.C. §102(a) and (b) because they were each published before the March 10, 2004 critical date for the ’403 Patent:

- Bowen is a printed publication published on September 10, 2001. EX1026 at 1655.
- Nagahama is a European patent application published on February 25, 2004. EX1027 at [43].
- Soukup is a printed publication published on July 1, 1970. EX1028 at cover, 3229.
- Sunai is a Japanese patent application published on July 19, 2002. EX1030 at [43].

U.S. Patent No. 7,270,896 to Parkin was filed on July 2, 2004. EX1062 at [22]. Parkin is prior art under pre-AIA 35 U.S.C. §102(a)/(e) because it was filed before the earliest possible filing date and before the purported invention of the subject matter of the ’403 Patent. Claim 4 requires a CoFeB ferromagnetic material layer. EX1001 at 9:51-53. There is no disclosure of a CoFeB layer in the March 12, 2004 Japanese priority application (JP 2004-071186). EX1001 at [30]. The earliest

disclosure of CoFeB is the October 28, 2004 Japanese priority application (JP 2004-313350), rendering Parkin prior art under both Sections 102(a)/(e).

V. LEVEL OF ORDINARY SKILL IN THE ART

One of ordinary skill in the art as of 2004 would have had

- a Ph.D. in electrical engineering, physics, materials science, or a related field, and at least one year of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent, or
- a Master's degree in electrical engineering, physics, materials science, or a related field, and four years of experience in the research, design, and/or development of magnetic/spintronic devices, or the equivalent.

EX1024 ¶25. Less work experience may be compensated by a higher level of relevant education, and vice versa. *Id.* This level of ordinary skill would be the same if the relevant time period were around the March 12, 2004 or October 28, 2004 Japanese priority applications, or the March 10, 2005 PCT filing date.

EX1024 ¶¶24-29.

VI. GROUND 1: CLAIMS 1-8 ARE OBVIOUS OVER BOWEN IN VIEW OF SOUKUP (AND SUNAI)

A. Obviousness Of Claim 1 Over Bowen In View Of Soukup And Alternatively Sunai

1. Claim 1[preamble]: “A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:”

To the extent limiting, Bowen disclosed a magnetoresistive device having a tunnel barrier junction structure as claimed. *E.g.*, EX1026 at Abstract, 1655 (discussing FeCo/MgO/Fe epitaxial structure), Fig. 1; EX1024 ¶¶107-112; *see infra* §§VI.A.2-VI.A.6.

MTJs were known. EX1001 at Figs. 8(A)-8(B), 1:21-46; EX1024 ¶¶110-112; *supra* §II.B.

2. Claim 1[a]: “a tunnel barrier layer;”

Bowen disclosed an MgO tunnel barrier layer: “We present tunneling experiments on Fe(001)/MgO (20 Å)/FeCo(001) single-crystal epitaxial junctions of high quality grown by sputtering and laser ablation.” EX1026 at Abstract; *id.* at 1655 (“[T]he **MgO barrier** is grown at 400 °C in order to obtain good crystallinity.”),² Fig. 1; EX1024 ¶113.

A tunnel barrier layer in an MTJ was conventional. EX1001 at 1:24-28 (Description of Related Art); *id.* at Figs. 8(A)-8(B); EX1024 ¶114; *supra* §II.B.

² All emphasis added unless otherwise noted.

3. **Claim 1[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”**

Bowen disclosed a first, Fe ferromagnetic layer as claimed: “FeCo/MgO/Fe epitaxial structures were grown on GaAs(001) in a combined sputtering/laser ablation system....” EX1026 at 1655; *id.* at Abstract, Fig. 1; EX1024 ¶¶115-16.

Iron (Fe) was a well-known ferromagnetic material. EX1030 ¶33 (“ferromagnetic materials” include “Fe, Co, Ni, and alloys containing them”); EX1026 at 1655; EX1024 ¶118.

Bowen taught that the Fe layer is on a first side of the MgO barrier layer. EX1026 at 1655 (“Fe bottom electrode”); *id.* at Abstract, Fig. 1, 1656; EX1024 ¶116. Bowen explained that the “Fe₅₀Co₅₀ and *Fe layers are bcc structured* with sharp diffraction lines for both azimuths.” EX1026 at 1655, Fig. 1; EX1024 ¶117.

MTJs with ferromagnetic layers were conventional. EX1001 at 1:24-28 (Description of Related Art); *id.* at Figs. 8(A)-8(B); EX1045 at 1 (describing “Fe/MgO/Fe(001) trilayers”); EX1024 ¶119; *supra* §II.D.1.

Alternatively, one of skill would have found it obvious to replace Bowen’s first ferromagnetic material layer (Fe layer) with a CoFeB ferromagnetic layer as taught by Sunai to improve TMR. EX1030 ¶¶28 (teaching CoFeB electrode by adding B to Co₉Fe), *id.* ¶¶24-29; EX1024 ¶¶120-126. Cobalt and iron were known ferromagnetic materials. EX1030 ¶33; EX1026 at 1655; EX1024 ¶¶115, 120.

Bowen sought to increase the TMR in its MgO MTJ, EX1026 at 1655, 1657, and understood that the properties of the MTJ's electrodes contributed to improve the tunneling and hence TMR of its device, EX1026 at 1657; EX1024 ¶123. A skilled artisan knew that using CoFeB electrodes improved TMR. EX1024 ¶¶125-126. CoFeB was known to improve TMR compared to CoFe, EX1030 ¶¶27-28 (describing improvements to TMR by adding B to CoFe), and CoFe was known to obtain better results than Fe, EX1035 at 3274; *see also* EX1024 ¶124. Other researchers obtained similar results. *E.g.*, EX1055 at 2269-70 (“a higher TMR value” from CoFeB); EX1056 ¶¶39 (“a larger TMR ratio” for CoFeB alloys), 78, 103-04, Fig. 7; EX1024 ¶¶122-124.

One of skill would have been motivated to replace either or both of Bowen's electrodes with CoFeB to improve TMR. EX1055 at 2270 (“[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value.”); EX1056 ¶¶67-68 (“[B]oth the ferromagnetic layers 5, 7 are made of an FeCoB” for improved TMR); EX1035 at 3274 (Fe and “CoFe alloys were tried in this study as both bottom and top electrodes.”); EX1024 ¶¶124-126. Such a “combination of familiar elements” is obvious. *KSR Int'l v. Teleflex*, 550 U.S. 398, 416 (2007).

One of skill would have looked to Sunai's teachings to improve Bowen's MTJ because both Bowen and Sunai focused on improving the TMR of magnetoresistive devices, a problem to which the '403 Patent was directed. EX1026 at Abstract, 1655;

EX1030 at Abstract, ¶¶1, 10; EX1001 at Abstract, 1:9-2:7. Both were directed to improving MRAM memory performance, as was the '403 Patent. EX1026 at 1655; EX1030 at Figs. 4-5, ¶¶1, 4, 37-40; EX1001 at 1:37-39; EX1024 ¶121. Both used ferromagnetic alloy electrodes. EX1026 at Abstract, 1655; EX1030 ¶¶24, 35; EX1024 ¶121. Because it was known that CoFeB alloys had successfully been used as electrodes for MTJs, one of skill would have found it to be a straightforward, predictable, and desirable improvement to the TMR in Bowen's MTJ. EX1024 ¶¶124-126; EX1030 ¶¶24-29; EX1055 at 2269-70; EX1056 ¶¶39, 78.

Additionally, it was known that use of CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures. EX1060 at 310; EX1062 at 18:55-59; EX1001 at 4:21-23 (MgO (001), (100), (010) planes are the same); EX1024 ¶125. Thus, substitution of CoFeB for Fe would still produce a bcc CoFeB structure.

4. Claim 1[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”

Bowen further disclosed a second, FeCo ferromagnetic layer, instructing how to grow its “FeCo/MgO/Fe epitaxial structures” with the “FeCo top electrode.” EX1026 at 1655; *id.* at Abstract, Fig. 1, 1657; EX1024 ¶¶127-28.

Iron cobalt (FeCo) was a well-known ferromagnetic material. EX1030 ¶33; EX1024 ¶130. The FeCo top electrode is grown on a second side of the MgO tunnel barrier layer. EX1026 at 1655; *id.* at Abstract, Fig. 1, 1657; EX1024 ¶128. It is bcc

structured: “Fe₅₀Co₅₀ and Fe layers are *bcc structured* with sharp diffraction lines for both azimuths.” EX1026 at 1655; EX1024 ¶129. MTJs with ferromagnetic layers were also conventional. EX1001 at 1:24-28, Figs. 8(A)-8(B); EX1045 at 1; EX1024 ¶128; *supra* §II.D.1.

Alternatively, it would have been obvious to replace the FeCo electrode with CoFeB as taught by Sunai for all the reasons provided above regarding Claim 1[b]. *Supra* §VI.A.3; EX1024 ¶¶127, 131.

5. **Claim 1[d]: “said tunnel barrier layer is formed by a single-crystalline MgO_x (001) (0<x<1) or a poly-crystalline MgO_x (0<x<1) in which (001) crystal plane is preferentially oriented, and”**

Bowen alone and/or in view of Soukup and/or Sunai taught or suggested this limitation. As explained for Claim 1[a] in this Ground, Bowen disclosed an MgO tunnel barrier layer. *Supra* §VI.A.2; EX1024 ¶¶132-33. Bowen described a “single-crystal... MgO(001)” tunnel barrier layer. EX1026 at 1655; *id.* at Abstract (“We present tunneling experiments on Fe(001)/*MgO*(20 Å)/FeCo(001) *single-crystal* epitaxial junctions of high quality....”); EX1024 ¶133.

