

United States Patent and Trademark Office
Before the Patent Trial and Appeal Board

Western Digital Technologies, Inc. et al.

(Petitioner)

v.

Godo Kaisha IP Bridge 1

(Patent Owner)

IPR2024-01447 | **U.S. Patent No. 8,405,134 B2**

IPR2024-01493 | **U.S. Patent No. 10,680,167 B2**

Patent Owner's Demonstratives

January 23, 2026

IP Bridge Exhibit 2090
Western Digital v. IP Bridge
IPR2024-01447

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

Dr. Yuasa's Inventions (167 / 134 Patent claim 1)

Before Dr. Yuasa's Inventions, MgO(001)-based MTJs Relied On Templating to Achieve MgO(001)

-01493 POR

After depositing the bottom Fe electrode (at room temperature) **Bowen** anneals it at 400°C (a step that the Petition repeatedly cites in mapping the claim limitations), forming a high-quality crystalline Fe(001) layer that crucially provides a lattice match for Bowen to thereafter epitaxially grow its single-crystal MgO(001) barrier layer.

-01493 POR, 8

By replacing the crystalline lower electrode with amorphous CoFeB in Bowen and Nagahama, Petitioner's combinations would discard the very feature and process steps—forming a crystalline lower electrode to **template** the epitaxial growth of an MgO barrier layer—that **Bowen** and **Nagahama** went to heroic efforts to accomplish by inventing their entirely new processes of forming a MgO(001) buffer layer on GaAs(001) (in **Bowen**) and a MgO double underlayer (in **Nagahama**). Ross, ¶213.

-01493 POR, 40

IPB's Expert Dr. Ross

Bowen describes MgO(001) as being epitaxially grown as a single crystal from a compatibly-oriented single crystal electrode and a substrate underlying the tunnel barrier.

-01493 EX2053, ¶56, cited POR, 8

Petitioner's expert agrees that achieving **Bowen's** near-perfect single-crystal MgO(001) barrier required the lattice match provided by the high-quality crystalline Fe(001) bottom electrode. EX2018, 74:6-9, 74:19-24; EX1026, 1655-1656; EX1084, 228-229.

-01493 EX2053, ¶189, cited POR, 34

Nagahama's MgO double underlayer was thus similar to Bowen's MgO buffer layer and provided a template for forming (001) ferromagnetic lower electrodes for an MTJ.

-01493 EX2053, ¶210, cited POR, 39

Parkin's layer 115 thus provided a template for the MgO layer 120' to form its "highly (001)" texture.

-01493 EX2053, ¶128 & EX1062, Fig. 3A, cited POR, 14-15

Conventional MgO(001) MTJ Required Crystalline (001) Layers That Templated Successive Layers So As To Form MgO(001) Barrier

yellow highlight ⇔ crystalline (001) layer(s)

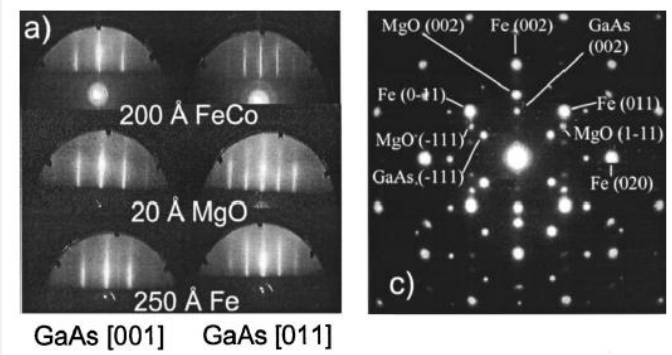
Bowen (EX1026)

We present tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) single-crystal epitaxial junctions of high quality[.]

FeCo/MgO/Fe epitaxial structures were grown on GaAs(001).... We use a MgO buffer layer as an interdiffusion barrier.... the MgO barrier is grown at 400 °C in order to obtain good crystallinity. This MgO buffer layer also offers an appropriate symmetry and lattice match for the epitaxy of Fe on top[.]

Figure 1(a) shows RHEED patterns for a typical Fe₅₀Co₅₀/MgO/Fe structure. Fe₅₀Co₅₀ and Fe layers are bcc structured with sharp diffraction lines for both azimuths. Similar information about epitaxial quality could be concluded from the MgO barrier pattern. Further x-ray diffraction symmetric and asymmetric scans confirm that the whole structure is epitaxial with lattice parameters close to bulk values.

EX1026, 1655-1656, Fig. 1(a), cited -01493: Pet., 21-23, 28-33; POR, 2-3, 33-35, 38-40, 52-54; Sur-reply, 1-3, 6-10
-01447: Pet., 29-33, 34-35, ; POR, 29-31, 44-46; Sur-reply, 1, 4-5, 20



Conventional MgO(001) MTJ Required Crystalline (001) Layers That Templated Successive Layers So As To Form MgO(001) Barrier

Nagahama (EX1027)

[0055] Fig. 12 is a schematic illustration of a flat tunnel magnetoresistive element according to the third group of the present invention.

[0056] In this figure, reference numeral 201 designates a substrate (Si LSI, SiO₂, or the like); 204 designates a double underlayer composed of an amorphous MgO layer 202 and MgO(001) crystal layer 203; and 205 designates a magnetoresistive element having a highly oriented, even interface.

[0065] Fig. 14 shows that the MgO diffraction line forms only a (002) peak, hence exhibiting excellent (001) orientation. The Fe diffraction also exhibits only a (002) peak with a high intensity. This shows that high quality crystals have grown in the (001) direction.

[0073] Still another magnetoresistive element was prepared which includes 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.

[0074] As a result, a larger tunnel magnetoresistive effect of more than 90% was produced by combining heat treatment. Thus, by preparing a tunnel magnetoresistive element including the (001)-highly-oriented MgO barrier layer overlying the MgO double underlayer, a still larger magnetoresistive effect was produced.

EX1027, [0055]-[0056], [0065], [0073]-[0074], cited -01493: Pet., 49-51, 54-55, 57-58; POR, 8-10, 12, 18-20, 38-40; Sur-reply, 1-3, 6-10; -01447: Pet., 46, 50-54, 56-57; POR, 29-31, 45-46; Sur-reply, 1, 4-5, 20

yellow highlight ⇔ crystalline (001) layer(s)

-01447 IPB POR

Nagahama's MgO underlayer provided a template for forming **crystalline (001) ferromagnetic lower electrodes**. EX1027, ¶¶62-65; Ross, ¶¶188-89.

-01447 POR, 46

-01493 IPB POR

Nagahama also specifies depositing an Fe bottom layer 213 by sputtering (EX1027, [0062], step 6), then annealing it (EX1027, [0062], step 7), **resulting in "high quality crystals... grown in the (001) direction," e.g., Fe(001)**. Ross, ¶¶72-73, 99-100, 110-111; EX1027, [0065].

-01493 POR, 9

Parkin Teaches Templating to Form MgO(001) Barrier —in Fig. 3A

Parkin (EX1062)

However, the high tunneling magnetoresistance is derived, not only from using a method of forming the MgO tunnel barrier which does not oxidize the lower ferromagnetic electrode, but also from forming a crystalline structure in which the ferromagnetic electrodes directly above and below the (100) textured MgO tunnel barrier have a bcc crystalline structure and are also textured in the (100) orientation. The layer 115 is preferably formed from a bcc alloy formed from one or more of Co and Fe. For example, layer 118 may be formed from Fe or $\text{Co}_{84}\text{Fe}_{16}$ and layer 119 may be formed from $\text{Co}_{70}\text{Fe}_{30}$. The crystallographic texture of these layers can be controlled by suitable choice of the underlayers. For example layer 112 may be formed from a bi-layer of TaN and Ta or from a layer of Ta alone. Layer 116 may be formed from an fcc antiferromagnetic alloy of Ir and Mn where the composition of Ir is less than ~30 atomic percent. The IrMn layer grows highly oriented in the (100) orientation when deposited on the layer 112 formed from Ta or TaN/Ta. The substrate 111 may be comprised of an amorphous material such as SiO_2 . Using this combination of underlayers, the layer 115, comprised of one or more bcc Co—Fe alloys, is textured in the (100) orientation and the MTJ 200 displays high TMR.

EX1062, 13:2-25, cited -01493: POR, 14-15, 54; Sur-reply, 13-14, 16-17
-01447: POR, 9-10, 24, 30; Sur-reply, 10-13

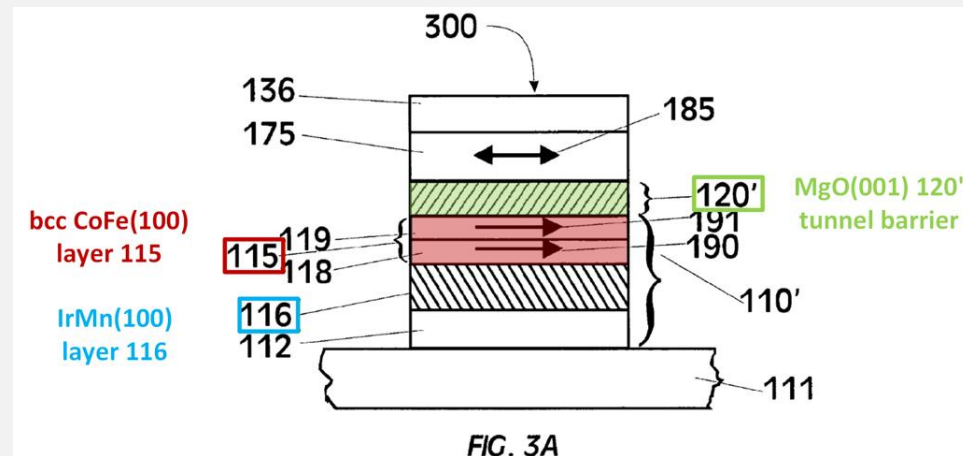
-01493 Sur-reply

1. Fig. 3A Device

Petitioner never disputes Parkin achieved **MgO(001) barrier 120'** in Fig. 3A (annotated below) by forming it on crystalline CoFe(001) layer 119. EX1062, 9:58-10:2, 13:10-25, 17:11-39; POR, 14-16; EX2053 ¶¶84-94 (forming MgO on a crystalline(001) layer promotes MgO(001)).

-01493: Sur-reply, 13; -01447: Sur-reply, 11 (similar)

Parkin (EX1062)



EX1062, 13:2-25, Fig. 3A (annotated), cited -01493: POR, 14-15, 54; Sur-reply, 13-14, 16-17
-01447: POR, 9-10, 24, 30; Sur-reply, 10-13

Parkin Teaches Templating to Form MgO(001) Barrier —in Fig. 3A

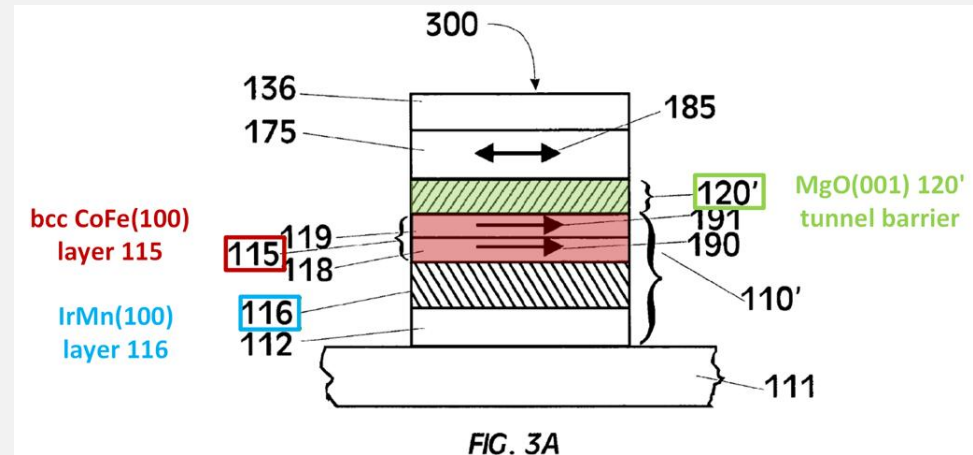
Parkin (EX1062)

U.S. patent application Ser. No. 10/824,835 to Parkin 25
titled “MgO tunnel barriers and method of formation” (filed
Apr. 14, 2004), which is hereby incorporated by reference,
discloses a method of forming a tunnel barrier comprised of
magnesium oxide (MgO) with which magnetic tunnel junc-
tions can be deposited which exhibit tunneling magnetore-
sistance values of more than 100% at low bias. The tunnel 30
barrier is formed by first depositing a thin layer of Mg using,
for example, magnetron or ion beam sputter deposition
followed by a layer of Mg deposited in the presence of
oxygen. In addition, Parkin discloses methods of forming
highly oriented crystalline MgO tunnel barriers by forming 35
the MgO barrier on a ferromagnetic electrode comprised of
a Co—Fe alloy, which is bcc and (100) textured. The CoFe
electrode is formed on a (100) oriented antiferromagnetic
layer of fcc IrMn which itself is grown highly oriented by
forming this layer on suitable underlayers, for example, a 40
combination of a TaN layer followed by a Ta layer.