Alternately, it would have been obvious to use a polycrystalline MgO with the (001) crystal plane preferentially oriented in place of Bowen’s single-crystal MgO barrier. EX1024 ¶¶134-37. Bowen explained that Moodera’s 1996 study used “polycrystalline MgO” to obtain the same barrier height of 0.9 eV Bowen obtained.

EX1026 at 1656 (citing EX1038); *KSR*, 550 U.S. at 416 (“combination of familiar elements” is obvious). Like Bowen, one of skill would have understood that substituting polycrystalline MgO for single-crystal MgO would yield desirable and entirely predictable results, such as improved flexibility in substrate selection. EX1026 at 1656; EX1024 ¶¶135-37.

Alternatively, if Sunai’s CoFeB electrodes are used as described in Claims 1[b] and 1[c], one of skill would understand that the MgO could be polycrystalline or single crystal but would still have the same (001) orientation. EX1024 ¶138; EX1060 at 310; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 (“highly textured (100) MgO tunnel barriers”); EX1001 at 4:21-23 (MgO (001), (100), (010) are the same).

Bowen taught or suggested MgO_x where $0 < x < 1$, a mathematical notation indicating less than a one-to-one stoichiometric ratio of oxygen to magnesium (*i.e.*, oxygen vacancy defects) in the MgO layer. EX1026 at 1656; EX1024 ¶¶139-40; EX1001 at 6:10-13, 6:50-51; EX1002 at 168 (Applicant: “ MgO_x ($0 < x < 1$)” means the MgO “crystals have oxygen vacancy defects.”); EX1062 at 17:21-39 (describing forming MgO layer by first forming Mg layer followed by addition of MgO in which “[t]he exact composition of the MgO layer may differ from the stoichiometric [sic] composition”); *supra* §II.E. Bowen observed a lower MgO tunnel “barrier height at

$\phi = 0.9 \text{ eV}$,” EX1026 at 1656, and attributed it to oxygen vacancy defects (stoichiometric inhomogeneities) in the MgO barrier:

This value is lower than half of the 5.5 eV MgO band gap calculated for an ultrathin layer. This difference may be due to metal-induced gap states in the MgO barrier although we cannot completely rule out the *presence of stoichiometric and/or thickness inhomogeneities in the insulating film*.

Id.; EX1024 ¶141.

Alternatively, Bowen in view of Soukup also taught or suggested an MgO barrier layer with oxygen vacancy defects. Soukup studied the “effect of nonstoichiometry on the device characteristics,” EX1028 at 3232, and experimented with devices fabricated with different levels of nonstoichiometry, EX1028 at Abstract, 3232-33, Table I; EX1024 ¶142. One of skill would have been motivated to apply Soukup’s teachings about oxygen vacancy defects to Bowen’s MgO MTJ to improve tunneling current and the TMR, for the same reasons as explained for limitation 1[e]. EX1024 ¶143; *infra* §VI.A.6.

One of skill would have understood that Bowen’s and/or Soukup’s stoichiometric inhomogeneities in the MgO barrier referred to oxygen vacancy defects in the MgO crystal. EX1001 at 6:10-13, 6:50-58; EX1042 at 162; EX1024 ¶¶74-76, 139; *supra* §II.E.

6. **Claim 1[e]: “wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.”**

This limitation requires a tunnel barrier height “in a range of 0.2 to 0.5 eV.”

EX1001 at 9:38-42. The claim language “a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value” merely recites the definition of a “tunnel barrier height” in an MTJ. EX1001 at 2:59-63, 3:38-42; EX1024 ¶¶48, 144-146; *supra* §II.C. As explained, the tunnel barrier height measures the difference between the Fermi level of the electrode and the bottom of the conduction band of the barrier layer. EX1031 at Fig. 1; EX1024 ¶¶46-48, 144; *supra* §II.C.

Bowen in view of Soukup taught or suggested a tunnel barrier height for an MgO barrier layer in the claimed range of 0.2 to 0.5 eV. EX1024 ¶¶147-148, 156-60. Bowen “place[d] the barrier height at $\phi = 0.9$ eV” for its MgO barrier device. EX1026 at 1656; EX1024 ¶148. Soukup observed a “barrier height” within the claimed range of “*about 0.33 eV*” for its MgO barrier. EX1028 at Abstract; *id.* at 3231-32, Fig. 5, Table I; EX1024 ¶148.

Soukup taught that oxygen vacancy defects had an impact on the barrier height for MgO. EX1024 ¶149. Soukup suggested a “higher barrier?[] present for the

devices fabricated with more oxygen present during MgO deposition, which could mean more stoichiometric oxide films” (i.e., fewer oxygen vacancy defects). EX1028 at 3232; EX1024 ¶149. In other words, Soukup suggested a higher level of oxygen vacancy defects lowered the barrier height. *See id.* One of skill reading Soukup would understand there was a relationship between oxygen vacancy defects and barrier height. EX1024 ¶149.

One of skill would have been motivated to apply Soukup’s teachings about an MgO thin film barrier with a “barrier height” of “about 0.33 eV” to Bowen’s MgO barrier. EX1028 at Abstract, 3232, 3236; EX1024 ¶150. According to the equation for TMR, lowering the resistance (barrier height) for parallel electrons (R_p) would improve TMR. EX1035 at 3273; EX1027 ¶2; EX1001 at 4:43-52; EX1024 ¶150. TMR was an “important parameter” for improving MRAM performance. EX1055 at 2269; EX1024 ¶151. Skilled artisans, including Bowen, had long been interested in increasing TMR to enable better performing MRAM. EX1026 at Abstract, 1655 (Bowen: “experimental results showing large TMR values” for MgO MTJ); EX1055 at 2271; EX1024 ¶151; *supra* §II.B.

Butler and Mathon taught that MgO barriers would achieve higher TMRs due to improved symmetry matching between the MgO barrier and ferromagnetic electrodes, facilitating tunneling of parallel electrons across the barrier compared to antiparallel tunneling. EX1044 at 1; EX1046 at 1; EX1024 ¶151. One of skill in

the art looking to increase TMR of an MgO barrier would have been motivated to explore lower barrier heights to facilitate tunneling of parallel electrons. EX1024 ¶152. Thus, one of skill seeking to improve Bowen's MgO MTJ would have looked to Soukup's teachings about MgO barriers and how defects lowered the barrier height. EX1024 ¶152. Indeed, both Bowen and Soukup studied properties of MgO barriers and were focused on improving tunneling devices, the problem to which the '403 Patent was directed. EX1026 at Abstract, 1655-57; EX1028 at 3229-30; EX1001 at Abstract, 1:9-2:7.

One of skill would have had a reasonable expectation of success in achieving a tunnel barrier height in the claimed range in Bowen's MTJ. EX1024 ¶153. Soukup fabricated an MgO barrier achieved a height of 0.33 eV, EX1028 at Abstract, and one of skill in the art would have been motivated to achieve Soukup's barrier height in an MgO MTJ to improve tunneling and hence TMR, EX1028 at Abstract, 3232, 3236; EX1024 ¶153. One of skill would have predictably followed the trail blazed by Bowen and Soukup. *Id.*

The claimed tunnel barrier height range of 0.2 to 0.5 eV also would have been obvious. EX1024 ¶154. One of skill was aware that oxygen vacancy defects impacted the barrier height. Bowen itself hypothesized that the low barrier height they observed, which was "lower than half" of the calculated value for "an ultrathin layer" of MgO, may be due to the "presence of stoichiometric... inhomogeneities in

the insulating film.” EX1026 at 1656; EX1024 ¶154. Soukup observed a relationship between barrier height and MgO stoichiometry (oxygen vacancy defects). EX1028 at 3232, 3236 (“[B]arrier height was a function of the amount of oxygen present... with a higher barrier for larger amounts of oxygen present” and “more stoichiometric” MgO film.). Thus, one of skill would have been motivated to adjust oxygen vacancy defects to improve TMR by lowering the barrier height as taught by Soukup.

Further, the ’403 Patent itself states that “[w]hen there are oxygen vacancy defects, the potential barrier height of the MgO tunnel barrier is thought to decrease (such as in the range of... 0.2 to 0.5 eV), which is thought to result in an increase in the tunneling current.” EX1001 at 6:52-56. Thus, according to the ’403 Patent, the tunnel barrier height limitation is inherent when there are oxygen vacancy defects as disclosed by both Bowen and Soukup. EX1026 at 1656; EX1028 at 3232, 3236; EX1024 ¶155. Additionally, in the co-pending litigation, IP Bridge asserted that this limitation is satisfied by the mere “presence of oxygen vacancy defects.” EX1064 at 17; *id.* at 19 (citing EX1001 at 6:47-7:2). Thus, this limitation is satisfied. *Spectrum Sols. v. Longhorn Vaccines*, IPR2021-00847, Paper 13 at 23 (P.T.A.B. Nov. 12, 2021) (ordering institution).

This limitation was taught or suggested by Bowen in view of Soukup. IP Bridge’s statements in the district court further confirm this limitation is obvious.

B. Claim 2: “The magnetoresistive device according to claim 1, wherein said ferromagnetic material comprises a single-crystalline (001) of Fe or Fe-based alloy, or a poly-crystalline of Fe or Fe-based alloy in which (001) crystal plane is preferentially oriented.”

Claim 2 would have been obvious over Bowen in view of Soukup and alternatively Sunai. EX1024 ¶¶161-65.

Bowen taught an MTJ with ferromagnetic single-crystalline (001) Fe and Fe-based alloys: “*Fe(001)/MgO(20 Å)/FeCo(001) single-crystal* epitaxial junctions of high quality grown by sputtering and laser ablation.” EX1026 at Abstract; *see also id.* at 1655 (“A test of these models can be performed on single-crystal epitaxially grown structures.... In this letter, we present experimental results showing large TMR values in Fe(001)/MgO(001)/FeCo(001) epitaxial tunnel junctions.”); EX1024 ¶163.

If the Board concludes that Claim 2 requires the same “ferromagnetic material” for the first and second ferromagnetic material layers, then it would be obvious to use Fe in place of FeCo for the second ferromagnetic layer. EX1024 ¶164. Butler and Mathon taught that Fe/MgO/Fe MTJs improved TMRs due to the symmetry between MgO and Fe crystalline structures. EX1044 at 1; EX1046 at 1; EX1024 ¶164. Using two Fe electrodes in an MgO MTJ was a known and desirable design choice. *Id.*; EX1045 at 1 (“Fe/MgO/Fe(001)” MTJ); EX1047 at 1

(“Fe/MgO/Fe(100) junctions”). Such a “combination of familiar elements” is obvious. *KSR*, 550 U.S. at 416.

Alternatively, if one or more CoFeB electrodes are used as described in Claims 1[b] and 1[c], the same (001) bcc structure would be present in the CoFeB electrodes because it adjoins the MgO (001) barrier. EX1024 ¶165; EX1060 at 310; EX1062 at 18:55-59 (describing the effect of using CoFeB adjacent to MgO crystal structure as the MgO “provides a template for the formation of a thin crystalline ferromagnetic layer which has the bcc structure of CoFe and is oriented in the same (100) direction as the MgO layer.”); EX1001 at 4:21-23 (MgO planes are the same).

C. Claim 3: “The magnetoresistive device according to claim 1, wherein a magnetoresistance ratio of said magnetoresistive device is more than 70%.”

Claim 3 would have been obvious over Bowen in view of Soukup and Sunai. EX1024 ¶¶166-75.

The claim’s requirement of a TMR of “more than 70%” does not specify any specific temperature for satisfying this limitation. EX1001 at 9:48-50; EX1024 ¶167. The addition of CoFeB electrodes as described in Claims 1[b] and 1[c] above would increase TMR over CoFe, which further improves TMR over Bowen’s Fe alone. EX1024 ¶168; EX1030 ¶¶27-28 (describing improvements to TMR by adding B to CoFe); EX1035 at 3274. Thus, in the alternative embodiment using CoFeB, TMR would be significantly higher than Bowen’s “experimental value

of 60%,” EX1026 at 1657, resulting in a TMR of greater than 70% as required by this claim. EX1024 ¶169; *see also* EX1062 18:13-16, 18:63-19:10, Fig. 5 (describing TMR of MgO/CoFeB device as “surprising and unexpected” and “nearly 140%”); EX1056 ¶¶103-04, Fig. 7 (showing TMR increase of more than 25% (from 35 to 44%) when switching from CoFe to CoFeB electrodes).

One of skill would have expected success in achieving TMRs above 70% given that reported results exceeded that number. *E.g.*, EX1062 18:13-16, Fig. 5 (“nearly 140%”); EX1001 at 4:66-5:5; EX1024 ¶174. Moreover, this performance criterion results from the structure of the MTJ such that the performance is inherent when the prior art teaches the same structure as claimed here. EX1024 ¶175; *Persion Pharms. v. Alvogen Malta Operations*, 945 F.3d 1184, 1191 (Fed. Cir. 2019) (“[I]nherency renders a claim limitation obvious only if the limitation is ‘necessarily present,’ or is ‘the natural result of the combination of elements explicitly disclosed by the prior art.’” (citation omitted)).

D. Claim 4: “The magnetoresistive device according to claim 1, wherein said first ferromagnetic material layer comprises CoFeB alloy.”

This claim was disclosed or suggested by Bowen in view of Soukup and Sunai for the reasons provided in Claim 1[b]. *Supra* §VI.A.3; EX1024 ¶¶176-79.

Claim 4 does not specify any molecular composition or stoichiometry of CoFeB, and thus any bcc CoFeB alloy satisfies it. EX1001 at 9:51-53; EX1024 ¶177.

Additionally, it was known that use of CoFeB adjacent to crystalline MgO produced bcc CoFeB crystalline structures. EX1060 at 310; EX1062 at 18:55-59 (describing the effect of using CoFeB adjacent to MgO crystal structure as the MgO “provides a template for the formation of a thin crystalline ferromagnetic layer which has the bcc structure of CoFe and is oriented in the same (100) direction as the MgO layer.”); EX1001 at 4:21-23 (MgO (001), (100), (010) are the same); EX1024 ¶179. Thus, substitution of CoFeB for Fe would still produce a bcc CoFeB structure.

E. Obviousness Of Claim 5 Over Bowen In View Of Soukup And Alternatively Sunai

- 1. Claim 5[preamble]: “A magnetoresistive device, comprising:”**

Supra Claim 1[preamble], §VI.A.1; EX1024 ¶180.

- 2. Claim 5[a]: “a first ferromagnetic material layer of a BCC structure;”**

Supra Claim 1[b], §VI.A.3; EX1024 ¶181.

- 3. Claim 5[b]: “a second ferromagnetic material layer of the BCC structure; and”**

Supra Claim 1[c], §VI.A.4; EX1024 ¶182.

4. **Claim 5[c]: “a magnesium oxide layer located between said first ferromagnetic material layer and said second ferromagnetic material layer, wherein”**

Supra Claims 1[a],[d], §§VI.A.2, VI.A.5; EX1024 ¶183.

5. **Claim 5[d]: “said magnesium oxide is a single-crystalline (001) or a poly-crystalline crystalline in which (001) crystal plane is preferentially oriented,”**

Supra Claim 1[d], §VI.A.5; EX1024 ¶184.

6. **Claim 5[e]: “wherein said magnesium oxide has oxygen vacancy defects, and”**

Supra Claim 1[d], §VI.A.5; EX1024 ¶185.

7. **Claim 5[f]: “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV.”**

Supra Claim 1[e], §VI.A.6; EX1024 ¶186.

F. Obviousness Of Claim 6 Over Bowen In View Of Soukup And Sunai

1. **Claim 6[preamble]: “A magnetoresistive device having a magnetic tunnel junction structure comprising:”**

Supra Claim 1[preamble], §VI.A.1; EX1024 ¶187.

2. **Claim 6[a]: “a tunnel barrier layer;”**

Supra Claim 1[a], §VI.A.2; EX1024 ¶188.

3. **Claim 6[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”**

Supra Claim 1[b], §VI.A.3; EX1024 ¶189.

4. **Claim 6[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”**

Supra Claim 1[c], §VI.A.4; EX1024 ¶190.

5. **Claim 6[d]: “said tunnel barrier layer comprises a polycrystalline MgO in which (001) crystal plane is preferentially oriented, said MgO having oxygen vacancy defects,”**

This limitation is obvious over Bowen in view of Soukup and alternatively Sunai as explained in Claim 1[d]. EX1024 ¶¶191-95; *supra* §VI.A.5 (explaining that it would have been obvious to use polycrystalline MgO).

Additionally, as explained, Bowen taught a single-crystal MgO(001) tunnel barrier layer with oxygen vacancy defects. *Supra* Claim 1[d], §VI.A.5. It would have been obvious to use a polycrystalline MgO with the (001) crystal plane preferentially oriented in place of Bowen’s single-crystal MgO barrier. EX1024 ¶¶193-195.

Bowen explained that Moodera’s 1996 study used “polycrystalline MgO” to obtain the same barrier height of 0.9 eV that Bowen obtained. EX1026 at 1656 (citing EX1038); *KSR*, 550 U.S. at 416 (“combination of familiar elements” is obvious). Like Bowen, one of skill would have understood that substituting polycrystalline MgO for single-crystal MgO would yield desirable and entirely predictable results. EX1026 at 1656; EX1024 ¶¶193-195.

6. **Claim 6[e]: “wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”**

Supra Claim 1[e], §VI.A.6; EX1024 ¶196.

7. **Claim 6[f]: “wherein a magnetoresistance ratio of said device is more than 70%.”**

Supra Claim 3, §VI.C; EX1024 ¶197.

G. Obviousness Of Claim 7 Over Bowen In View Of Soukup And Sunai

1. **Claim 7[preamble]: “A magnetoresistive device having a magnetic tunnel junction structure, the magnetoresistive device comprising:”**

Supra Claim 1[preamble], §VI.A.1; EX1024 ¶198.

2. **Claim 7[a]: “a tunnel barrier layer;”**

Supra Claim 1[a], §VI.A.2; EX1024 ¶199.

3. **Claim 7[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”**

Supra Claim 1[b], §VI.A.3; EX1024 ¶200.

4. **Claim 7[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”**

Supra Claim 1[c], §VI.A.4; EX1024 ¶201.

5. **Claim 7[d]: “said tunnel barrier layer comprises a polycrystalline magnesium oxide having oxygen vacancy defects in which (001) crystal plane is preferentially oriented,”**

Supra Claim 6[d], §VI.F.5; EX1024 ¶202.

6. **Claim 7[e]: “said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”**

Supra Claim 1[e], §VI.A.6; EX1024 ¶203.

7. **Claim 7[f]: “a magnetoresistance ratio of said device is more than 70%.”**

Supra Claim 3, §VI.C; EX1024 ¶204.