EX1062, 3:24-41, cited -01493: Sur-reply, 3, 8, 13-14, 16, 18
-01447: Sur-reply, 2, 11, 16-17

An MgO tunnel barrier 120' is then formed on top of the
lower ferromagnetic electrode 110' using the method
described in U.S. patent application Ser. No. 10/824,835 to
Parkin titled “MgO tunnel barriers and method of forma- 25
tion” (filed Apr. 14, 2004), supra, by first depositing a thin

EX1062, 17:21-25, cited -01493 Sur-reply, 13-14;
-01447: POR, 9-10, 19, 24, 29



EX1062, 13:2-25, Fig. 3A (annotated), cited -01493: POR, 14-15, 54; Sur-reply, 13-14, 16-17
-01447: POR, 9-10, 24, 30; Sur-reply, 10-13

Parkin Teaches Templating to Form MgO(001) Barrier —in Fig. 11

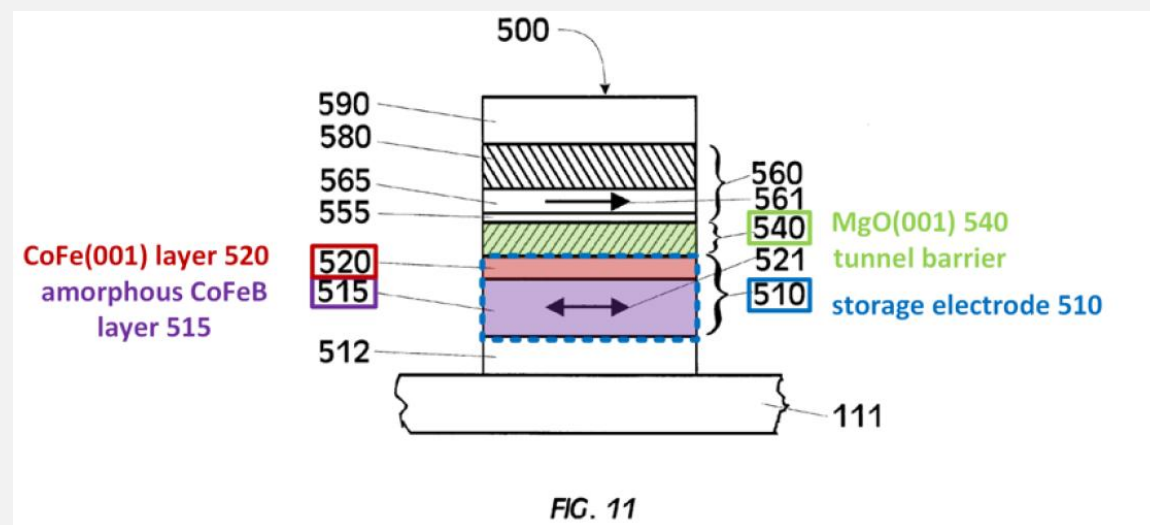
Parkin (EX1062)

U.S. patent application Ser. No. 10/824,835 to Parkin 25
titled “MgO tunnel barriers and method of formation” (filed
Apr. 14, 2004), which is hereby incorporated by reference,
discloses a method of forming a tunnel barrier comprised of
magnesium oxide (MgO) with which magnetic tunnel junc-
tions can be deposited which exhibit tunneling magnetore-
sistance values of more than 100% at low bias. The tunnel 30
barrier is formed by first depositing a thin layer of Mg using,
for example, magnetron or ion beam sputter deposition
followed by a layer of Mg deposited in the presence of
oxygen. In addition, Parkin discloses methods of forming
highly oriented crystalline MgO tunnel barriers by forming 35
the MgO barrier on a ferromagnetic electrode comprised of
a Co—Fe alloy, which is bcc and (100) textured. The CoFe
electrode is formed on a (100) oriented antiferromagnetic
layer of fcc IrMn which itself is grown highly oriented by
forming this layer on suitable underlayers, for example, a 40
combination of a TaN layer followed by a Ta layer.

EX1062, 3:24-41, cited -01493: Sur-reply, 3, 8, 14, 16, 18
-01447: Sur-reply, 2, 11, 16-17

A MgO tunnel barrier **540** is then formed according to the
methods described in U.S. patent applications Ser. No.
10/824,835 to Parkin titled “MgO tunnel barriers and 10
method of formation” (filed Apr. 14, 2004) and Ser. No.
10/646,246 to Parkin titled “MgO tunnel barriers and
method of formation” (filed Aug. 22, 2003). First a layer of

EX1062, 23:6-11, cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13



EX1062, Fig. 11 (annotated), cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13

Dr. Yuasa's Inventions Achieved MgO(001) Barrier / Crystalline (001) Ferromagnetic Electrodes Without Templating Successive Layers

167 Patent claim 1

1[pre] A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:

- 1[a] forming a first CoFeB layer that is amorphous;
- 1[b] forming a magnesium oxide (MgO) layer over the first CoFeB layer;
- 1[c] forming a second CoFeB layer that is amorphous over the MgO layer; and
- 1[d] annealing the first and second CoFeB layers and the MgO layer, wherein the first and second CoFeB layers are crystallized by the annealing, and
- 1[e] wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.

EX1013 claim 1 (-01493-Pet., xvii)

134 Patent claim 1

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

- 1[a] a first ferromagnetic material layer deposited on a substrate;
- 1[b] a second ferromagnetic material layer; and
- 1[c] a tunnel barrier layer located between the first and second ferromagnetic material layers, and
- 1[d] wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and
- 1[e] at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.

EX1005 claim 1 (-01447-Pet., xiv)

EX2006 (APL2005)

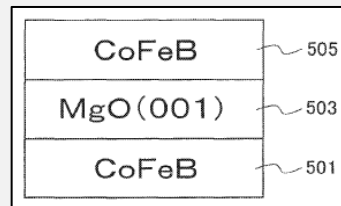
APPLIED PHYSICS LETTERS 86, 092502 (2005)

230% room-temperature magnetoresistance in CoFeB/MgO/CoFeB magnetic tunnel junctions

Undisputed that post-dated EX2006 describes method (MTJ) meeting 167 (134) Patent claim 1

-01493: POR, 59-60; Sur-reply, 27
-01447: POR, 61-62; Sur-reply, 28

167 / 134 Patent



EX1013 / EX1005 Fig. 11

We found that the CoFeB layers were essentially amorphous, although some parts of the CoFeB layers were crystallized. The partial crystallization may have been caused by the high annealing temperature. Surprisingly, the MgO layer, grown on the amorphous CoFeB layer, showed a good crystalline structure with a (001) fiber texture.

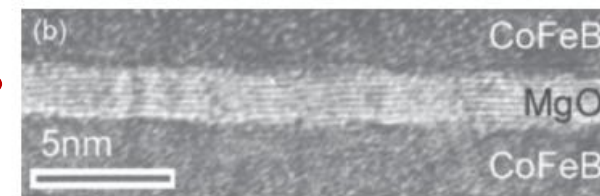
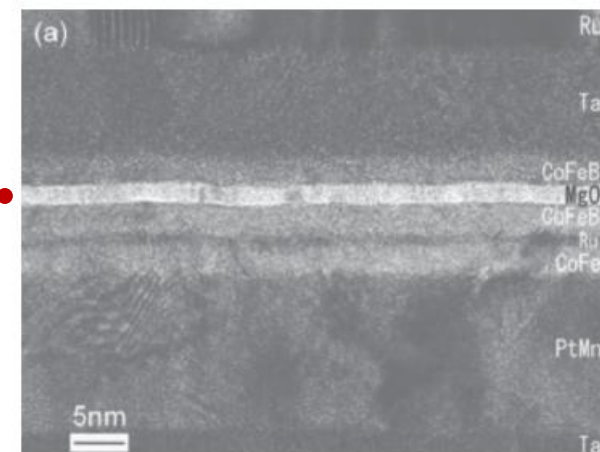


FIG. 2. (a) Cross-section HRTEM image of CoFeB/MgO/CoFeB MTJs. (b) Enlarged cross-section HRTEM image of the MTJs shown in (a). Only the CoFeB/MgO/CoFeB layers are shown.

EX2006 (APL2005) at 1-2, cited -01493: POR, 26-27, 59-60, 67; Sur-reply, 1, 25, 27, 30
-01447: POR, 26, 61-63, 69; Sur-reply, 24, 31

Petitioner's Expert Admits Achieving Crystalline MgO(001) on Amorphous CoFeB Is Surprising Because There Is No Templating

Petitioner's Expert Dr. Bokor

A. Epitaxy is a process where highly oriented crystalline layer is grown on an -- another highly oriented crystalline layer where the lattices of the two layers match and align to each other due to favorable chemical bonding between the atoms of the upper layer and the atoms of the lower layer. So the chemical bonds can continue to form a periodic crystalline structure because the periods of the two layers are comparable.

Q. And in that scenario, what happens if the lattices do not match?

A. If the lattices do not match, then you don't get epitaxy.

Q. Well, what happens?

A. It depends. That can vary. It depends on the details. So, for instance, if you have an amorphous layer and you try to grow a crystalline on it, there is no epitaxy, there is no templating, and so it is surprising that you get MgO to grow on an amorphous layer.

EX2018, 76:12-77:8, cited - 01493: POR, 14
- 01447: POR, 45, 58

Petitioner's Expert Admits Dr. Yuasa's Invention Enabled Mass Production of MTJs

Petitioner's Expert Dr. Bokor

Q. Do you agree that the process of forming CoFeB/magnesium oxide/CoFeB MTJs described in Yuasa's 2005 APL paper enabled mass production on large diameter wafers by room temperature sputter deposition?

A. I'll agree that the paper contributed to that.

Q. Do you agree that that consequence opened the door to industrial applications of MgO MTJ devices?

A. It contributed toward opening the door to industrial applications, yes. I agree with that.

Q. Do you agree that the CoFeB -- the process of making CoFeB/magnesium oxide/CoFeB MTJs described in Yuasa's 2005 Applied Physics Letter paper enabled device fabrication on arbitrary underlying layers?

A. I will agree with that.

-01493 POR

structure)."). Dr. Yuasa's EX2006 paper has been cited at least 1268 times since its publication in 2005. EX2052. *See also* EX1057, 46-48 (citing EX2006 and

- 01493: POR, 26; - 01447 POR, 26 (similar)

EX2085, 140:22-141:14, cited - 01493: Sur-reply, 29-30
- 01447: Sur-reply, 30

Lattice Mismatch Between Crystalline (111) Underlayer and MgO(001) Barrier Was a Fundamental Problem

-01493 POR

peak); EX1061, 2273 (describing “some (111) texturing”). Petitioner’s own evidence makes clear that MgO(001) cannot be grown on a (111)-oriented surface. EX1057, 47 (“A fundamental problem with this structure is that an NaCl-type MgO(001) tunnel barrier... which [has] fourfold in-plane crystallographic symmetry, *cannot be grown on [a] fcc(111)-oriented... structure*, which has threefold in-plane crystallographic symmetry, *because of the lattice mismatch.*”), 127 (similar); EX2018, 76:12-78:3 (no epitaxy without lattice match). Thus, even

-01493 POR, 14
-01447 POR, 35 (similar)

Petitioner’s Expert Dr. Bokor

A. Epitaxy is a process where highly oriented crystalline layer is grown on an -- another highly oriented crystalline layer where the lattices of the two layers match and align to each other due to favorable chemical bonding between the atoms of the upper layer and the atoms of the lower layer. So the chemical bonds can continue to form a periodic crystalline structure because the periods of the two layers are comparable.

Q. And in that scenario, what happens if the lattices do not match?

A. If the lattices do not match, then you don't get epitaxy.

Q. Well, what happens?

A. It depends. That can vary. It depends on the details. So, for instance, if you have an amorphous layer and you try to grow a crystalline on it, there is no epitaxy, there is no templating, and so it is surprising that you get MgO to grow on an amorphous layer.

EX2018, 76:12-77:8, cited - 01493: POR, 14
- 01447: POR, 45, 58

Dr. Yuasa's Inventions Solve a Fundamental Manufacturing Problem by Discarding the Prior Art Templating Approach

EX1057 (Dieny), Ch. 2

MTJs for practical applications need to have the stacking structure shown in Fig. 2.2. Ir–Mn or Pt–Mn is used as the antiferromagnetic layer, and Co–Fe/Ru/Co–Fe trilayer is used as the SAF structure to attain an exchange bias that is strong enough for commercial devices. This type of reliable AF/SAF structure is based on an fcc structure with (1 1 1)-orientation.

A fundamental problem with this structure is that an NaCl-type MgO(0 0 1) tunnel barrier and a bcc(0 0 1) ferromagnetic electrode, both of which have fourfold in-plane crystallographic symmetry, cannot be grown on the fcc(1 1 1)-oriented AF/SAF structure, which has threefold in-plane crystallographic symmetry, because of the lattice mismatch. We could theoretically solve this problem by developing a new pinned layer structure with fourfold in-plane symmetry. This solution, however, is not generally acceptable to the electronics industry because it has spent more than a decade in developing the reliable pinned layer structure. The reliability of practical devices is determined by the reliability of the pinned layer.