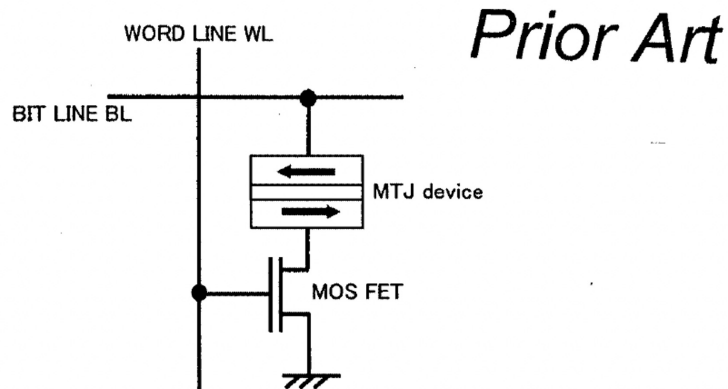
H. Obviousness Of Claim 8 Over Bowen In View Of Soukup And Sunai

1. **Claim 8[preamble]: “A memory device comprising:”**

To the extent limiting, Bowen taught or suggested using its MgO MTJ in a memory device as claimed. EX1024 ¶¶205-09. Bowen taught the “uncontested interest for important applications” of its MTJ was “for the fabrication on *nonvolatile memories (Magnetic RAM)*.” EX1026 at 1655; EX1024 ¶206.

Further, using an MTJ in a memory device was well known. EX1024 ¶207-209; *supra* §II.B. The ’403 Patent acknowledged “basic structure of the MRAM” using an MTJ in a memory device was “Prior Art”:

FIG. 9 (B)



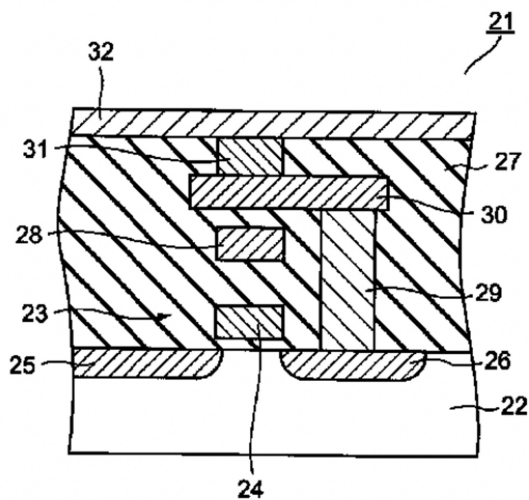
EX1001 at 1:47-2:7, Fig. 9(B); *id.* at 1:17-20 (“Research and development of MRAM devices... are being extensively carried out, and sample products of a 4 Mbit MRAM have actually been delivered.”); EX1024 ¶208.

2. Claim 8[a]: “a transistor; and”

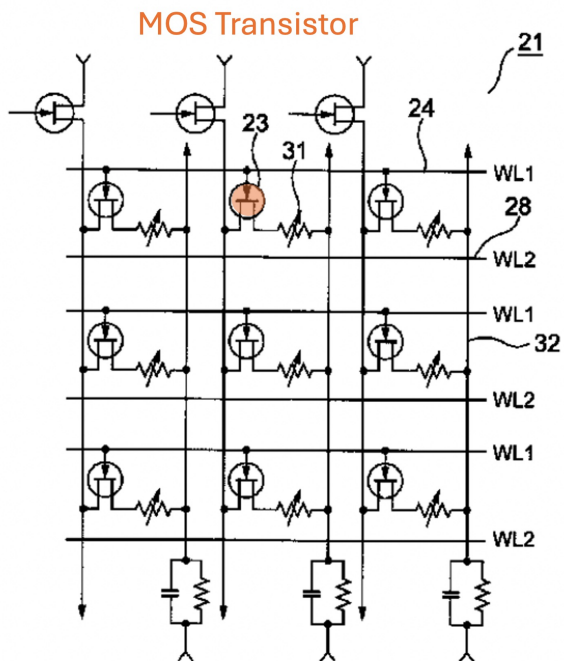
Using an MTJ with a transistor was obvious over Bowen in view of Soukup and Sunai. EX1024 ¶¶210-15. As explained for the preamble, Bowen taught or suggested using its MTJ in an MRAM memory device. *Supra* Claim 8[preamble], §VI.H.1.

Using a transistor in an MRAM memory cell was conventional. Sunai taught and depicted an MRAM using an MTJ and a “MOS transistor 23” in Figures 4-5:

[Figure 4]

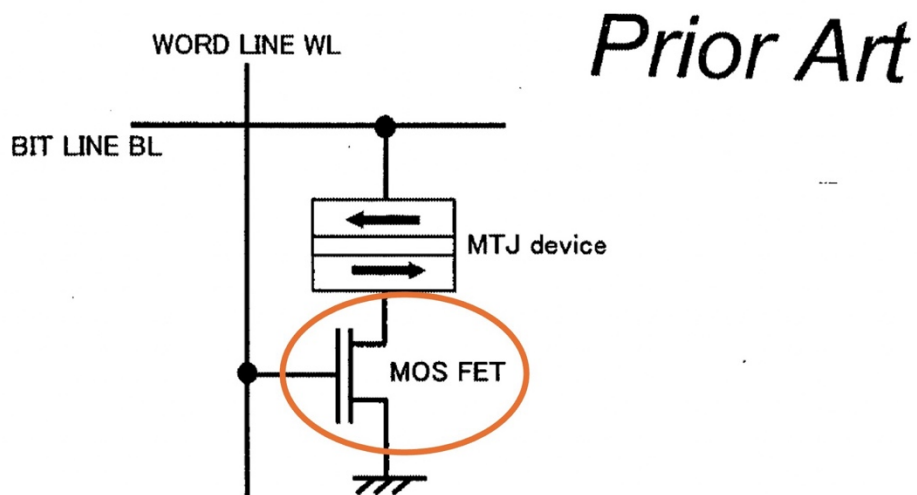


[Figure 5]



EX1030 ¶¶37-40, Figs. 4-5 (Fig. 5 annotated); EX1024 ¶212.

The '403 Patent acknowledges that “the basic structure of the MRAM” includes “a MOSFET directly connected to the MTJ device”:



Prior Art

EX1001 at 1:47-56, Fig. 9(B) (annotated); EX1024 ¶213; *supra* §II.B. A MOSFET is a type of transistor. EX1079 at 347-48; EX1024 ¶213.

It would have been obvious for one of skill in the art to combine Bowen and Sunai with a reasonable expectation of success because Sunai disclosed an end use for Bowen's MTJs. Both Bowen and Sunai taught improvements to MTJs for MRAMs, which is the problem to which the '403 Patent is directed. EX1026 at 1655; EX1030 at Figs. 4-5, ¶¶4, 37-40; EX1024 ¶214. An MRAM using a transistor to control access to an MTJ was a routine and well-known feature, as even the '403 Patent acknowledged. EX1001 at 1:47-56, Fig. 9(B); EX1030 at Figs. 4-5, ¶¶37-40; EX1024 ¶¶214-215; *supra* §II.B. As shown in Sunai, the transistor's load was the MTJ that stored information in the magnetic states of the electrodes, affecting the load resistance. EX1030 at Fig. 5; EX1024 ¶214; *see also* EX1001 at 1:53-59 ("Stored information can be read by reading the resistance value of the MTJ device that functions as a load resistance, using the MOSFET.").

Because existing MRAM architectures already used transistors in MRAM memory cells, combining Bowen's MTJ design in Sunai's MRAM memory architecture with a transistor would be readily accomplished by one of skill with a reasonable expectation of success. EX1030 at Figs. 4-5, ¶¶37-40; EX1024 ¶215.

3. **Claim 8[b]: “a magnetoresistive device comprising a tunnel barrier layer;”**

Supra Claim 1[preamble]-1[a], §§VI.A.1-VI.A.2; EX1024 ¶216.

4. **Claim 8[c]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”**

Supra Claim 1[b], §VI.A.3; EX1024 ¶217.

5. **Claim 8[d]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”**

Supra Claim 1[c], §VI.A.4; EX1024 ¶218.

6. **Claim 8[e]: “said tunnel barrier layer is formed by a single-crystalline MgO_x (001) (0<x<1) or a poly-crystalline MgO_x (0<x<1) in which (001) crystal plane is preferentially oriented, wherein”**

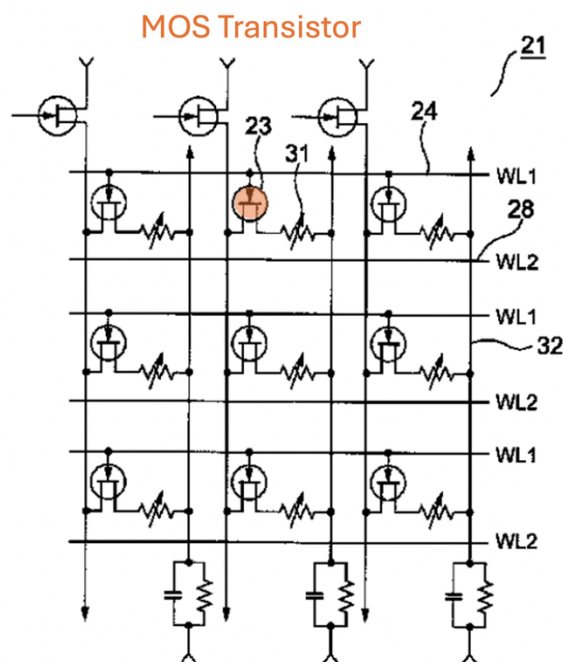
Supra Claim 1[d], §VI.A.5; EX1024 ¶219.

7. **Claim 8[f]: “a tunnel barrier height of said tunnel barrier layer is in a range of 0.2 to 0.5 eV and said magnetoresistive device is used as a load for said transistor.”**

This limitation is obvious over Bowen in view of Soukup and Sunai. As explained, Bowen in view of Soukup disclosed or rendered obvious a tunnel barrier height in a range of 0.2 to 0.5 eV. *Supra* Claim 1[e], §VI.A.6; EX1024 ¶220.

Using an MTJ as a load for a transistor in magnetic memory was well known. As shown at right, Sunai plainly disclosed an MTJ used as a load for a transistor, and the motivation to do so is explained in Claim 8[a]. EX1030, Fig. 5 (annotated); *supra* §VI.H.2; EX1024 ¶¶212, 221; *supra* §II.B.

[Figure 5]



VII. GROUND 2: CLAIMS 1-8 ARE OBVIOUS OVER NAGAHAMA IN VIEW OF SOUKUP (AND SUNAI)

Nagahama disclosed a series of MTJ embodiments focused on a basic structure of a ferromagnetic layer on top of an insulating layer on top of an ultrathin ferromagnetic layer on top of an underlayer. *E.g.*, EX1027 at 10 (claim 1), ¶¶73-74 (describing same arrangement with MgO barrier layer). Additionally, Nagahama disclosed that “[t]he present invention relates to... a tunnel magnetoresistive element

whose crystal orientation is set to the (001) direction of a body-centered cubic lattice, a face-centered cubic lattice, or a tetragonal lattice.” *Id.* ¶1; EX1024 ¶224. It would have been obvious to a skilled artisan to use Nagahama’s teachings regarding MTJs to form a single structure satisfying the challenged claims as discussed below.

A. Obviousness Of Claim 1 Over Nagahama In View Of Soukup And Alternatively Sunai

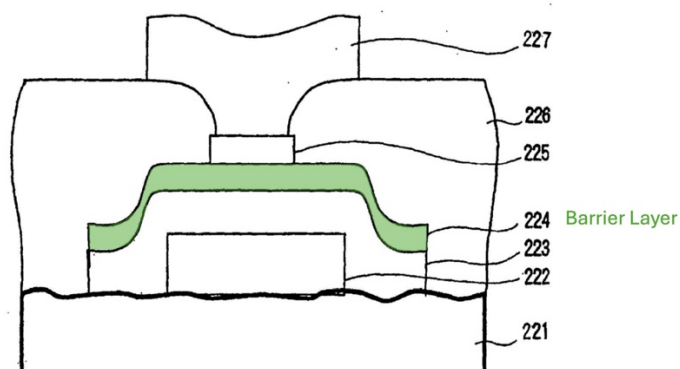
1. Claim 1[preamble]: “A magnetoresistive device having a tunnel barrier junction structure, the magnetoresistive device comprising:”

To the extent limiting, Nagahama taught “tunnel magnetoresistive elements,” having a tunnel barrier junction structure as claimed. EX1027 ¶¶73-75, Abstract, Claim 1, Figs. 3, 17; EX1024 ¶¶223-29; *infra* §0. As explained in Ground 1, MTJs were well known in the art. EX1024 ¶227-229; *supra* §§II.B, VI.A.2.

2. Claim 1[a]: “a tunnel barrier layer;”

Nagahama taught this limitation. EX1024 ¶¶230-32. Its paragraphs 73-74 embodiment described a “tunnel magnetoresistive element” including “a (001)-highly-oriented MgO barrier layer.” EX1027 ¶¶73-74. Another example of this **barrier layer** is shown in Figure 17 below. EX1027 ¶¶75-76; EX1024 ¶230.

FIG. 17



EX1027 at Fig. 17 (annotated).

As explained in Ground 1, an MTJ with a barrier layer was conventional.

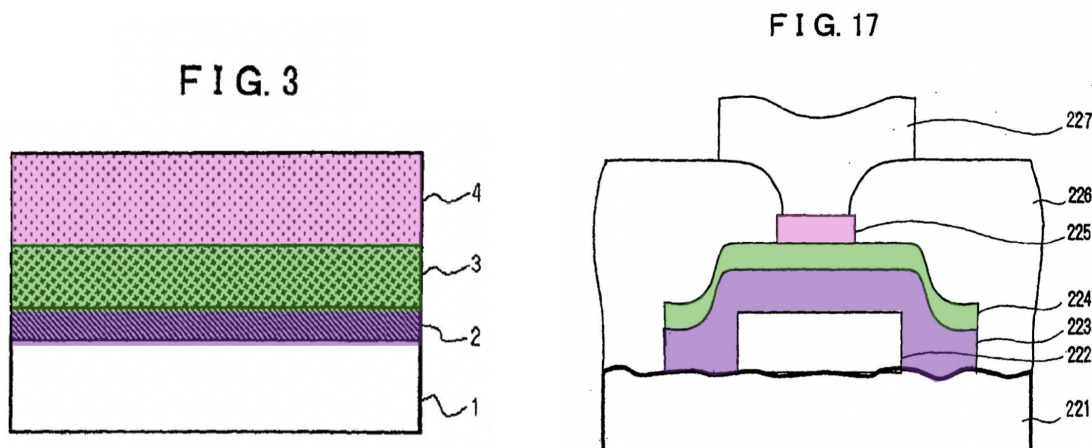
EX1024 ¶232; *supra* §§II.B, VI.A.2.

3. Claim 1[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”

This limitation was taught or suggested by Nagahama. EX1024 ¶¶233-44.

The “ferromagnetic material layer” refers to an “electrode made of a ferromagnetic metal.” EX1001 at 1:25-29, Fig. 8(a); EX1024 ¶233; *supra* §**Error! Reference source not found.** The “tunnel barrier” layer refers to “an oxide [that] is sandwiched between a first and a second electrode made of a ferromagnetic metal.” EX1001 at 1:25-29. “First” refers to the “lower” ferromagnetic electrode that is closest to the substrate, and “second” refers to the “upper” ferromagnetic electrode. EX1001 at Abstract; EX1024 ¶233.

Nagahama disclosed “a (001)-highly-oriented **lower** ferromagnetic electrode layer, a (001)-highly-oriented MgO barrier layer, and a (001)-highly-oriented **upper** ferromagnetic electrode layer on the MgO double underlayer of the present invention.” EX1027 ¶73. Such an arrangement is depicted in Figures 3 and 17 as well. EX1027 ¶¶21-22, 75-76; EX1024 ¶¶234-235. In Figures 3 and 17, 1 and 222 represent a substrate (or underlayer); 2 and 223 represent a **lower ferromagnetic electrode**; 3 and 224 represent a **barrier layer**; and 4 and 225 represent an upper ferromagnetic layer. EX1027 ¶¶21-22, 75-76; EX1024 ¶235.



EX1027 at Figs. 3, 17 (Fig. 3 excerpted, both annotated).

Nagahama taught that its “**lower ferromagnetic electrode**” of its “high-quality tunnel magnetoresistive element” was the “first ferromagnetic layer” and its “upper ferromagnetic electrode” was the “second ferromagnetic layer.” EX1027 ¶¶75-76, Fig. 17; *see also id.* ¶22, Fig. 3 (describing the same relationships); EX1024

¶233-234. Nagahama discloses various examples of this “lower ferromagnetic electrode” material, including Fe, Co, Ni, or an alloy of these metals. *E.g.*, EX1027 ¶¶28, 31, 61, 68, Fig. 17 (reference numeral 223).

Nagahama explained that its MTJ used “a ferromagnetic electrode layer... oriented in the (001) direction of a *body-centered cubic lattice*, a face-centered cubic lattice, or a tetragonal lattice.” EX1027 ¶18 (item [20]); *id.* ¶¶1, 23; EX1024 ¶236. To the extent IP Bridge asserts that this disclosure does not apply to the paragraphs 73-74 embodiment, it would have been obvious to a skilled artisan to generate these ferromagnetic layers in bcc structure with a reasonable likelihood of success because Nagahama itself taught that bcc structure was desirable to achieve “a large magnetoresistive effect.” EX1027 ¶¶18 (item [20]), 81 (item [F]); *id.* at 11 (claim 20).

Alternatively, one of skill would have found it obvious to replace Nagahama’s lower ferromagnetic electrode material with CoFeB as taught by Sunai. EX1030 ¶¶25-29; EX1024 ¶238.

One of skill would have been motivated to substitute Sunai’s CoFeB electrode for Nagahama’s lower electrode (made of Fe, Co, Ni or combinations thereof) to increase the TMR of Nagahama’s MTJ. EX1024 ¶¶238-239. Nagahama sought to “obtain a high magnetoresistive effect” in its MgO MTJ, EX1027 ¶6, and understood that the properties of the ferromagnetic electrodes impacted TMR, EX1027 ¶23;

EX1024 ¶239 As explained for Claim 1[b] in Ground 1, a skilled artisan knew that using CoFeB electrodes improved TMR. *Supra* §VI.A.3; EX1030 ¶27; EX1035 at 3274; EX1055 at 2269-70; EX1056 ¶¶39, 78; EX1024 ¶241.

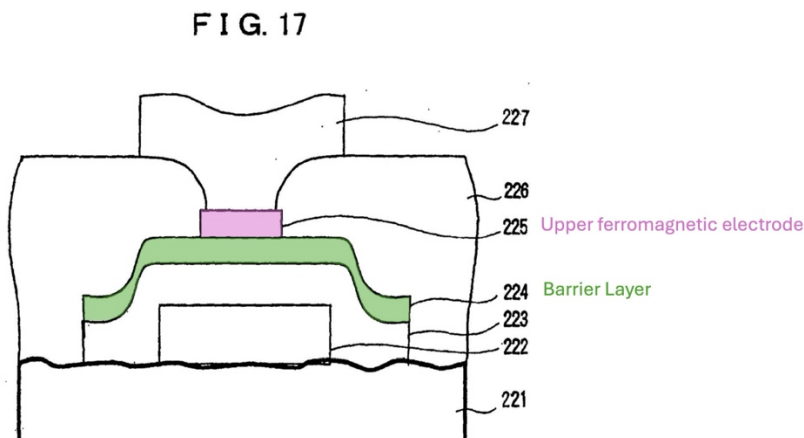
One of skill would have been motivated to replace either or both of Nagahama's upper and lower electrodes with CoFeB to improve TMR. EX1055 at 2270 (“[I]t is natural to replace both the free and pinned layers to CoFeB to further increase the TMR value.”); EX1056 ¶¶67-68; EX1035 at 3274; EX1024 ¶¶242-244. Such a “combination of familiar elements” is obvious. *KSR*, 550 U.S. at 416.