To solve this problem concerning crystal growth, Djayaprawira et al. developed a new MTJ structure, CoFeB/MgO/CoFeB, by using a sputtering deposition technique [33]. Figure 2.22a shows a cross-sectional TEM image of such a MTJ in an as grown state. As can be seen in the figure, the bottom and top CoFeB electrode layers have an amorphous structure in the as-grown state. Surprisingly, the MgO barrier layer grown on the amorphous CoFeB is a (0 0 1)-oriented polycrystal (textured structure). Because the bottom CoFeB electrode is amorphous, this CoFeB/MgO/CoFeB MTJ can theoretically be grown on all kinds of underlayers.

lattice mismatch

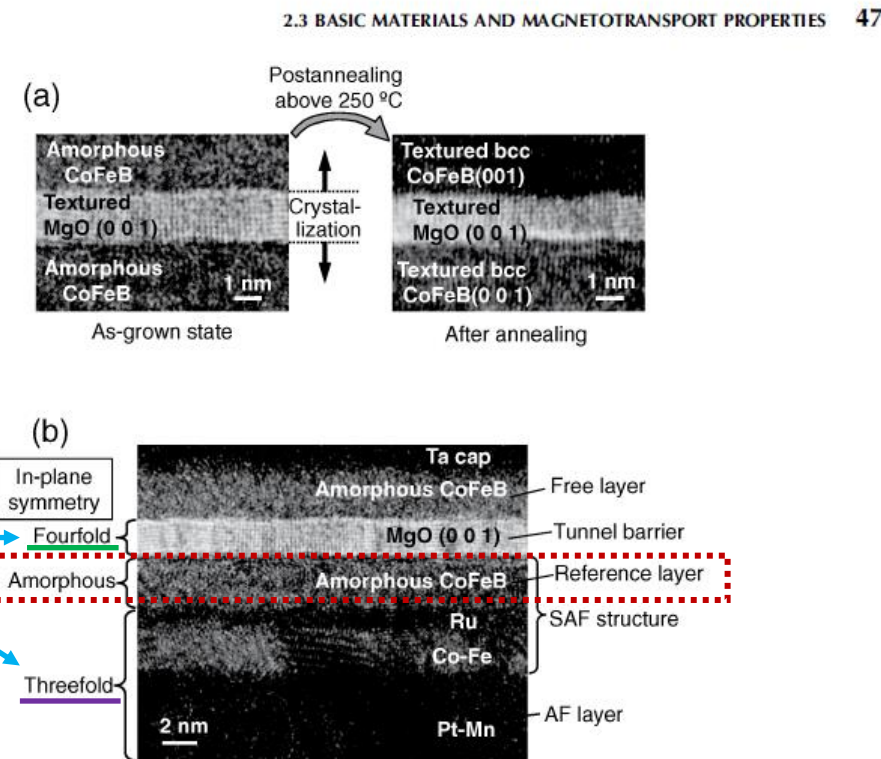


Figure 2.22 Cross-sectional TEM image of CoFeB/MgO/CoFeB MTJ (a) in as-grown state and (b) after postannealing. Cross-sectional TEM image of CoFeB/MgO/CoFeB MTJ with practical AF/SAF structure underneath MTJ part. (Courtesy of Canon-Anelva Corporation.)

EX1057 at 46-47 & Fig. 2.22, cited -01493: POR, 1-2, 5, 14, 18, 26-27, 52, 60-62
-01447: POR, 8, 12, 26, 35-36, 38, 43, 47-48, 55, 63, 70

EX1057 reference [33] is EX2006 (APL2005)

-01493 POR, 60, citing EX1057 at 52;
-01447 POR, 12 (same)

In -01493 Institution Decision, the Board Mistakenly Treated Dieny's Discussion of Dr. Yuasa's Inventions as Describing Prior Art

-01493 Petition

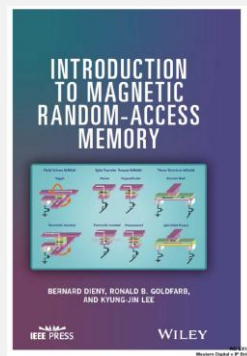
As a result, a “CoFeB/MgO/CoFeB MTJ can theoretically be grown on all kinds of underlayers.” EX1057 at 47.

-01493 Petition at 11, cited D.I. at 14; POR, 26

-01493 Institution Decision

Thus, the evidence supports Petitioner's contention that a MgO layer could be grown on a CoFeB layer. *E.g.*, Ex. 1057, 47.

-01493 DI (Paper 9), 14, cited POR, 26 & n.3



EX1057 cover

-01493 POR

Remarkably, Petitioner's *only cited evidence* that annealing a CoFeB/MgO/CoFeB trilayer (with amorphous CoFeB) would *actually achieve* the claimed MgO microstructure is a 2017 “textbook”—*citing Dr. Yuasa's famous post-filing publication from 2005*—that describes Dr. Yuasa's result as surprising. EX1057, 47 (“[Yuasa] developed a new MTJ structure, CoFeB/MgO/CoFeB, by using a sputtering deposition technique [citing EX2006][...] *Surprisingly*, the MgO layer grown on the amorphous CoFeB is (001)-oriented polycrystal (textured structure).”). Dr. Yuasa's EX2006 paper has been cited at least 1268 times since its publication in 2005. EX2052. *See also* EX1057, 46-48 (citing EX2006 and EX2013); Pet., 10 (citing EX1024, ¶¶60-61), 11 (citing EX1024, ¶¶60-61 and EX1057, 47), 31 (citing EX1024, ¶60); EX1024, ¶¶60 (citing EX1057, 47), 61 (citing EX1057, 48), 283 (citing EX1057, 46).³ Petitioner's expert described

³ At Institution the Board also relied on EX1057, 47—describing the *inventor's post-dated publications*, describing the claimed invention—as evidence “that a MgO layer could be grown on a CoFeB layer.” Paper 9, 14.

-01493 POR, 26 & n.3

Petitioner's Own Employees Immediately Recognized That Dr. Yuasa's Inventions Solved a Fundamental Manufacturing Problem

EX1044 (Butler), EX1046 (Mathon),
EX1026 (Bowen)

167 (EX1013) /
134 (EX1005)

EX2006
(APL2005)

EX2005 (Park)

2001

2004

2005

2006

year

Chando Park²

²Western Digital

Magnetic tunnel junctions **REVIEW FEATURE**

MTJs with crystalline MgO barrier layers

As discussed previously, achieving a high TMR ratio in MgO-based MTJs requires correct crystalline orientation of the ferromagnetic electrodes, which are either bcc Co, bcc Fe, or an alloy of the two, and lattice matching at the interfaces between the electrodes and the tunnel barrier. However, it has proven difficult to grow bcc Co or bcc Fe with (001) texture directly by any practical physical vapor deposition technique without a single crystal substrate (the use of which would vastly limit commercial applications).

The development of CoFeB/MgO/CoFeB tunnel junctions by Anelva^[21] provides a practical solution to overcome this difficulty. In this technique, a (CoFe)₈₀B₂₀/MgO/(CoFe)₈₀B₂₀ multilayer is deposited using conventional sputtering. At 20% B content, the as-deposited (CoFe)₈₀B₂₀ film layer is amorphous in nature. A thin MgO layer grown on top of an amorphous (CoFe)₈₀B₂₀ layer can readily achieve a well-oriented (001) texture. Postannealing of the film stack at temperatures around 360°C induces crystallization of the two (CoFe)₈₀B₂₀ layers, which occurs epitaxially from the two MgO interfaces. In this way, the

Dr. Bokor Agrees:

Q. And you agree that in 2004, a POSA would have understood that using a single crystal substrate would vastly limit commercial allocations of MTGs -- MTJs grown in this fashion; right?

A. I agree with that.

EX2085, 32:19-25, cited -01493 Sur-reply, 28; -01447 Sur-reply, 28

-01447 Sur-reply

Park (EX2005) - Petitioner *never disputes* its employee praised Yuasa's

invention as a "practical solution to overcome" the difficulty in forming crystalline underlayers for MgO by showing MgO(001) could form on amorphous CoFeB.

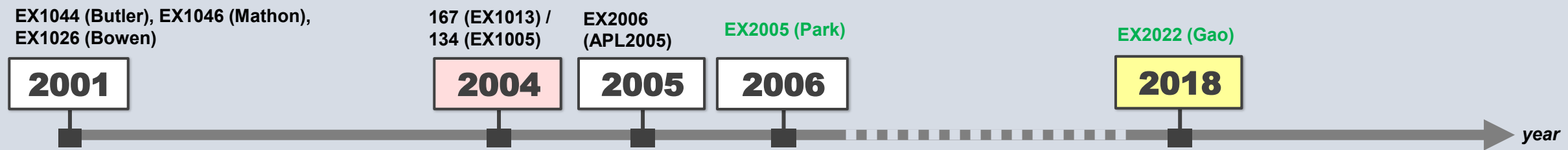
-01447 Sur-reply, 28; -01493 Sur-reply, 27-28 (same)

EX2005 reference [21] is EX2006 (APL2005)

-01493 POR, 62, citing EX2005, 45;
-01447 POR, 64

EX2005, 39, cited: -01493, POR, 37-38 ; Sur-reply 27-30
-01447 POR, 64; Sur-reply, 28

Dr. Yuasa's Inventions Received Sustained Praise from **Petitioner's Own Employees**



Zheng Gao

Western Digital

Djayaprawira et al^[10] reported, in 2005, an even higher TMR ratio of 230% with a CoFeB/MgO/CoFeB MTJ. The significance of this work was not only the high MR ratio, but also that it was a fully integrated film directly produced from sensor deposition sputtering tool. Instead of a single crystalline or polycrystalline ferromagnetic layer, amorphous (*a*)-CoFeB was used to promote strong (001)

MgO texture in the as-deposited state; post annealing transforms *a*-CoFeB layer from amorphous to a (001)-textured polycrystalline CoFe layer, templated from the (001)MgO layer, giving rise to the orientation relationship (001)[100]_{CoFe}//(001)[110]_{MgO} in each grain as shown in **Figure 2**.¹² In 2006, the same group reported that the MgO layer can be thinned down to the 0.4 Ω μm² range while maintaining an MR of around 50%.¹³ This *RA* range was desired for read head application.

Dr. Bokor Agrees:

Q. And a POSA would have understood that the technique described in Yuasa's APL 2005 performing a CoFeB/MgO/CoFeb MTJ was consistent with providing a fully integrated film directly produced from sensor deposition sputtering tools; right?

A. I think that is probably correct.

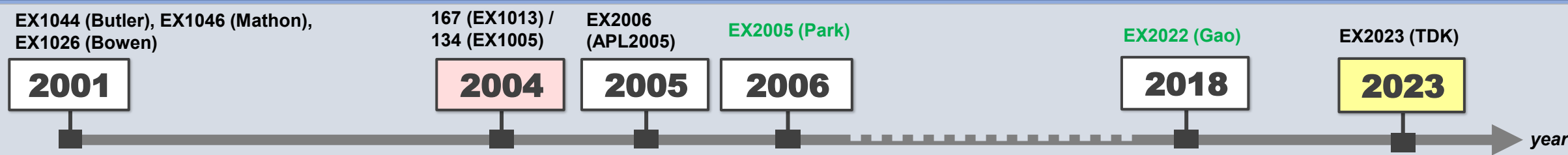
EX2085, 127:18-128:1, cited :-01493 Sur-reply, 28; -01447 Sur-reply, 28-29

EX2022 reference [10] is EX2006 (APL2005)

-01493 POR, 62, citing EX2022, 110;
-01447 POR, 64 (same)

EX2022, 106-107, cited : -01493 POR, 62; Sur-reply, 28
-01447 POR, 64-65; Sur-reply, 28-29

Dr. Yuasa's Inventions Received Praise from **Petitioner's** Competitors



Dr. Bokor Agrees:

Q. Okay. And so this -- this whole sentence here, "Their work made the technology transition from aluminum oxide to magnesium oxide barrier much easier thanks to the use of simple CoFeb magnetic electrodes to preserve magnesium oxide structure from being impacted by fcc underlayers and free layer structures." Do you agree with that statement?

A. Okay. Yeah. I'll agree with that.

EX2085, 137:4-15, cited -01493 Sur-reply, 28; -01447 Sur-reply, 29

EX2023 reference [20] is EX2006 (APL2005)

-01447 POR, 65, citing EX2023, 7;
-01493 POR, 63 (same)

experimental works. In 2004, Yuasa et al. demonstrated giant TMR ratios of up to 180 % in single-crystal Fe/MgO/Fe MTJs deposited by MBE [18,9]. Parkin et al. showed 220 % in highly oriented (001) CoFe/MgO/CoFe MTJs within the same year, and demonstrated that high TSP can be preserved with crystalline MgO barriers. [19]. In particular, Djavaprawira *et al.* obtained 230 % TMR with sputtered CoFeB/MgO/CoFeB MTJs. Their results are of significant technology importance for the magnetic recording head industry because they deposited MTJs with standard spin-valve structure technology performed at room temperature. They used a conventional sputtering method instead of an MBE system; and they achieved a giant TMR ratio with simple amorphous CoFeB ferromagnetic electrodes, instead of strenuously high temperature deposition with single crystal structures. [20] Their work made the technology transition from Al2O3 to MgO barrier much easier thanks to the use of simple CoFeB amorphous magnetic electrodes to preserve MgO structure from being impacted by FCC underlayers and free layer structures. Upon annealing CoFeB and MgO can be crystallized to BCC structures. After demonstrating superior performance compared to Al2O3 TMR as shown in Fig. 2, MgO TMR became the state-of-art technology for all future spintronic devices including HDD recording read heads.