One of skill would have looked to Sunai's teachings to improve Nagahama's MTJ. EX1024 ¶242. Both Nagahama and Sunai focused on improving the TMR of magnetoresistive devices, a problem to which the '403 Patent was directed. EX1027 ¶¶6, 15; EX1030 at Abstract, ¶¶1, 10; EX1001 at Abstract, 1:9-2:7. Both were directed to improving MRAM memory performance, as was the '403 Patent. EX1027 ¶¶3, 49; EX1030 at Figs. 4-5, ¶¶1, 4, 37-40; EX1001 at 2:37-39; EX1024 ¶242. Both used the same MgO barrier layer and similar ferromagnetic alloy electrodes. EX1027 ¶¶6, 73; EX1030 ¶¶24, 33; EX1024 ¶242. Because it was known that CoFeB alloy electrodes had been successfully used as electrodes for MTJs, one of skill would have found it to be a straightforward, predictable, and desirable improvement to Nagahama's MTJ. EX1024 ¶242; EX1030 ¶¶24-29; EX1055 at 2269-70; EX1056 ¶¶39, 78.

Despite replacing the material as recommended by Sunai, one of skill would have heeded Nagahama's recommendation that the electrode material layer portions of its tunnel magnetoresistive element remain "set to the (001) direction of a *body-centered cubic lattice*" as taught by Nagahama. EX1027 ¶¶1, 11 (claim 20: "by using the underlayer so that a ferromagnetic electrode layer is oriented in the (001) direction of a *body-centered cubic lattice*, ... and using a (001)-highly-oriented MgO layer as a barrier layer, a large magnetoresistive effect is produced."); EX1060 at 310; EX1062 at 18:55-59 (MgO barrier provides template for bcc CoFeB electrode); EX1024 ¶¶243-244.

4. **Claim 1[c]: "a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein"**

As explained for Claim 1[b], Nagahama's taught element "225, an **upper ferromagnetic electrode**" formed on a second side of tunnel barrier layer 224 as the claimed "second ferromagnetic material layer," as shown annotated below:



EX1027 ¶76; *id.* at Abstract, ¶¶21-22, Figs. 3, 17; EX1024 ¶246; *supra* §VII.A.3.

Nagahama further taught that its MTJ “includes a (001)-highly-oriented upper ferromagnetic electrode layer.” EX1027 ¶73; EX1024 ¶¶245, 247.

Nagahama explained that its second ferromagnetic layer was likewise “*body-centered cubic lattice*,” EX1027 ¶18 (item [20]); *id.* ¶¶1, 23; EX1024 ¶247, or it would have been obvious to use a BCC upper electrode for the same reasons explained in Claim 1[b]. EX1027 ¶1; EX1024 ¶¶233-244, 247; *supra* §VII.A.3.

Alternatively, it would have been obvious to replace the Nagahama’s upper ferromagnetic electrode with CoFeB as taught by Sunai for all the reasons provided above regarding Claim 1[b]. *Supra* §VII.A.3; EX1024 ¶248.

5. **Claim 1[d]: “said tunnel barrier layer is formed by a single-crystalline MgO_x (001) ($0 < x < 1$) or a poly-crystalline MgO_x ($0 < x < 1$) in which (001) crystal plane is preferentially oriented, and”**

Nagahama in view of Soukup taught or suggested this limitation. EX1024 ¶¶249-54. As explained for Claim 1[a], Nagahama taught a polycrystalline $\text{MgO}(001)$ tunnel barrier layer in its magnetoresistive element: “a (001)-highly-oriented MgO barrier layer.” EX1027 ¶73; EX1024 ¶249; *supra* §VII.A.2. Because single-crystal layers have the same orientation throughout the crystalline lattice, “highly-oriented” is a term that describes the predominant orientation of a polycrystalline layer containing many crystals. EX1024 ¶250; EX1040 at 2842

(MgO “polycrystalline structures” have “preferred orientation”). Describing “a (001)-highly-oriented MgO barrier layer,” EX1027 ¶73, confirms Nagahama’s MgO barrier was polycrystalline and preferentially oriented in the (001)-plane, EX1024 ¶250.

Nagahama inherently satisfied MgO_x where $0 < x < 1$, a mathematical notation indicating oxygen vacancy defects in the MgO layer. EX1024 ¶251; EX1001 at 6:10-13, 6:50-51; EX1002 at 168); *supra* §II.E. One of skill would have understood that Nagahama’s MgO tunnel barrier necessarily included oxygen vacancy defects because these defects occur in all MgO barriers. EX1042 at 162 (“Oxygen vacancies are naturally present in every oxide,” including MgO.); EX1024 ¶252; *supra* §II.E.

Alternatively, Nagahama in view of Soukup also taught an MgO barrier layer with oxygen vacancy defects. Soukup studied the “effect of nonstoichiometry on the device characteristics,” EX1028 at 3232, and experimented with devices fabricated with different levels of nonstoichiometry, EX1028 at Abstract, 3232-33, Table I; EX1024 ¶253. One of skill would have been motivated to apply Soukup’s teachings about oxygen vacancy defects to Nagahama’s MgO MTJ to improve tunneling current and the TMR, for the same reasons as explained for limitation 1[e]. EX1024 ¶254; *infra* §VII.A.6.

6. **Claim 1[e]: “wherein a tunnel barrier height between a bottom of a conduction band of said tunnel barrier layer and a Fermi energy of at least one of said first and second ferromagnetic layers is a discontinuous value in a range of 0.2 to 0.5 eV.”**

As explained in Ground 1, Claim 1[e] merely recites the definition of a “tunnel barrier height” and specifies a range of 0.2-0.5 eV. EX1001 at 2:59-63, 3:37-41; *supra* §§VI.A.6, II.C; EX1024 ¶¶48, 255-256.

Nagahama in view of Soukup taught or suggested an MgO tunnel barrier height for an MgO barrier layer in the claimed range of 0.2 to 0.5 eV. EX1024 ¶¶255-71. Nagahama taught an MgO MTJ. EX1027 ¶¶73-74, Abstract, Figs. 3, 17. Soukup observed a “barrier height” of “*about 0.33 eV*” for its MgO barrier. EX1028 at Abstract; *id.* at 3231-32, Fig. 5, Table I; EX1024 ¶257. As explained for Claim 1[e] in Ground 1, one of skill reading Soukup understood there was a relationship between oxygen vacancy defects and barrier height. *Supra* §VI.A.6; EX1024 ¶258.

One of skill would have been motivated to apply Soukup’s teachings about an MgO thin film barrier with a “barrier height” of “about 0.33 eV” to Nagahama’s MgO barrier. EX1028 at Abstract, 3232, 3236; EX1024 ¶259. As explained in Ground 1, TMR was an “important parameter” and of high interest for improving MRAM performance, and lowering the resistance (barrier height) for parallel electrons would improve TMR. EX1055 at 2269, 2271; EX1035 at 3273; EX1027 ¶2; EX1024 ¶¶260-261; *supra* §§VI.A.6. Nagahama’s stated goal was to improve

TMR in its MTJ. EX1027 ¶¶6, 15; *see also id.* ¶¶3-8; EX1024 ¶261. Nagahama sought to increase TMR by modifying properties of the MgO barrier layer. EX1027 ¶¶15-17. Indeed, Nagahama discussed prior research on increasing TMR in MgO barriers by Mathon, Bowen, and others. EX1027 ¶¶2-14.

As explained, Butler and Mathon taught that MgO barriers improved TMRs due to improved symmetry, facilitating tunneling of parallel electrons, and would have been motivated to explore lower barrier heights to accomplish that. EX1044 at 1; EX1046 at 1; EX1024 ¶¶259-60; *supra* §VI.A.6. One of skill seeking to improve Nagahama's MTJ would have looked to Soukup's teachings about how defects lowered MgO barrier height. EX1024 ¶¶259, 265. Indeed, both Nagahama and Soukup studied tunneling and other properties of MgO barriers and were focused on improving tunneling devices, the problem to which the '403 Patent was directed. EX1027 ¶¶2-4, 13-15; EX1028 at 3229-30; EX1001 at Abstract, 1:9-2:7.

One of skill would have had a reasonable expectation of success in achieving a tunnel barrier height in the claimed range in Nagahama's MTJ. EX1024 ¶¶262, 266. Soukup had already shown that an MgO barrier achieved a height of 0.33 eV, EX1028 at Abstract, and that the barrier height was varied by adjusting the oxygen vacancy defects in the MgO barrier layer, EX1028 at Abstract, 3232, 3236; EX1024 ¶¶261, 267. One of skill would have predictably followed this trail. *Id.*

For the same reasons explained in Ground 1, the claimed tunnel barrier height range of 0.2 to 0.5 eV also would have been obvious. *Supra* §VI.A.6; EX1028 at 3232, 3236; EX1043 at 1; EX1045 at 7; EX1047 at 510-11; EX1051 at 1; EX1026 at 1656; EX1053 at 8042-43; EX1024 ¶267.

The '403 Patent's assertion that this limitation is inherent when there are oxygen vacancy defects and Patent Owner's district court statements that the claim requirement of a 0.2 to 0.5 eV barrier height is satisfied by the mere "presence of oxygen vacancy defects" also show this limitation is obvious. EX1064 at 17; *id.* 19 (citing EX1001 at 6:47-7:2); *supra* §VI.A.6; *Longhorn Vaccines*, IPR2021-00847, Paper 13 at 23; EX1024 ¶269.

B. Claim 2: "The magnetoresistive device according to claim 1, wherein said ferromagnetic material comprises a single-crystalline (001) of Fe or Fe-based alloy, or a poly-crystalline of Fe or Fe-based alloy in which (001) crystal plane is preferentially oriented."

Claim 2 would have been obvious over Nagahama in view of Soukup and alternatively Sunai as explained for Claims 1[b]-1[c] in this Ground. *Supra* §§VII.A.3-VII.A.4; EX1024 ¶¶272-76. A skilled artisan understood that Nagahama's paragraphs 73-74 embodiment used polycrystalline electrodes because they are described as "(001)-highly-oriented," EX1027 ¶73, which means that they are polycrystalline as explained for the MgO barrier layer in Claim 1[d]. *Supra* §VII.A.5; EX1024 ¶273.

Nagahama discloses various examples of materials for its ferromagnetic layers, including Fe, Co, CoFe, Ni, or an alloy of these metals. *E.g.*, EX1027 ¶¶6, 28, 31, 61, 68. A skilled artisan would be motivated to use Fe or CoFe for ferromagnetic layers as taught by Nagahama because at least some of its exemplary electrodes were made of these materials. *Id.*; EX1024 ¶274. A skilled artisan would have expected success because these are the electrode materials that Nagahama described successfully using to achieve “a tunnel magnetoresistive element outputting a large signal” or “producing a larger magnetoresistive effect.” EX1027 ¶¶1, 15; EX1024 ¶275. Nagahama suggested combining different features of its MTJ designs to one of skill, explaining that “various modifications may be made” to its “above-described embodiments.” EX1027 ¶78.

C. Claim 3: “The magnetoresistive device according to claim 1, wherein a magnetoresistance ratio of said magnetoresistive device is more than 70%.”

Claim 3 would have been obvious over Nagahama in view of Soukup and alternatively Sunai. EX1024 ¶¶277-79.

Nagahama taught “a larger tunnel magnetoresistive effect of more than 90%” for its MTJ with an MgO barrier. EX1027 ¶74; EX1024 ¶278; *supra* §II.D.2; *Fike Corp. v. Donadon Safety Discs & Devices*, IPR2015-00341, 2016 WL 483193, at *16 (P.T.A.B. Feb. 4, 2016) (“Overlapping prior art ranges and prior art values within the claimed ranges render the claimed ranges obvious.”). To the extent increased

oxygen vacancies lowered barrier height in Nagahama's MTJ as explained above, that would have increased the TMR even more. *Supra* Claim 1[e], §VII.A.6; EX1024 ¶278.

D. Claim 4: “The magnetoresistive device according to claim 1, wherein said first ferromagnetic material layer comprises CoFeB alloy.”

Claim 4 does not specify any molecular composition or stoichiometry of CoFeB, and thus any bcc CoFeB alloy satisfies it. EX1001 at 9:51-53; EX1024 ¶281.

This claim was taught or suggested by Nagahama in view of Soukup and Sunai for the reasons provided in Claim 1[b]. *Supra* §VII.A.3; EX1024 ¶¶280-83.

E. Obviousness Of Claim 5 Over Nagahama In View Of Soukup And Sunai

1. Claim 5[preamble]: “A magnetoresistive device, comprising:”

Supra Claim 1[preamble], §VII.A.1; EX1024 ¶284.

2. Claim 5[a]: “a first ferromagnetic material layer of a BCC structure;”

Supra Claim 1[b], §VII.A.3; EX1024 ¶285.

3. Claim 5[b]: “a second ferromagnetic material layer of the BCC structure; and”

Supra Claim 1[c], §VII.A.4; EX1024 ¶286.

4. **Claim 5[c]: “a magnesium oxide layer located between said first ferromagnetic material layer and said second ferromagnetic material layer, wherein”**

Supra Claims 1[a],[d], §§VII.A.2-VII.A.5; EX1024 ¶287.

5. **Claim 5[d]: “said magnesium oxide is a single-crystalline (001) or a poly-crystalline crystalline in which (001) crystal plane is preferentially oriented,”**

Supra Claim 1[d], §VII.A.5; EX1024 ¶288.

6. **Claim [5e]: “wherein said magnesium oxide has oxygen vacancy defects, and”**

Supra Claim 1[d], §VII.A.5; EX1024 ¶289.

7. **Claim [5f]: “wherein said magnesium oxide has a tunnel barrier height in a range of 0.2 to 0.5 eV.”**

Supra Claim 1[e], §VII.A.6; EX1024 ¶290.

F. Obviousness Of Claim 6 Over Nagahama In View Of Soukup And Sunai

1. **Claim [6-pre]: “A magnetoresistive device having a magnetic tunnel junction structure comprising:”**

Supra Claim 1[preamble], §VII.A.1; EX1024 ¶291.

2. **Claim 6[a]: “a tunnel barrier layer;”**

Supra Claim 1[a], §VII.A.2; EX1024 ¶292.

3. **Claim 6[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”**

Supra Claim 1[b], §VII.A.3; EX1024 ¶293.

4. **Claim 6[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”**

Supra Claim 1[c], §VII.A.4; EX1024 ¶294.

5. **Claim 6[d]: “said tunnel barrier layer comprises a polycrystalline MgO in which (001) crystal plane is preferentially oriented, said MgO having oxygen vacancy defects,”**

Supra Claim 1[d], §VII.A.5; EX1024 ¶295.

6. **Claim 6[e]: “wherein said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”**

Supra Claim 1[e], §VII.A.6; EX1024 ¶296.

7. **Claim 6[f]: “wherein a magnetoresistance ratio of said device is more than 70%.”**

Supra Claim 3, §VII.C; EX1024 ¶297.

G. Obviousness Of Claim 7 Over Nagahama In View Of Soukup And Sunai

1. **Claim 7[preamble]: “A magnetoresistive device having a magnetic tunnel junction structure, the magnetoresistive device comprising:”**

Supra Claim 1[preamble], §VII.A.1; EX1024 ¶298.

2. **Claim 7[a]: “a tunnel barrier layer;”**

Supra Claim 1[a], §VII.A.2; EX1024 ¶299.

3. **Claim 7[b]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”**

Supra Claim 1[b], §VII.A.3; EX1024 ¶300.

4. **Claim 7[c]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”**

Supra Claim 1[c], §VII.A.4; EX1024 ¶301.

5. **Claim 7[d]: “said tunnel barrier layer comprises a polycrystalline magnesium oxide having oxygen vacancy defects in which (001) crystal plane is preferentially oriented,”**

Supra Claim 1[d], §VII.A.5; EX1024 ¶302.

6. **Claim 7[e]: “said tunnel barrier layer has a tunnel barrier height of 0.2 to 0.5 eV, and”**

Supra Claim 1[e], §VII.A.6; EX1024 ¶303.

7. **Claim 7[f]: “a magnetoresistance ratio of said device is more than 70%.”**

Supra Claim 3, §VII.C; EX1024 ¶304.

H. Obviousness Of Claim 8 Over Nagahama In View Of Soukup And Sunai

1. **Claim 8[preamble]: “A memory device comprising:”**

To the extent limiting, Nagahama disclosed using its MTJ in an MRAM as claimed. EX1027 ¶82; *see also id.* ¶49 (using MTJ in an MRAM); EX1024 ¶¶305-09.

Using an MTJ in a memory device was known. EX1001 at 1:17-20, 1:47-2:7, Fig. 9; EX1002 at 233, 252; EX1024 ¶¶307-309; *supra* §II.B.

2. Claim 8[a]: “a transistor; and”

Nagahama taught or suggested using a transistor. EX1024 ¶¶310-13. Nagahama described improved MTJs for “a ferromagnetic random access memory.” EX1027 ¶3; *id.* ¶18 (item [14]); EX1024 ¶310. Nagahama explained that using a MOSFET transistor with an MTJ was known: “In known ferromagnetic random access memories, a *MOS-FET has to be used as a pass transistor* to access a tunnel magnetoresistive element...” EX1027 ¶49; *id.* ¶¶47-48; EX1079 at 347-48 (MOSFET is a type of transistor); EX1024 ¶311.

A skilled artisan understood that Nagahama’s MRAM using a MOSFET was generally applicable to all of its MTJs. EX1027 ¶¶49, 78; EX1024 ¶312. Using a transistor to control access to an MTJ in an MRAM was a routine and well-known feature in the prior art, as even the ’403 Patent acknowledged. EX1001 at 1:47-56, Fig. 9(B); EX1024 ¶¶312-313. In such systems, the transistor’s load was the information-storing MTJ. EX1024 ¶313; *see also supra* §II.B; EX1001 at 1:53-59.

3. Claim 8[b]: “a magnetoresistive device comprising a tunnel barrier layer;”

Supra Claim 1[preamble]-1[a], §§VII.A.1-VII.A.2; EX1024 ¶314.

4. Claim 8[c]: “a first ferromagnetic material layer of a BCC structure formed on a first side of said tunnel barrier layer; and”

Supra Claim 1[b], §VII.A.3; EX1024 ¶315.

5. **Claim 8[d]: “a second ferromagnetic material layer of the BCC structure formed on a second side of said tunnel barrier layer, wherein”**

Supra Claim 1[c], §VII.A.4; EX1024 ¶316.

6. **Claim 8[e]: “said tunnel barrier layer is formed by a single-crystalline MgO_x (001) (0<x<1) or a poly-crystalline MgO_x (0<x<1) in which (001) crystal plane is preferentially oriented, wherein”**

Supra Claim 1[d], §VII.A.5; EX1024 ¶317.