EX2023, 2, cited -01493 POR 38, 62-63, 67;
-01447 POR, 70

Petitioner's Employees and Others Acknowledge Parkin but Credit Dr. Yuasa for Inventing CoFeB/MgO/CoFeB MTJs

EX1044 (Butler), EX1046 (Mathon),
EX1026 (Bowen)

2001

167 (EX1013) /
134 (EX1005)

2004

EX2006
(APL2005)

2005

EX2005 (Park)

2006

EX2022 (Gao)

2018

EX2023 (TDK)

2023

year

Park

In 2001, a series of theoretical calculations predicted extremely high TMR ratios for Fe/MgO/Fe MTJs, where the tunnel barrier is a crystalline MgO layer with (001) texture^{13,14}. The study argued that a
* * *
could become highly spin-dependent. In 2004, two independent experimental investigations, one using a molecular beam epitaxy (MBE) thin-film growth technique and the other using a conventional sputtering technique with specialized underlayer texturing, showed greater than 180% and 220% TMR ratios at room temperature, respectively^{18,19}. Encouraged by these two studies, a surge in research

The development of CoFeB/MgO/CoFeB tunnel junctions by Anelva²¹ provides a practical solution to overcome this difficulty. In this technique, a (CoFe)₈₀B₂₀/MgO/(CoFe)₈₀B₂₀ multilayer is deposited using conventional sputtering. At 20% B content, the as-deposited

19. Parkin, S. S. P., et al, Nat. Mater. (2004) 3, 862

EX2005 reference [21] is EX2006 (APL2005)

-01493 POR, 62;
-01447 POR, 64
EX2005, 38-39, 45, cited: -01493 POR, 37, 62 ; Sur-reply 27-29
-01447 POR, 64; Sur-reply, 29

Gao

based on this theoretical prediction.⁸ Parkin et al.⁹ demonstrated an MR ratio of 220% with fully integrated polycrystalline TMR stack of CoFe/MgO/CoFe. This result motivated many
* * *
Djayaprawira et al^{10,11} reported, in 2005, an even higher TMR ratio of 230% with a CoFeB/MgO/CoFeB MTJ. The significance of

EX2022, 107, 110, cited -01493 Sur-reply, 28-29;
-01447 Sur-reply, 29

EX2022 reference [10] is EX2006 (APL2005)

-01493 POR, 62, citing EX2022, 110;
-01447 POR, 64 (same)

TDK

[18,9]. Parkin et al. showed 220 % in highly oriented (001) CoFe/MgO/CoFe MTJs within the same year, and demonstrated that high TSP can be preserved with crystalline MgO barriers. [19]. In particular, Djavaprawira et al. obtained 230 % TMR with sputtered CoFeB/MgO/CoFeB MTJs. Their results are of significant technology importance for the magnetic recording head industry because they deposited MTJs with standard spin-valve structure technology performed at room temperature. They used a conventional sputtering method instead of an MBE system; and they achieved a giant TMR ratio with simple amorphous CoFeB ferromagnetic electrodes, instead of strenuously high temperature deposition with single crystal structures. [20] Their work made the

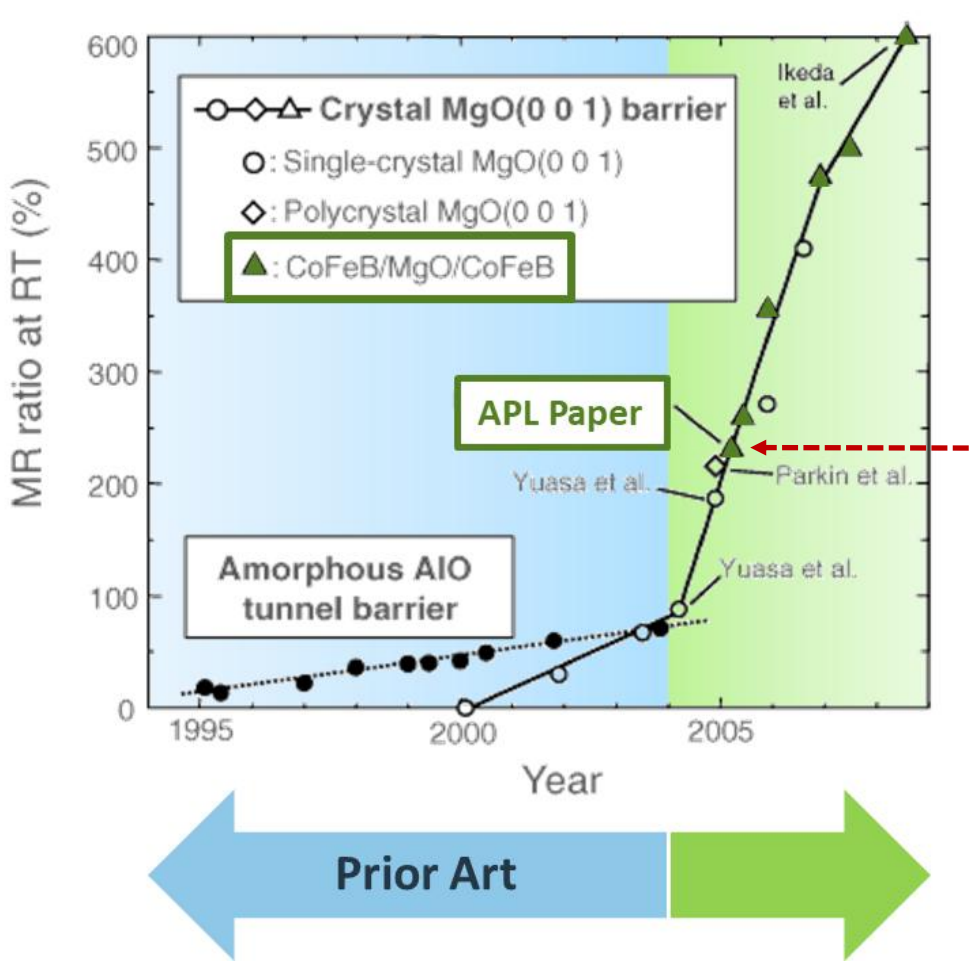
EX2023, 2, 7, cited -01493 Sur-reply, 28-29;
-01447 Sur-reply, 29

EX2023 reference [20] is EX2006 (APL2005)

-01447 POR, 65, citing EX2023, 7;
-01493 POR, 63 (same)

Later Improvements in MTJ Performance Followed Dr. Yuasa's Approach

EX1057 (Dieny)



-01493 POR

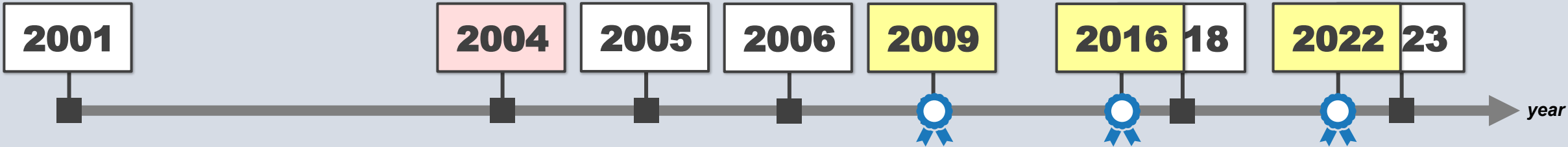
structure).”). Dr. Yuasa’s EX2006 paper has been cited at least 1268 times since its publication in 2005. EX2052. See also EX1057, 46-48 (citing EX2006 and

- 01493: POR, 26; - 01447 POR, 26 (similar)

EX2006 (APL2005)

EX1057 at 46, Fig. 2.21 (annotated), cited -01493: POR, 60-62, 68;
-01447: POR, 12-13, 63, 69-70

Dr. Yuasa Won Several Awards for His Groundbreaking Inventions



2009

Inoue Harunai Award

Dr. Yuasa developed a [MTJ] using magnesium oxide (MgO) ... achieving revolutionary high performance.... Furthermore, he ... made industrial application of MgO-MTJ elements possible with an original method of growing a crystalline layer on an amorphous layer.

EX2034, 1, cited: -01493 POR, 64-65; Sur-reply, 29
-01447 POR, 67; Sur-reply, 30

2016

Science and Technology Award

[M]ass production technology was developed that combines MgO and the magnetic alloy CoFeB, making industrial applications of MgO tunnel magnetoresistance elements possible...., [which is] now used in all hard disk storage devices (HDDs) currently being manufactured.

EX2029, 2, cited: -01493 POR, 64; Sur-reply, 29-30
-01447 POR, 66; Sur-reply, 30

2022

Japan Society of Applied Physics Achievement Award

Dr. Shinji Yuasa’s pioneering work on magnetic tunnel junctions (MTJs) with magnesium oxide (MgO) tunnel barriers, which have a large room temperature magnetoresistance (MR) ratio, has contributed significantly to the practical application of MgO MTJ devices.

EX2024, 2, cited: -01493 POR, 67; Sur-reply, 29-30
-01447 POR, 66

Petitions Are Facially Defective—For Different Reasons

-01447 (134 Patent)

-01493 (167 Patent)

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

'134 Ground 2 Maps the MgO(001) Limitations 1[d] / 3[d] to Nagahama's Unmodified MgO(001)

134 Patent claim 1

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

1[a] a first ferromagnetic material layer deposited on a substrate;

1[b] a second ferromagnetic material layer; and

1[c] a tunnel barrier layer located between the first and second ferromagnetic material layers, and

1[d] wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and

1[e] at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.

134 Patent claim 3

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

3[a] a first ferromagnetic material layer deposited on a substrate;

3[b] a second ferromagnetic material layer; and

3[c] a tunnel barrier layer located between the first and second ferromagnetic material layers, and

3[d] wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and

3[e] wherein at least said first ferromagnetic material layer is entirely crystallized and comprises CoFeB alloy.

EX1005 claims 1, 3 (-01447-Pet., xiv)

'134 Ground 2 Maps the MgO(001) Limitations 1[d] / 3[d] to Nagahama's Unmodified MgO(001) Barrier

-01447 Petition

5. Claim 1[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

Nagahama taught or suggested this limitation. As explained for Claim 1[c] in this Ground, Nagahama disclosed the claimed tunnel barrier layer. *Supra* §VII.A.4; EX1024 ¶¶178, 181.

Nagahama taught a polycrystalline MgO(001) tunnel barrier layer in its magnetoresistive element: “a (001)-highly-oriented MgO barrier layer.” EX1027 ¶73; EX1024 ¶¶181-82. 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 ¶182; EX1040 at 2842 (MgO “polycrystalline structures” have “preferred orientation”). Nagahama describing its tunnel barrier layer as “a (001)-highly-oriented MgO barrier layer,” EX1027 ¶73, confirms its MgO barrier was polycrystalline and preferentially oriented in the (001) plane, EX1024 ¶¶181-82.

-01447 Petition, 56

5. Claim 3[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

Supra Claim 1[d], §VII.A.5.

-01447 Petition, 63

-01447 POR

A. Ground 2 Never Maps its Nagahama-Sunai/Parkin Combination to Limitation 1[d] or 3[d] that Require an MgO(001) Layer

Ground 2 alleges that Nagahama alone, *unmodified* by Sunai and/or Parkin, meets Limitations 1[d] and 3[d]. Petition, 56 and 63. Petitioner fails to even allege that Ground 2's combination—which modifies Nagahama based on Sunai and/or Parkin to replace Nagahama's (001)-highly-oriented lower ferromagnetic electrode with a CoFeB electrode (Petition, 56-61)—meets Limitation 1[d] or 3[d], let alone explain how or why that would have been so.

-01447 POR, 19

Nagahama – like every reference Petitioner cites with an MgO(001) layer – achieved its MgO(001) layer by depositing the MgO layer on a highly-oriented (001) ferromagnetic electrode. EX1027, ¶73 (“magnetoresistive element ...

-01447 POR, 20

But Nagahama's highly-oriented (001) electrode is *not* used in Ground 2's combination—it is “replace[d]” by an CoFeB electrode that Petitioner never even alleges is of (001) crystalline structure. Petition, 57 (Nagahama's (001) ferromagnetic layer is “replace[d] ... with CoFeB”). That Nagahama achieved an MgO(001) layer provides no evidence of what MgO structure would have formed on the CoFeB electrode – which Petitioner never alleges is crystalline with an (001) orientation—in Ground 2's *Nagahama-Sunai/Parkin combination*. Ross, ¶¶116-117.

-01447 POR, 20

Nagahama

[0073] Still another magnetoresistive element was prepared which includes 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, [0073], cited -01447 Pet., 56, 63

Petitioner's Expert Admits Achieving Crystalline MgO(001) on Amorphous CoFeB Is Surprising Because There Is No Templating

Petitioner's Expert Dr. Bokor

A. Epitaxy is a process where highly oriented crystalline layer is grown on an -- another highly oriented crystalline layer where the lattices of the two layers match and align to each other due to favorable chemical bonding between the atoms of the upper layer and the atoms of the lower layer. So the chemical bonds can continue to form a periodic crystalline structure because the periods of the two layers are comparable.

Q. And in that scenario, what happens if the lattices do not match?

A. If the lattices do not match, then you don't get epitaxy.

Q. Well, what happens?

A. It depends. That can vary. It depends on the details. So, for instance, if you have an amorphous layer and you try to grow a crystalline on it, there is no epitaxy, there is no templating, and so it is surprising that you get MgO to grow on an amorphous layer.

EX2018, 76:12-77:8, cited - 01493: POR, 14
- 01447: POR, 45, 58

'134 Ground 2 Asserts the MgO(001) Barrier In Unmodified Nagahama Meets 1[d] / 3[d] But Never Addresses the Consequence of Using Amorphous CoFeB for the Lower Electrode

Personal Web Techs. v. Apple



“[A] clear, evidence-supported account of the contemplated workings of the combination is a prerequisite to adequately explaining and supporting a conclusion that a [POSA] would have been motivated to make the combination and reasonably expect success in doing so.”

Personal Web Techs. v. Apple, 848 F.3d 987, 994 (Fed. Cir. 2017), cited -01447 POR, 21

-01447 POR

The Petition’s failure to explain how or why its Nagahama-Sunai/Parkin combination allegedly meets the claimed MgO(001) layer in Limitations 1[d] and 3[d] is far from a harmless oversight because a POSA would have expected the MgO layer in this combination to **not** have an (001) orientation for the reasons discussed *infra* §IV.B-C. Given the “complexity ... of the technology,” Petitioner needed to provide a detailed explanation of the “contemplated workings” of its Ground 2 combination as a prerequisite to showing obviousness of any Challenged Claim. *Personal Web*, 848 F.3d at 994. The Petition’s failure to do so is fatal to Ground 2.

-01447 POR, 21

-01447 Sur-reply

A. Ground 2

Petitioner never disputes that the Petition mapped the MgO(001) limitations to *Nagahama unmodified* by Sunai and/or Parkin, that Nagahama formed its MgO barrier on a crystalline(001) electrode, and that the Petition never alleged, let alone cited evidence establishing, that POSAs would have reasonably expected MgO(001) to form in Ground 2’s combination that replaces Nagahama’s crystalline(001) electrode with amorphous CoFeB. Petition, 56; POR, 19-21.

The Reply misapplies the law (*infra* § IV.C), seeks to burden shift, and advances improper new arguments. Reply, 12-13. IPB carries no burden to show that POSAs would have expected the combination’s MgO barrier “to **not** have an (001) orientation.” Reply, 12 (emphasis original).² To establish *prima facie* obviousness, the Petition needed to provide argument and *evidence* explaining how and why POSAs **would** have reasonably expected the *combination’s* MgO barrier to be (001). The Petition’s failure to do so is fatal to Ground 2.

-01447 Sur-reply, 5-6

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

'134 Ground 1 Fails for Similar Reasons That Ground 2 Fails

-01447 Petition

5. Claim 1[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

Bowen taught or suggested this limitation. EX1024 ¶¶123-29. As explained for Claim 1[c] in this Ground, Bowen disclosed an MgO tunnel barrier layer. *Supra* §VIA.4; EX1024 ¶124. Bowen described a “single-crystal” MgO(001) tunnel barrier layer:

A test of these models can be performed on *single-crystal* epitaxially grown structures... [and] we present experimental results showing large TMR values in Fe(001)/MgO(001)/FeCo(001) epitaxial tunnel junctions.

EX1026 at 1655; *id.* at Abstract (“We present tunneling experiments on Fe(001)/MgO(20 Å)/FeCo(001) *single-crystal* epitaxial junctions of high

-01447 Petition, 32

Further, if Sunai’s or Parkin’s CoFeB electrodes are used as described in Claims 1[e] and 2 in this Ground, one of skill would understand that the MgO could be polycrystalline or single-crystal but would still have the same (001) orientation.

EX1024 ¶129; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 (“highly textured (100) MgO tunnel barriers”); EX1005 at 4:30-32 (MgO (001), (100), (010) planes are the same).

-01447 Petition, 33-34

5. Claim 3[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

Supra Claim 1[d], §VIA.5.

-01447 Petition, 45

-01447 POR

In Ground 1’s Bowen-Sunai/Parkin Combination, the MgO layer is formed on a CoFeB layer rather than on Bowen’s crystalline Fe(001) layer. Petition, 34-41 (Bowen’s Fe layer is “replaced” with a CoFeB layer). Petitioner admits boron inhibits crystallization. *Id.*, 37. Petitioner fails to show that a POSA would have reasonably expected the MgO layer in its Bowen-Sunai/Parkin combination to meet the MgO(001) limitation despite being formed on a CoFeB layer. Ross, ¶101.

-01447 POR, 22

None of the cited evidence supports Petitioner’s conclusory assertion that a POSA “would understand that the MgO ... would still have the same (001) orientation” despite being formed on a CoFeB layer. *Id.*; Ross, ¶102.

-01447 POR, 22

Petition's References Cited at 33-34 Do Not Support Argument That POSA "would understand... MgO would still have... (001) orientation"

-01447 Petition

Further, if Sunai's or Parkin's CoFeB electrodes are used as described in Claims 1[e] and 2 in this Ground, one of skill would understand that the MgO could be polycrystalline or single-crystal but would still have the same (001) orientation. EX1024 ¶129; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 ("highly textured (100) MgO tunnel barriers"); EX1005 at 4:30-32 (MgO (001), (100), (010) planes are the same).

-01447 Petition, 33-34



-01447 Sur-reply

B. Ground 1

The Reply never disputed that:

- "[n]one of the cited evidence supports ... that a POSA 'would understand that the MgO ... would still have the same (001) orientation'" (POR, 22-27);
 - Petitioner cited the '134 Patent only to establish the undisputed fact that Parkin's (100)-orientation is the same as the claimed (001)-orientation (POR, 23);
 - Bokor's testimony (EX1024, ¶129) warrants no weight because it merely parrots the Petition's conclusory assertion (POR, 25);
 - Parkin, 18:49-51 describes MgO(001) but says nothing about how it is formed (POR, 23); and
 - Parkin, 9:58-10:2 explains that a crystalline(001) layer is used to promote MgO(001) formation which does *not* support the Petition's assertion that POSAs would have expected MgO to "still" be (001) in Ground 1's combination that *eliminates* Bowen's crystalline(001) layer (POR, 23-25).

-01447 Sur-reply, 6-7

Petition's References Cited at 33-34 Do Not Support Argument That POSA "would understand... MgO would still have... (001) orientation"

-01447 Petition

Further, if Sunai's or Parkin's CoFeB electrodes are used as described in Claims 1[e] and 2 in this Ground, one of skill would understand that the MgO could be polycrystalline or single-crystal but would still have the same (001) orientation. EX1024 ¶129; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 ("highly textured (100) MgO tunnel barriers"); EX1005 at 4:30-32 (MgO (001), (100), (010) planes are the same).

-01447 Petition, 33-34

134 Patent

³⁰ In the context of the present specification, because MgO has a cubic crystal structure (NaCl structure), the (001) plane, the (100) plane, and the (010) plane are all equivalent. The

EX1005, 4:30-32

Orexo v. Actavis



"It is inappropriate to use the template provided by the inventor, to render the inventor's contribution obvious."

Orexo v. Actavis, 903 F.3d 1265, 1271 (Fed. Cir. 2018), cited -01447 POR, 23

-01447 Sur-reply

B. Ground 1

The Reply never disputed that: * * *

- "[n]one of the cited evidence supports ... that a POSA 'would understand that the MgO ... would still have the same (001) orientation'" (POR, 22-27);
 - Petitioner cited the '134 Patent only to establish the undisputed fact that Parkin's (100)-orientation is the same as the claimed (001)-orientation (POR, 23);
 - Bokor's testimony (EX1024, ¶129) warrants no weight because it merely parrots the Petition's conclusory assertion (POR, 25);
 - Parkin, 18:49-51 describes MgO(001) but says nothing about how it is formed (POR, 23); and
 - Parkin, 9:58-10:2 explains that a crystalline(001) layer is used to promote MgO(001) formation which does *not* support the Petition's assertion that POSAs would have expected MgO to "still" be (001) in Ground 1's combination that *eliminates* Bowen's crystalline(001) layer (POR, 23-25).

-01447 Sur-reply, 6-7

Petition's References Cited at 33-34 Do Not Support Argument That POSA "would understand... MgO would still have... (001) orientation"



Xerox v. Bytemark

"[C]onclusory and unsupported" declaration testimony
"adds little to the conclusory assertion for which it is offered to support, and is entitled to little weight.")

Xerox v. Bytemark, IPR2022-00624, Paper 9, 15 (Aug. 24, 2022) (precedential), cited POR, 25

-01447 POR

Petition, 33-34 with EX1024, ¶129. Because Dr. Bokor's testimony parrots the Petition's conclusory assertion, does not explain the basis for the conclusion, and only cites prior art evidence that fails to support the conclusion, it warrants no weight. Bokor-Depo, 94:1-10, 96:22-97:4, 103:22-104:13, 109:2-6, 118:11-24; Xerox v. Bytemark, IPR2022-00624, Paper 9, 15 (Aug. 24, 2022) (precedential)
-01447 POR, 25

-01447 Sur-reply

- o Bokor's testimony (EX1024, ¶129) warrants no weight because it merely parrots the Petition's conclusory assertion (POR, 25);
-01447 Sur-reply, 7

-01447 Petition

Further, if Sunai's or Parkin's CoFeB electrodes are used as described in Claims 1[e] and 2 in this Ground, one of skill would understand that the MgO could be polycrystalline or single-crystal but would still have the same (001) orientation. EX1024 ¶129; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 ("highly textured (100) MgO tunnel barriers"); EX1005 at 4:30-32 (MgO (001), (100), (010) planes are the same).

-01447 Petition, 33-34

Petitioner's Expert Dr. Bokor Decl.

129. In addition, if Sunai's or Parkin's CoFeB ferromagnetic layers are used as I explain below for Claims 1[e] and 2 in Sections XII.A.6 and XII.B.1 of this Declaration, a skilled artisan would have understood that the MgO barrier could be either polycrystalline or single-crystal but would still have the same (001) orientation. EX1062 (Parkin) at cols. 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 ("highly textured (100) MgO tunnel barriers").

-01447 EX1024 ¶129, cited Pet. 33

Petition's References Cited at 33-34 Do Not Support Argument That POSA “would understand... MgO would still have... (001) orientation”

-01447 Petition

Further, if Sunai's or Parkin's CoFeB electrodes are used as described in Claims 1[e] and 2 in this Ground, one of skill would understand that the MgO could be polycrystalline or single-crystal but would still have the same (001) orientation. EX1024 ¶129; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 (“highly textured (100) MgO tunnel barriers”); EX1005 at 4:30-32 (MgO (001), (100), (010) planes are the same).

-01447 Petition, 33-34

-01447 Sur-reply

- Parkin, 18:49-51 describes MgO(001) but says nothing about how it is formed (POR, 23); and

-01447 Sur-reply, 7

Parkin (EX1062)

Thus, very high TMR values are unexpectedly found for MTJs with highly textured (100) MgO tunnel barriers but with nominally amorphous storage layers. Cross-section

EX1062, 18:49-51

IPB's Expert Ross

104. Parkin (EX1062), 18:49-51 says the MgO layer is (100) but says nothing about why that is so. The other cited section of Parkin explains that “the

-01447 EX2053, ¶104, cited -01447 POR, 23

Parkin Teaches Templating to Form MgO(001) Barrier —in Fig. 3A

Parkin (EX1062)

However, the high tunneling magnetoresistance is derived, not only from using a method of forming the MgO tunnel barrier which does not oxidize the lower ferromagnetic electrode, but also from forming a crystalline structure in which the ferromagnetic electrodes directly above and below the (100) textured MgO tunnel barrier have a bcc crystalline structure and are also textured in the (100) orientation. The layer 115 is preferably formed from a bcc alloy formed from one or more of Co and Fe. For example, layer 118 may be formed from Fe or $\text{Co}_{84}\text{Fe}_{16}$ and layer 119 may be formed from $\text{Co}_{70}\text{Fe}_{30}$. The crystallographic texture of these layers can be controlled by suitable choice of the underlayers. For example layer 112 may be formed from a bi-layer of TaN and Ta or from a layer of Ta alone. Layer 116 may be formed from an fcc antiferromagnetic alloy of Ir and Mn where the composition of Ir is less than ~30 atomic percent. The IrMn layer grows highly oriented in the (100) orientation when deposited on the layer 112 formed from Ta or TaN/Ta. The substrate 111 may be comprised of an amorphous material such as SiO_2 . Using this combination of underlayers, the layer 115, comprised of one or more bcc Co—Fe alloys, is textured in the (100) orientation and the MTJ 200 displays high TMR.

25

EX1062, 13:2-25, cited -01493: POR, 14-15, 54; Sur-reply, 13-14, 16-17
-01447: POR, 9-10, 24, 30; Sur-reply, 10-13

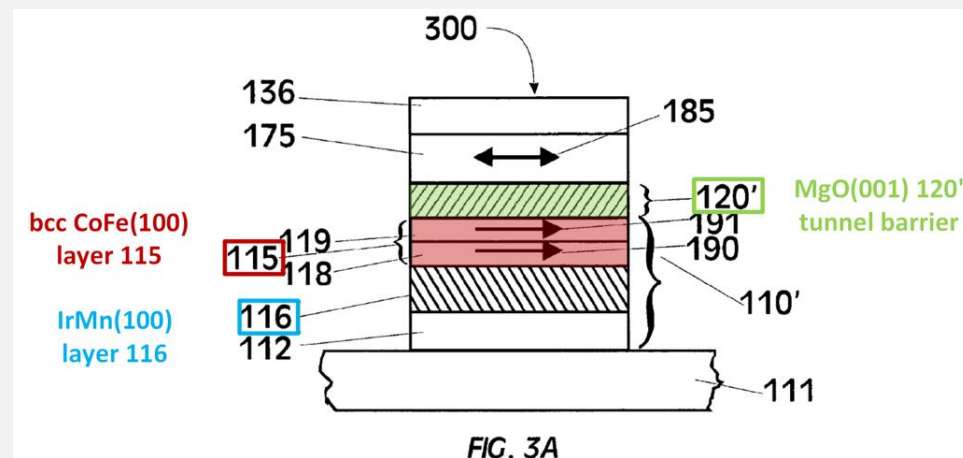
-01493 Sur-reply

1. Fig. 3A Device

Petitioner never disputes Parkin achieved **MgO(001) barrier 120'** in Fig. 3A (annotated below) by forming it on crystalline CoFe(001) layer 119. EX1062, 9:58-10:2, 13:10-25, 17:11-39; POR, 14-16; EX2053 ¶¶84-94 (forming MgO on a crystalline(001) layer promotes MgO(001)).

-01493: Sur-reply, 13; -01447: Sur-reply, 11 (similar)

Parkin (EX1062)



EX1062, 13:2-25, Fig. 3A (annotated), cited -01493: POR, 14-15, 54; Sur-reply, 13-14, 16-17
-01447: POR, 9-10, 24, 30; Sur-reply, 10-13

Petition's References Cited at 33-34 Do Not Support Argument That POSA "would understand... MgO would still have... (001) orientation"

-01447 Sur-reply

B. Ground 1

The Reply never disputed that: * * *

- “[n]one of the *cited evidence* supports ... that a POSA ‘would understand that the MgO ... would still have the same (001) orientation’” (POR, 22-27);
 - Petitioner cited the ‘134 Patent only to establish the undisputed fact that Parkin’s (100)-orientation is the same as the claimed (001)-orientation (POR, 23);
 - Bokor’s testimony (EX1024, ¶129) warrants no weight because it merely parrots the Petition’s conclusory assertion (POR, 25);
 - Parkin, 18:49-51 describes MgO(001) but says nothing about how it is formed (POR, 23); and
 - Parkin, 9:58-10:2 explains that a crystalline(001) layer is used to promote MgO(001) formation which does *not* support the Petition’s assertion that POSAs would have expected MgO to “still” be (001) in Ground 1’s combination that *eliminates* Bowen’s crystalline(001) layer (POR, 23-25).