7. **Claim 8[f]: “a tunnel barrier height of said tunnel barrier layer is in a range of 0.2 to 0.5 eV and said magnetoresistive device is used as a load for said transistor.”**

This limitation is obvious over Nagahama and Soukup. As explained, Nagahama in view of Soukup disclosed or rendered obvious a tunnel barrier height in a range of 0.2 to 0.5 eV. *Supra* Claim 1[e], §VII.A.6; EX1024 ¶318. Nagahama further taught or suggested an MTJ used as a load for a transistor, which was well known in the art. EX1027 ¶49; *supra* Claim 8[a], §VII.H.2; EX1024 ¶319; *supra* §II.B.

VIII. SECONDARY CONSIDERATIONS

Western Digital is unaware of any relevant secondary considerations of non-obviousness for the '403 Patent. EX1024 ¶320.

IX. DISCRETIONARY DENIAL IS UNWARRANTED HERE

Discretionary denial under either Section 314(a) or 325(d) is inappropriate.

A. *Fintiv* Is No Roadblock To Institution

The *Fintiv* factors do not support denying institution under Section 314(a) here. *See Apple v. Fintiv*, IPR2020-00019, 2020 WL 2126495, at *2 (P.T.A.B. Mar. 20, 2020) (precedential); Director’s Interim Procedure for Discretionary Denials (June 21, 2022) (“Guidance Memo”).

IP Bridge filed its initial complaint in March 2024, and the 38-month median time to trial in the District of Delaware puts any trial long after the final written decision here. *F5 v. Sunstone Info.*, IPR2022-00483, Paper 13 at 12 (P.T.A.B. Aug. 12, 2022); EX1063; EX1078 at 2; Guidance Memo at 8-9 (median time-to-trial statistics must be considered).

The district court litigation is still in its infancy and progressing slowly. After Western Digital filed a motion to dismiss, IP Bridge asked for an extension and filed a First Amended Complaint on July 8, 2024. EX1077 at 3. Western Digital’s renewed motion to dismiss and motion to transfer the case to California are presently pending, and the district court has not set a date for an initial scheduling conference, let alone a trial date. *See* EX1077.

To date, IP Bridge has asserted only a single claim of the ’403 Patent in Delaware, EX1067 ¶50, while this Petition challenges all claims, leading to little risk of duplication, *see Precision Planting v. Maschio Gaspardo*, IPR2024-00008, 2024 WL 1283507, at *7 (P.T.A.B. Mar. 26, 2024). This Petition presents a compelling

challenge showing all aspects of the claims existed in the prior art, including the aspects of the claims the Examiner found allegedly novel. *Supra* §§VI-VII; Guidance Memo at 4-5. *Fintiv* presents no bar to instituting trial here.

B. Discretionary Denial Under 35 U.S.C. §325(d) Is Unwarranted

Section 325(d) also does not support discretionary denial. The Examiner was not informed that researchers had already observed what he believed was a critical limitation: MgO thin films with a barrier height in the range of 0.2 to 0.5 eV. EX1002 at 235. He never considered the combinations presented in this Petition. EX1002 at 199-202, 231-36. Under either part one or two, the Board has ample reason to conclude, either under part one or two, that *Advanced Bionics* does not apply.

The Board applies a two-part framework to determine whether Section 325(d) bars institution: (1) “whether the same or substantially the same art previously was presented to the Office,” and (2) “whether the petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims.” *Advanced Bionics v. MED-EL Elektromedizinische Geräte*, IPR2019-01469, 2020 WL 740292, at *3 (P.T.A.B. Feb. 13, 2020) (precedential).

Part one supports ordering trial here. In part one of *Advanced Bionics*, the Board considers “the similarities and material differences between the asserted art and the prior art involved during examination, the cumulative nature of the art, and the overlap of the arguments presented.” *BMW of N. Am. v. Stragent*, IPR2021-

00419, 2021 WL 3039219, at *5 (P.T.A.B. July 19, 2021) (citing *Advanced Bionics*, 2020 WL 740292, at *4).

The Examiner believed that the claimed barrier height of 0.2 to 0.5 eV was inventive, EX1002 at 235, and applicant never informed him otherwise, *see* EX1002 at 251-60; EX1028 at Abstract (Soukup: barrier height of 0.33 eV). Nor was the Examiner informed of Patent Owner’s position that the “the presence of oxygen vacancy defects indicates a tunnel barrier height as claimed.” EX1064 at 19; EX1002 at 251-60.

The Examiner did not have the benefit of Soukup, the combinations of prior art presented here,³ or Patent Owner’s positions on barrier height, all of which render obvious the claimed tunnel barrier height in a range of 0.2 to 0.5 eV. This Petition presents new information that the Examiner did not have the opportunity to consider during his initial examination. The grounds in this Petition were not “previously

³ Bowen, Nagahama, and Sunai were listed in an IDS, but never discussed or meaningfully addressed by either applicant or the Examiner. *See generally* EX1002; *supra* §II.G. An international search report listing Nagahama and Sunai also does not show the Examiner substantively considered them. *See, e.g., Intel v. Qualcomm*, IPR2019-00047, 2019 WL 3001483, at *5-6 (P.T.A.B. July 9, 2019); *Cellco P’ship v. Huawei*, IPR2020-01117, 2021 WL 389532, at *6 (P.T.A.B. Feb. 3, 2021).

presented” to the Patent Office, and trial is warranted here. *See, e.g., Lifecore Fitness v. Woodway USA*, IPR2024-00083, Paper 13 at 22 (P.T.A.B. May 17, 2024) (refusing to deny institution under step one of *Advanced Bionics* even though some of the references were cited on the face of the patent because of Petitioner’s reliance on new art that was not previously presented to the PTO); *JUUL Labs. v. NJOY*, IPR2024-00160, 2024 WL 2697567, at *5 (P.T.A.B. May 24, 2024) (*Advanced Bionics* part one not met because “mere prior citation of prior art in an IDS will not automatically satisfy the first prong”).

If the Board deems consideration of step two necessary, it also supports instituting trial here. None of the references were meaningfully or substantively considered during prosecution because the Examiner never rejected the claims over the prior art. *See* EX1002; *Amcol Int’l v. Oil-Dri Co.*, IPR2022-01107, Paper 10 at 12 (P.T.A.B. Dec. 5, 2022) (ordering trial where prior art “was not the subject of a rejection, or discussion in any amount of detail by the Examiner”); *Chemtronics USA v. Flatfrog Labs.*, IPR2024-00015, 2024 WL 1719468, at *9 (P.T.A.B. Apr. 22, 2024) (ordering trial because “the Examiner did not issue a rejection based on” the Petitioner’s prior art). The Examiner can hardly be said to have erred when he never had the benefit of Soukup’s disclosures, which disclose the limitation the Examiner believed to be critical, Patent Owner’s litigation positions, or the combinations of prior art presented in this Petition.

Advanced Bionics does not block the Board from considering the patentability of the '403 Patent based on the prior art presented in this Petition.

X. CONCLUSION

For the reasons set forth above, Western Digital requests judgment cancelling Claims 1-8 of U.S. Patent No. 7,884,403.

XI. GROUNDS FOR STANDING

Western Digital hereby certifies that the '403 Patent is available for IPR and meets the requirements of 37 C.F.R. §42.101.

XII. MANDATORY NOTICES

Pursuant to 37 C.F.R. §42.8(a)(1), the mandatory notices identified in 37 C.F.R. §42.8(b) are provided below as part of this Petition.

A. Real Party-In-Interest (37 C.F.R. §42.8(b)(1))

Petitioner Western Digital Technologies, Inc., and related entity Western Digital Corporation, are the real parties-in-interest.

B. Related Matters (37 C.F.R. §42.8(b)(2))

Petitioner is currently aware of the following matters related to the '403 Patent: *Godo Kaisha IP Bridge 1 v. Western Digital Technologies, Inc.*, No. 24-cv-00342 (D. Del. Mar. 15, 2024); *Godo Kaisha IP Bridge 1 v. Seagate Technology LLC*, No. 24-cv-00341 (D. Del. Mar. 15, 2024).

C. Lead and Backup Counsel (37 C.F.R. §42.8(b)(3))

Petitioner provides the following designation of counsel:

Lead Counsel	Backup Counsel
Michelle E. Armond (Reg. No. 53,954) michelle.armond@armondwilson.com	Douglas R. Wilson (Reg. No. 54,542) doug.wilson@armondwilson.com
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Pursuant to 37 C.F.R. §42.10(b), a Power of Attorney accompanies this Petition.

D. Service Information (37 C.F.R. §42.8(b)(4))

Service information for lead and backup counsel is above. Petitioner hereby consents to service by email at the following email address:
ipr@armondwilson.com.

Western Digital v. Godo Kaisha IP Bridge
IPR Petition – U.S. Patent No. 7,884,403

ARMOND WILSON LLP

Dated: August 30, 2024

By: /Michelle E. Armond/

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Attorneys for Western Digital Technologies, Inc.

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. §42.24(d), the undersigned certifies that foregoing
PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,884,403
exclusive of the parts exempted as provided in 37 C.F.R. §42.24, contains 13,985
words and therefore complies with the type-volume limitations of 37 C.F.R. §42.24.

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CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing **PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,884,403** and **EXHIBITS 1001-1079**, are being served on August 30, 2024, via overnight mail on the patent owner at the correspondence address of record for U.S. Patent No. 7,884,403, as addressed below:

Juan Carlos A. Marquez
Marquez Intellectual Property Law Office PLLC
1629 K Street, NW, Suite 300
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A courtesy copy is also being served by electronic mail on counsel for the patent holder in the pending litigation:

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