-01447 Sur-reply, 6-7

Parkin (EX1062)

Notwithstanding the polycrystalline nature of the film structures described herein, which are in any case preferable for ease of manufacturing, the method of forming the MgO (or Mg—ZnO) tunnel barrier described herein can also be applied to the growth of epitaxial single crystalline film structures, wherein the structures are prepared on a face of a single crystalline substrate chosen so that the crystalline spacing and crystalline cell is compatible with the growth of a bcc ferromagnetic metal layer oriented in the (100) growth direction and the subsequent growth of a MgO (or Mg—ZnO) tunnel barrier according one of the preferred embodiments described herein.

EX1062, 9:58-10:2

IPB's Expert Ross

herein.” EX1062, 9:58-10:2. This teaches that the ferromagnetic layer on which the MgO layer is grown has (100) orientation so that the MgO will similarly have (100) orientation.

-01447 EX2053, ¶104, cited -01447 POR, 23

Petition's References Cited at 33-34 Do Not Support Argument That POSA "would understand... MgO would still have... (001) orientation"

-01447 Sur-reply

Petitioner must make its case "with particularity" in the *Petition*. 35 U.S.C. §312; 37 C.F.R. §42.22. The Petition never addressed the impact that eliminating Bowen's/Nagahama's crystalline(001) layer would have on a POSA's expectation of whether MgO(001) would form in Petitioner's *combinations*. That is stunning given the evidence that POSAs would *not* have expected MgO(001) to form on CoFeB. POR, 60-71; *infra* §VI.

-01447 Sur-reply, 9

-01447 Motion to Strike

3. New Arguments Cannot Establish *Prima Facie* Obviousness

The *Petition* must make its case "with particularity." 35 U.S.C. §312; *see also* 37 C.F.R. §§42.22 (requiring a "detailed explanation") and 42.104(b)(5) (*Petition* must identify supporting evidence). The Reply impermissibly "proceed[s] in a new direction" by "rais[ing] a new issue" and relying on "new evidence" in an attempt to belatedly demonstrate a reasonable expectation of success necessary to establish *prima facie* obviousness. TPG, 73-74. That is clearly improper.

-01447 Paper 31, 8

Consolidated Trial Practice Guide

Petitioner may not submit new evidence or argument in reply that it could have presented earlier, e.g. to make out a *prima facie* case of unpatentability.

Consolidated Trial Practice Guide, 73, cited -01447 Paper 31, 8

It is also improper for a reply to present new evidence (including new expert testimony) that could have been presented in a prior filing, for example newly cited prior art references intended to "gap-fill" by teaching a claim element that was not present in the prior art presented with the petition.

Consolidated Trial Practice Guide, 74-75, cited -01447 Paper 31, 8

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

Petition Relies On Bowen (Ground 1) And Nagahama (Ground 2) Manufacturing Methods

-01493 Petition

Ground 1 (Bowen)

1. **Claim 1[preamble]: “A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:”**

To the extent limiting, Bowen taught or suggested a method of manufacturing a magnetic tunnel junction (MTJ) device as claimed. *E.g.*, EX1026 at Abstract, 1655-56 (discussing epitaxially growing FeCo/MgO/Fe MTJs), Fig. 1; EX1024 ¶¶109-19; *see also infra* §§VI.A.2-VI.A.6.

-01493 Pet., 21

Ground 2 (Nagahama)

1. **Claim 1[preamble]: “A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:”**

To the extent limiting, Nagahama taught or suggested a method of manufacturing a magnetic tunnel junction (MTJ) device as claimed. EX1027 ¶73 (“magnetoresistive element was prepared”); *id.* ¶¶74-76, Abstract, Claim 1, Figs. 3, 17; EX1024 ¶¶225-36; *see also infra* §§VII.A.2-VII.A.6.

-01493 Pet., 49-50

-01493 Sur-reply

The Petition contradicts the Reply’s contention that the grounds eliminated Bowen’s/Nagahama’s step of annealing the lower electrode before forming MgO on it. Reply, 2-3. The grounds relied on the manufacturing methods in Bowen/Nagahama. Petition, 21 (“Bowen taught... a method of manufacturing a [MTJ] device as claimed”), 49 (same for Nagahama). Petitioner’s *only* modification concerning the lower electrode was changing its *material* from Fe to CoFeB. POR, 9-11; Petition, 23-29 (Bowen), 50-55 (Nagahama). “[S]ubstitut[ing]” the *material* (Reply, 2) does not eliminate Bowen’s/Nagahama’s step of annealing the lower electrode before forming MgO on it. POR, 8-9; EX1026, 1655; EX1027, [0062] (step (7)).

-01493 Sur-reply, 5

Ground 1 Relies On Bowen Annealing the Lower Ferromagnetic Electrode Before Forming MgO On It

-01493 Petition

5. Claim 1[d]: “annealing the first and second CoFeB layers and the MgO layer, wherein the first and second CoFeB layers are crystallized by the annealing, and”

-01493 Pet., 30

Annealing ferromagnetic electrodes and MgO barrier layers was known. *E.g.*, EX1026 at 1655; EX1062 at 7:53-59; EX1041 at Abstract, 131-34; EX1045 at 1; EX1047 at 509-10; EX1052 at 4507; EX1060 at 1; EX1024 ¶¶151-57. Bowen taught or suggesting annealing at 400°C its first ferromagnetic layer (“Fe bottom electrode”) and MgO barrier layer. EX1026 at 1655 (“Optimal deposition temperatures were “400°C for the MgO, RT for FeCo top electrode, and RT plus annealing at 400°C for the Fe bottom electrode.”); *id.* (“In a subsequent step, the MgO barrier is grown at 400°C in order to obtain good crystallinity.”); EX1024 ¶151.

-01493 Pet., 30

-01493 Institution Decision

In particular, we agree with Petitioner and find that Bowen teaches annealing its Fe bottom layer (closest to the substrate) and MgO barrier layer. Pet. 30; Ex. 1026, 1655 (teaching that (i) “[o]ptimal deposition

-01493 D.I. (Paper 9), 15

-01493 Sur-reply

Ground 1 relied on Bowen’s annealing step. Petition, 30 (“Bowen taught... annealing... its bottom electrode”). The Board saw this. DI, 15 (“*we agree with Petitioner* and find that *Bowen teaches annealing its Fe bottom layer*”). And Bokor admitted he did not modify Bowen’s annealing step. EX2018, 172:18-24, 180:24-181:8; *generally id.*, 172:18-182:11.

-01493 Sur-reply, 5

Bowen (EX1026)

sition rates in the range of 0.1–0.3 Å/s. Optimal deposition temperatures were 400 °C for the MgO, RT for FeCo top electrode, and RT plus annealing at 400 °C for the Fe bottom electrode. This low-temperature deposition and subsequent annealing process leads to an optimal Fe electrode in terms of crystallinity, continuity, and interface sharpness.

EX1026, 1655

Ground 2 Relies on Nagahama Annealing the Lower Ferromagnetic Electrode Before Forming MgO on It

-01493 Petition

1. Claim 1[preamble]: “A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:”

To the extent limiting, Nagahama taught or suggested a method of manufacturing a magnetic tunnel junction (MTJ) device as claimed. EX1027 ¶73 (“magnetoresistive element was prepared”); *id.* ¶¶74-76, Abstract, Claim 1, Figs. 3, 17; EX1024 ¶¶225-36; *see also infra* §§VII.A.2-VII.A.6.

-01493 Pet., 49

EX1027 ¶74; EX1024 ¶232. Nagahama provided further details on a “procedure” and “method of manufacturing” the MTJs in Figures 12-13. EX1027 ¶¶57, 62; *see also id.* ¶¶28, 78; EX1024 ¶¶228-30. To the extent IP Bridge asserts the Figures 12-13 disclosures do not apply to Nagahama’s paragraphs 73-74 embodiment, it would have been obvious to one of skill to use these deposition techniques with a reasonable expectation of success because they were conventional and all applied to Nagahama’s “third group” of MTJs. EX1027 ¶55; EX1024 ¶¶229-30.

-01493 Pet., 49-50

lower ferromagnetic electrode
tunnel barrier
(MgO in [0073]-[0074])

-01493 Pet., 49-50

-01493 Sur-reply

Ground 2 relied on Nagahama’s step of annealing the lower electrode before forming MgO on it. Petition, 50 (*citing EX1027, [0062]* for Nagahama’s “method of manufacturing”); EX1027, [0062] (annealing step (7)); DI, 22 (not addressing Ground 2).

-01493 Sur-reply, 5-6

5. Claim 1[d]: “annealing the first and second CoFeB layers and the MgO layer, wherein the first and second CoFeB layers are crystallized by the annealing, and”

-01493 Pet., 56

As explained in Ground 1, annealing ferromagnetic electrodes and MgO barrier layers, and crystallizing CoFeB electrodes by annealing, were known. *Supra* §VIA.5 (Claim 1[d]); EX1024 ¶¶273, 278-80. Indeed, Nagahama taught that annealing (“heat treatment”) netted “a larger tunnel magnetoresistive effect of more than 90%.” EX1027 ¶74; EX1024 ¶274. For the reasons explained in Ground 1,

-01493 Pet., 57

Nagahama (EX1027)

[0062] A method for manufacturing the flat tunnel magnetoresistive element will be described below: * * *

- (6) Deposit the Fe 213 (20 nm) by sputtering.
- (7) Annealing the object to planarize the surface.
- (8) After reducing substrate temperature to room temperature, deposit Al and naturally oxidize it to form the Al-O tunnel barrier layer (amorphous Al-O layer) 214.
- (9) Form the upper electrode (polycrystalline Ni-Fe) layer 215 and the Au cap layer 216.

'167 Grounds Form MgO Directly on Amorphous CoFeB

-01493 Petition

'167 Ground 1 (Bowen)

2. Claim 1[a]: “forming a first CoFeB layer that is amorphous;”

-01493 Petition, 22

One of skill would have found it obvious to replace Bowen’s Fe layer with an amorphous ferromagnetic CoFeB layer as taught by Sunai. EX1030 ¶28 (teaching

-01493 Petition, 23

3. Claim 1[b]: “forming a magnesium oxide (MgO) layer over the first CoFeB layer;”

-01493 Petition, 28

crystal epitaxial junctions”); EX1024 ¶139. As explained for Claim 1[a], one of skill would have been motivated to replace Bowen’s lower, Fe electrode with a CoFeB layer. *Supra* Claim 1[a], §VI.A.2; EX1024 ¶139.

Forming an MgO layer over a ferromagnetic layer in an MTJ was conventional. EX1013 at 1:42-46; *id.* at Figs. 8(A)-8(B); EX1045 at 8 (describing “high quality... MgO tunnel barrier”); EX1024 ¶140; *supra* §II.B.

-01493 Petition, 29

'167 Ground 2 (Nagahama)

2. Claim 1[a]: “forming a first CoFeB layer that is amorphous;”

-01493 Petition, 50

One of skill would have found it obvious to replace Nagahama’s lower ferromagnetic electrode material with amorphous CoFeB as taught by Sunai increase the TMR and lower the H_f and H_c . EX1030 ¶¶24-29; EX1024 ¶¶245-50. Cobalt and iron were known ferromagnetic materials. EX1030 ¶33; EX1026 at 1655; EX1024 ¶246. As explained in Ground 1, it was known that CoFeB would be formed as an amorphous layer. *Supra* §VI.A.2 (Claim 1[a]); EX1024 ¶250.

-01493 Petition, 51

3. Claim 1[b]: “forming a magnesium oxide (MgO) layer over the first CoFeB layer;”

-01493 Petition, 54

In its paragraphs 73-74 embodiment, Nagahama described forming an MTJ with an MgO layer over a lower ferromagnetic layer: “magnetoresistive element was prepared which includes... a (001)-highly-oriented MgO barrier layer.” EX1027 ¶¶73-74; *id.* ¶¶75-76, Fig. 17; *see also id.* ¶¶21-22, Fig. 3 (describing same arrangement for Fig. 3), ¶28 (An “insulating [barrier] layer” is “deposited on the Fe layer.”); EX1024 ¶¶257-58.

-01493 Petition, 54

Petitioner's Expert Could Not Say What Would Have Happened If the Process Alleged in Ground 1 Were Used

-01493 Petition

1. Claim 1[preamble]: "A method of manufacturing a magnetic tunnel junction (MTJ) device, comprising:"

To the extent limiting, Bowen taught or suggested a method of manufacturing a magnetic tunnel junction (MTJ) device as claimed. E.g., EX1026 at Abstract, 1655-56 (discussing epitaxially growing FeCo/MgO/Fe MTJs), Fig. 1; EX1024

-01493 Pet., 21

2. Claim 1[a]: "forming a first CoFeB layer that is amorphous;"

One of skill would have found it obvious to replace Bowen's Fe layer with an amorphous ferromagnetic CoFeB layer as taught by Sunai. EX1030 ¶28 (teaching

-01493 Pet., 22-23

5. Claim 1[d]: "annealing the first and second CoFeB layers and the MgO layer, wherein the first and second CoFeB layers are crystallized by the annealing, and"

EX1047 at 509-10; EX1052 at 4507; EX1060 at 1; EX1024 ¶¶151-57. Bowen taught or suggesting annealing at 400°C its first ferromagnetic layer ("Fe bottom electrode") and MgO barrier layer. EX1026 at 1655 ("Optimal deposition

-01493 Pet., 30

-01493 Institution Decision

In particular, we agree with Petitioner and find that Bowen teaches annealing its Fe bottom layer (closest to the substrate) and MgO barrier layer. Pet. 30; Ex. 1026, 1655 (teaching that (i) "[o]ptimal deposition

-01493 D.I. (Paper 9), 15

Petitioner's Expert Dr. Bokor

Q. So in Bowen's device now, if we modified Bowen's process, its fabrication method, and instead of depositing iron at room temperature for the bottom electrode, we deposited cobalt iron boron for the bottom electrode, what would happen when you then annealed that layer at 400 Celsius?

A. Right off the top of my head, ***I can't answer that question.*** We would - I would have to go look through - I don't - if you - if you are aware of a - somewhere in all of the literature where somebody did that, we could - I would be happy to look at that. But ***I can't - I'm unwilling to speculate just off the top of my head what would happen....I don't know - I don't know what - what - what that might - what might happen in that situation. I can't speculate.***

EX2018, 169:16-170:12, cited -01493 POR, 7-8

Petition Never Proposes Any Modification to Bowen's or Nagahama's Process—It Only Modifies the *Materials*

-01493 Petition replaces material for lower Fe electrode in Bowen/Nagahama

-01493 Petition

One of skill would have found it obvious to replace Bowen's Fe layer with an amorphous ferromagnetic CoFeB layer as taught by Sunai. EX1030 ¶28 (teaching

-01493 Petition, 23, cited POR, 9

One of skill would have found it obvious to replace Nagahama's lower ferromagnetic electrode material with amorphous CoFeB as taught by Sunai increase

-01493 Petition, 51, cited POR, 9

-01493 Reply

23-26, 28; *see also id.*, 51-54 (Nagahama). IPB cannot prevail by arguing the Petition *implicitly* adopted Bowen's/Nagahama's procedure for annealing a crystalline Fe electrode when the Petition *explicitly* substituted it out.

-01493 Reply, 2-3

... BUT FAILS TO CITE WHERE THE PETITION DOES SO.

-01493 Sur-reply

If the Petition “substituted... out” annealing the lower electrode in Bowen/Nagahama (Reply, 2-3), Petitioner should have been able to provide a pinpoint citation. It cites *nothing* because the Petition never made that argument.

-01493 Sur-reply, 6

Petitioner Must State Its Grounds With Particularity In the Petition

-01493 Sur-reply

EX2018, 172:18-24 (Bokor admitted he never said this for Bowen). The Petition must state its grounds with “particularity” and provide a “detailed explanation” clearly explaining its combinations. 35 U.S.C. §312(a)(3); 37 C.F.R. §42.22; POR, 4, 6, 19-21 (*citing Personal Web*). Those requirements prevent Petitioner from leveraging alleged ambiguity in the Petition to change course and offer a different theory after the grounds are proven deficient. *Wasica Finance v. Cont’l Auto. Sys.*, 853 F.3d 1272, 1286–1287 (Fed. Cir. 2017). The Board should not allow it.

-01493 Sur-reply, 6

Wasica Fin. v. Cont’l Auto Sys.



“Rather than explaining how its original petition was correct, Continental’s subsequent arguments amount to an entirely new theory of *prima facie* obviousness absent from the petition. ***Shifting arguments in this fashion is foreclosed by statute, our precedent, and Board guidelines.*** See 35 U.S.C. § 312(a)(3) (requiring petitions to identify “with particularity . . . the grounds on which the challenge to each claim is based”); *Illumina*, 821 F.3d at 1369–70; *Dell Inc. v. Accelaron, LLC*, 818 F.3d 1293, 1301 (Fed. Cir. 2016) (vacating a finding of unpatentability when the Board relied on an argument first made during oral hearing); Trial Practice Guide, 77 Fed. Reg. 48,756, 48,767 (Aug. 14, 2012) (prohibiting parties from submitting evidence necessary for a *prima facie* showing of obviousness in a reply). We therefore see no error in the Board declining to engage such an argument here.”

853 F.3d 1272, 1286-1287 (Fed. Cir. 2017), cited -01493 Sur-reply, 6

Bokor Could Not Say What a POSA Would Have Expected to Happen If the POSA Followed the Processes Alleged in Each Ground

Petitioner's Expert Dr. Bokor

Q. So in Bowen's device now, if we modified Bowen's process, its fabrication method, and instead of depositing iron at room temperature for the bottom electrode, we deposited cobalt iron boron for the bottom electrode, what would happen when you then annealed that layer at 400 Celsius?

A. Right off the top of my head, **I can't answer that question.** We would - I would have to go look through - I don't - if you - if you are aware of a - somewhere in all of the literature where somebody did that, we could - I would be happy to look at that. But **I can't - I'm unwilling to speculate just off the top of my head what would happen....I don't know - I don't know what - what - what that might - what might happen in that situation. I can't speculate.**

EX2018, 169:16-170:12, cited -01493 POR, 7-8

-01493 POR

Dr. Bokor's bewilderment is *fatal* to both grounds because with no expectation what surface conditions that bottom CoFeB layer would have provided for the subsequent MgO deposition, a POSA had no reasonable expectation that the manufacturing process alleged in either ground would achieve a polycrystalline MgO with a preferentially-oriented (001) crystal plane (i.e., the claimed MgO microstructure) as the claims require (1[e], 11[b]). This brings Petitioner's entire house of cards crashing down.

-01493 POR, 8, 12 (similar)

Q. And what would a person of ordinary skill in the art in 2004 have expected to have [happened] if in Bowen's process they deposited amorphous cobalt iron boron at room temperature on that magnesium oxide buffer layer and then annealed at 400 Celsius?

A. I don't recall anywhere right off the top of my head as I sit here any references that describe a process like that. And I think it's - I - **I'm unwilling to try to predict.** An uncapped cobalt iron boron layer that would be annealed - yeah, that - **I want to read through the references to see if anybody did that.** Off the top of my head, **I don't recall such a situation.** I'm not saying it's not anywhere in the references. I just don't recall that. And without having something to refer to, I - **I'm not willing to speculate.**

EX2018, 170:13-171:19, cited -01493 POR, 11-12

Bokor Testified a POSA “Would Have a Natural Reticence” to Anneal Amorphous CoFeB as Alleged Before Forming MgO on It

Petitioner’s Expert Dr. Bokor

Q. Dr. Bokor, where -- in your declaration on the '167 patent, where do you describe modifying Bowen to avoid the anneal step after the room temperature deposition of the bottom electrode?

A. **So I don't have explicit discussion of that.** Again, in the context of the art, for example, Sunai -- not Sunai, sorry. Cardoso. Cardoso deposits all the layers and then anneals. I believe. **And I think a person of ordinary skill starting to work with CoFeB, cobalt iron boron, would have natural reticence to anneal that without a layer on top.** And Cardoso would also give a person of ordinary skill that -- that idea, that suggestion.

EX2018, 172:18-173:7, cited POR, 11-12

-01493 Sur-reply

Bowen's/Nagahama's manufacturing methods—which anneal a lower Fe electrode before forming MgO on it—would not work with amorphous CoFeB electrodes, and POSAs would not have used them. POR, 5-13. Bokor admitted this. EX2018, 169:16-171:19, 173:2-5. That the claims do not require annealing the

-01493 Sur-reply, 4

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

POSA Has No Motivation to Form A Combination That Changes a Reference's Basic Principle of Operation

In re Ratti



“[T]he combination of Jepson with Chinnery et al. is not a proper ground for rejection of the claims here on appeal. This suggested combination of references would require a substantial reconstruction and redesign of the elements shown in Chinnery et al. as well as a change in the basic principles under which the Chinnery et al. construction was designed to operate.

In re Ratti, 270 F.2d 810, 813 (C.C.P.A. 1959)), cited -01493 POR, 39-40

Netflix v. DivX



“The Board also found that there was no motivation to combine Vehviläinen with Kadono. The Board noted that ‘select[ing] a filter based on the differences between adjacent pixels [as in Kadono] rather than variance across the region would have been understood by an ordinarily skilled artisan as changing the basic principle of Vehviläinen's operation.’ . . . We hold that the Board's finding is supported by substantial evidence, and we therefore affirm the Board's decision on that issue.”

Netflix v. DivX, No. 2021-1931, 2022 WL 2298983, at *3, 5-7 (Fed. Cir. June 22, 2021) (cleaned up), cited -01493 Sur-reply, 7-8

Plas-Pak Indus. v. Sulzer Mixpac



“[The combination] fundamentally alters Fukuta's principle of operation. Such a change in a reference's principle of operation is unlikely to motivate a person of ordinary skill to pursue a combination with that reference. Accordingly, the Board did not err in concluding that claims 1–15 would not have been obvious over Fukuta in view of Morris.”

Plas-Pak Indus. v. Sulzer Mixpac, 600 F. App'x 755, 758-759 (Fed. Cir. 2015) (cleaned up), cited -01493 Sur-reply, 8

Petitioner Never Disputes That Each Combination Destroys the Basic Manufacturing Principle In Bowen/Nagahama—Templating the MgO(001) Barrier

POR

6, 2024) (applying *Ratti*). By replacing the crystalline lower electrode with amorphous CoFeB in Bowen and Nagahama, Petitioner's combinations would discard the very feature and process steps—forming a crystalline lower electrode to template the epitaxial growth of an MgO barrier layer—that Bowen and Nagahama went to heroic efforts to accomplish by inventing their entirely new processes of forming a MgO(001) buffer layer on GaAs(001) (in Bowen) and a MgO double underlayer (in Nagahama). Ross, ¶13. Petitioner's combinations fail because they would so alter the processes in Bowen and Nagahama, contrary to their principle of operation, as to make them unrecognizable. *Ratti*, 270 F.2d at 813.

POR, 40

Sur-reply

III. Petitioner Never Refutes That Its Combinations Destroy the Principle of Operation of Bowen's/Nagahama's Manufacturing Methods

The Reply fails to refute that Petitioner's combinations fail because they alter Bowen's/Nagahama's manufacturing processes contrary to their principle of operation. POR, 39-40 (citing caselaw).

Petitioner never disputes the operative manufacturing principle in Bowen/Nagahama is templating—each forms a crystalline(001) underlayer to template formation of a crystalline(001) lower electrode, which templates formation of an MgO(001) barrier. The combinations eviscerate this templating principle by replacing Bowen's/Nagahama's crystalline(001) electrode with non-crystalline amorphous CoFeB. POR, 30-39; *Netflix v. DivX*, No. 2021-1931, 2022

Sur-reply, 6-7

Reply

Non-Responsive

2. Improvement Does Not Fundamentally Change An MTJ's Principle of Operation

IPB asserts Grounds 1-2 resulted in combinations that would change Bowen's/Nagahama's basic principles of operation. POR, 39-40 (citing *In re Ratti*, 270 F.2d 810, 813 (C.C.P.A. 1959)). That is easily disproved when forming MgO(100) barrier layers on CoFeB electrodes already had been done, by, for example, Parkin. EX1062, 17:7-10; *supra* §II.C. IPB agrees Parkin's MTJ taught an "amorphous CoFeB electrode 175" in Figure 3A, POR, 15 (citing EX1062, Fig. 3A), and does not dispute that Parkin taught a lower CoFeB electrode when Figure 3A was inverted, EX1062, 17:7-20; *supra* §II.C. Everyone agrees that Parkin's MgO-CoFeB MTJ performed phenomenally, achieving a "very high TMR value[]" of "more than 220%" for his prior art CoFeB MTJ. EX1062, 18:44-51; EX2006, 1 (Yuasa: acknowledging Parkin's "220% of MR ratio at RT").

Parkin's disclosure defeats IPB's specious argument that one of skill would not use a CoFeB electrode because it would subvert the operation of Bowen's/Nagahama's MTJ. See *id.*; see, e.g., *Moultet*, 686 F.3d at 1332 ("finding *Ratti* inapplicable where the modified apparatus will operate 'on the same principles as before'" (quoting *In re Umbarger*, 407 F.2d 425, 430-31 (C.C.P.A. 1969)).

Reply, 15

undisputed

Petitioner's Reply Is Obfuscation: The Combinations Destroy Bowen/Nagahama Manufacturing Principle

-01493 Reply

2. Improvement Does Not Fundamentally Change An MTJ's Principle of Operation

IPB asserts Grounds 1-2 resulted in combinations that would change Bowen's/Nagahama's basic principles of operation. POR, 39-40 (citing *In re Ratti*, 270 F.2d 810, 813 (C.C.P.A. 1959)). That is easily disproved when forming MgO(100) barrier layers on CoFeB electrodes already had been done, by, for example, Parkin. EX1062, 17:7-10; *supra* §II.C. IPB agrees Parkin's MTJ taught an "amorphous CoFeB electrode 175" in Figure 3A, POR, 15 (citing EX1062, Fig. 3A), and does not dispute that Parkin taught a lower CoFeB electrode when Figure 3A was inverted, EX1062, 17:7-20; *supra* §II.C. Everyone agrees that Parkin's MgO-CoFeB MTJ performed phenomenally, achieving a "very high TMR value[]" of "more than 220%" for his prior art CoFeB MTJ. EX1062, 18:44-51; EX2006, 1 (Yuasa: acknowledging Parkin's "220% of MR ratio at RT").

Parkin's disclosure defeats IPB's specious argument that one of skill would not use a CoFeB electrode because it would subvert the operation of Bowen's/Nagahama's MTJ. *See id.*; *see, e.g., Mouttet*, 686 F.3d at 1332 ("finding *Ratti* inapplicable where the modified apparatus will operate 'on the same principles as before'" (quoting *In re Umbarger*, 407 F.2d 425, 430-31 (C.C.P.A. 1969))).

Reply, 15



-01493 Sur-reply

The Reply obfuscates. IPB did not allege that a CoFeB electrode would "subvert the operation of Bowen's/Nagahama's MTJ" *device*. Reply 15 (citing *Mouttet* to allegedly refute this strawman); *see also id.* ("MTJ's Principle of Operation" does not change). The claims recite methods of manufacture—not a device. Petitioner never refutes IPB's argument that Petitioner's combinations change the "principle of operation" of Bowen's/Nagahama's manufacturing processes. Reply, 15; POR, 39-40.

Sur-reply, 7

Petitioner's combinations abandon Bowen's/Nagahama's operative manufacturing principle by eliminating the templating that achieves an MgO(001) barrier in favor of an approach nowhere taught in the prior art. That fails to establish obviousness.

Sur-reply, 8



Non-Responsive

Petitioner's Reply Is Obfuscation: The Combinations Modify Processes in Bowen/Nagahama—Not Parkin

-01493 Reply

2. Improvement Does Not Fundamentally Change An MTJ's Principle of Operation

IPB asserts Grounds 1-2 resulted in combinations that would change Bowen's/Nagahama's basic principles of operation. POR, 39-40 (citing *In re Ratti*, 270 F.2d 810, 813 (C.C.P.A. 1959)). That is easily disproved when forming MgO(100) barrier layers on CoFeB electrodes already had been done, by, for example, Parkin. EX1062, 17:7-10; *supra* §II.C. IPB agrees Parkin's MTJ taught an "amorphous CoFeB electrode 175" in Figure 3A, POR, 15 (citing EX1062, Fig. 3A), and does not dispute that Parkin taught a lower CoFeB electrode when Figure 3A was inverted, EX1062, 17:7-20; *supra* §II.C. Everyone agrees that Parkin's MgO-CoFeB MTJ performed phenomenally, achieving a "very high TMR value[]" of "more than 220%" for his prior art CoFeB MTJ. EX1062, 18:44-51; EX2006, 1 (Yuasa: acknowledging Parkin's "220% of MR ratio at RT").

Parkin's disclosure defeats IPB's specious argument that one of skill would not use a CoFeB electrode because it would subvert the operation of Bowen's/Nagahama's MTJ. *See id.*; *see, e.g., Mouttet*, 686 F.3d at 1332 ("finding *Ratti* inapplicable where the modified apparatus will operate 'on the same principles as before'" (quoting *In re Umbarger*, 407 F.2d 425, 430-31 (C.C.P.A. 1969))).

Reply, 15



-01493 Sur-reply

Petitioner's remaining argument that Parkin "already" formed MgO(001) barriers on CoFeB electrodes fails. Reply, 15.

First, the combinations modify *Bowen's/Nagahama's* manufacturing methods—not Parkin's. POR, 30-39.

Second, touting performance of Parkin's *device* says nothing about Parkin's *manufacturing process*. Reply, 15.

Third, Petitioner cites Parkin's disclosure that Fig. 3A's device can be "inverted" (*id.*) as in Fig. 11 (*id.*, 5-7) but ignores Parkin's *process* for forming Fig. 11's device. Parkin formed Fig. 11's MgO(001) barrier 540 using a templating crystalline(001) layer 520. EX1062, 23:5-10, 3:24-41; *infra* §VI.B. Parkin provides no support for discarding Bowen's/Nagahama's operative templating principle — forming an MgO(001) barrier on a crystalline(001) layer—because Parkin used it too. POR, 39-40; *Netflix*, 2022 WL 2298983, at *3, 5-7; *Plas-Pak Indus. v. Sulzer Mixpac*, 600 F. App'x 755, 759 (Fed. Cir. 2015) (affirming Board's non-obviousness finding and explaining "[A] change in a reference's 'principle of operation' is unlikely to motivate [POSAs] to pursue a combination with that reference.").

Sur-reply, 7-8

Parkin Teaches Templating to Form MgO(001) Barrier 540 —in Fig. 11 (i.e., “Inverted” Fig. 3A)

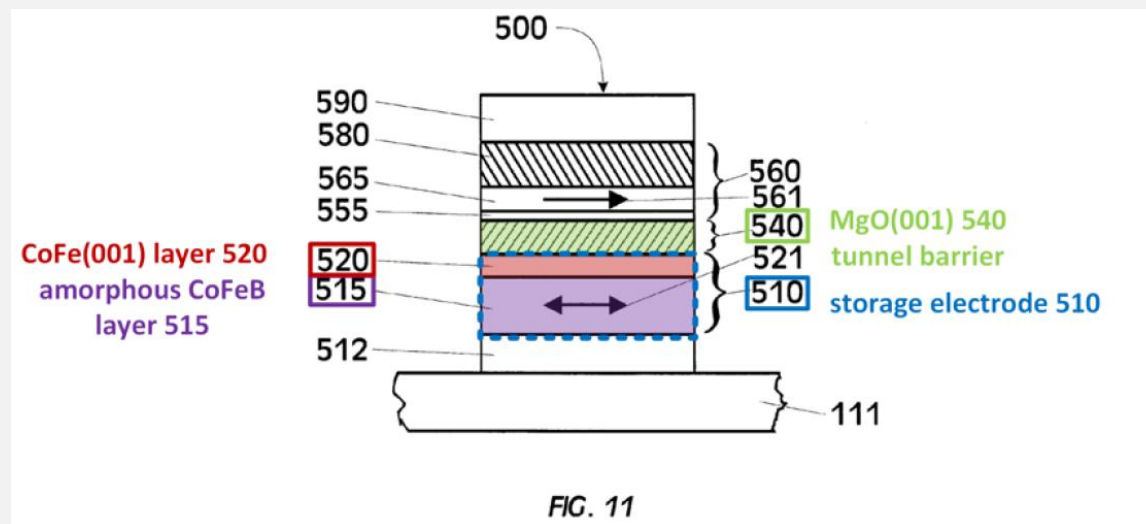
Parkin (EX1062)

U.S. patent application Ser. No. 10/824,835 to Parkin •
titled “MgO tunnel barriers and method of formation” (filed 25
Apr. 14, 2004), which is hereby incorporated by reference,
discloses a method of forming a tunnel barrier comprised of
magnesium oxide (MgO) with which magnetic tunnel junc-
tions can be deposited which exhibit tunneling magnetore-
sistance values of more than 100% at low bias. The tunnel 30
barrier is formed by first depositing a thin layer of Mg using,
for example, magnetron or ion beam sputter deposition
followed by a layer of Mg deposited in the presence of
oxygen. In addition, Parkin discloses methods of forming
highly oriented crystalline MgO tunnel barriers by forming 35
the MgO barrier on a ferromagnetic electrode comprised of
a Co—Fe alloy, which is bcc and (100) textured. The CoFe
electrode is formed on a (100) oriented antiferromagnetic
layer of fcc IrMn which itself is grown highly oriented by
forming this layer on suitable underlayers, for example, a 40
combination of a TaN layer followed by a Ta layer.

EX1062, 3:24-41, cited -01493: Sur-reply, 3, 8, 14, 16, 18
-01447: Sur-reply, 2, 11, 16-17

A MgO tunnel barrier 540 is then formed according to the
methods described in U.S. patent applications Ser. No.
10/824,835 to Parkin titled “MgO tunnel barriers and 10
method of formation” (filed Apr. 14, 2004) and Ser. No.
10/646,246 to Parkin titled “MgO tunnel barriers and
method of formation” (filed Aug. 22, 2003). First a layer of

EX1062, 23:6-11, cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13



EX1062, Fig. 11 (annotated), cited -01493: Sur-reply, 15-17
-01447: Sur-reply, 12-13

Parkin Teaches Templating to Form MgO(001) Barrier 120' —in Fig. 3A

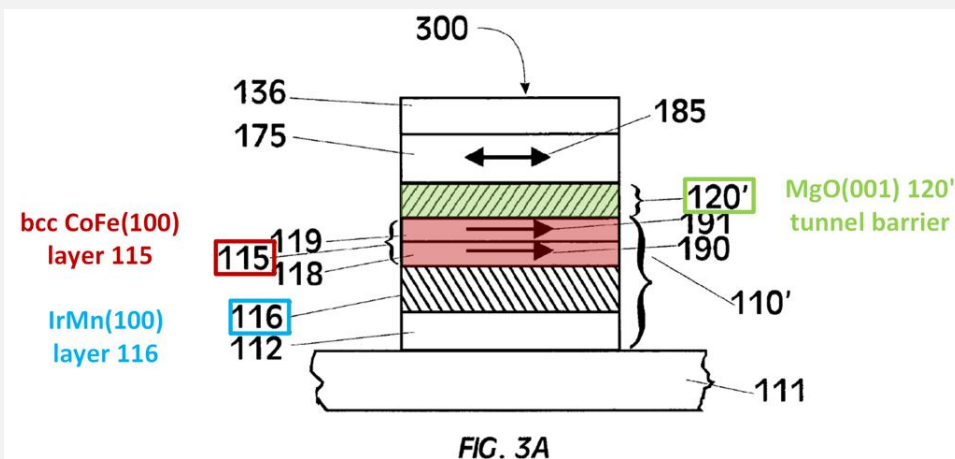
Parkin (EX1062)

U.S. patent application Ser. No. 10/824,835 to Parkin 25
titled “MgO tunnel barriers and method of formation” (filed
Apr. 14, 2004), which is hereby incorporated by reference,
discloses a method of forming a tunnel barrier comprised of
magnesium oxide (MgO) with which magnetic tunnel junc-
tions can be deposited which exhibit tunneling magnetore-
sistance values of more than 100% at low bias. The tunnel 30
barrier is formed by first depositing a thin layer of Mg using,
for example, magnetron or ion beam sputter deposition
followed by a layer of Mg deposited in the presence of
oxygen. In addition, Parkin discloses methods of forming
highly oriented crystalline MgO tunnel barriers by forming 35
the MgO barrier on a ferromagnetic electrode comprised of
a Co—Fe alloy, which is bcc and (100) textured. The CoFe
electrode is formed on a (100) oriented antiferromagnetic
layer of fcc IrMn which itself is grown highly oriented by
forming this layer on suitable underlayers, for example, a 40
combination of a TaN layer followed by a Ta layer.

EX1062, 3:24-41, cited -01493: Sur-reply, 3, 8, 13-14, 16, 18
-01447: Sur-reply, 2, 11, 16-17

An MgO tunnel barrier 120' is then formed on top of the
lower ferromagnetic electrode 110' using the method
described in U.S. patent application Ser. No. 10/824,835 to
Parkin titled “MgO tunnel barriers and method of forma- 25
tion” (filed Apr. 14, 2004), supra, by first depositing a thin

EX1062, 17:21-25, cited -01493 Sur-reply, 13-14;
-01447: POR, 9-10, 19, 24, 29



EX1062, 13:2-25, Fig. 3A (annotated), cited -01493: POR, 14-15, 54; Sur-reply, 13-14, 16-17
-01447: POR, 9-10, 24, 30; Sur-reply, 10-13

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

**Each Petition Fails to Show A Reasonable Expectation
That MgO(001) Would Form on the Amorphous CoFeB**

Each Petition Failed to Show a Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB: 134 Patent (-01447)

-01447 POR: Ground 1

B. Ground 1 Fails to Show that a POSA Would Have Reasonably Expected the Bowen-Sunai/Parkin Combination to Meet the Claimed MgO(001) Layer

In Ground 1's Bowen-Sunai/Parkin Combination, the MgO layer is formed on a CoFeB layer rather than on Bowen's crystalline Fe(001) layer. Petition, 34-41 (Bowen's Fe layer is "replaced" with a CoFeB layer). Petitioner admits boron inhibits crystallization. *Id.*, 37. Petitioner fails to show that a POSA would have reasonably expected the MgO layer in its Bowen-Sunai/Parkin combination to meet the MgO(001) limitation despite being formed on a CoFeB layer. Ross, ¶101.

* * *

None of the cited evidence supports Petitioner's conclusory assertion that a POSA "would understand that the MgO ... would still have the same (001) orientation" despite being formed on a CoFeB layer. *Id.*; Ross, ¶102.

-01447 POR, 22

-01447 Sur-reply: Ground 2

IV. The Reply Never Refutes the Petition's Failure to Establish a Reasonable Expectation of Success in Meeting the MgO(001) Limitations

Every claim requires an MgO(001) barrier. *See* Limitations 1[d] and 3[d] (the "MgO(001) limitations").

A. Ground 2

Petitioner never disputes that the Petition mapped the MgO(001) limitations to *Nagahama unmodified* by Sunai and/or Parkin, that Nagahama formed its MgO barrier on a crystalline(001) electrode, and that the Petition never alleged, let alone cited evidence establishing, that POSAs would have reasonably expected MgO(001) to form in Ground 2's combination that replaces Nagahama's crystalline(001) electrode with amorphous CoFeB. Petition, 56; POR, 19-21.

-01447 Sur-reply, 5

(001) orientation." Reply, 12 (emphasis original).² To establish *prima facie* obviousness, the Petition needed to provide argument and *evidence* explaining how and why POSAs *would* have reasonably expected the *combination's* MgO barrier to be (001). The Petition's failure to do so is fatal to Ground 2.

-01447 Sur-reply, 6

Each Petition Failed to Show a Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

-01493 Sur-reply

V. Petitioner Never Refutes the Petition's Failure to Establish a Reasonable Expectation of Success in Achieving MgO(001) On Amorphous CoFeB

Every claim requires forming an MgO(001) barrier on amorphous CoFeB. See Limitations 1[b]/1[e] and 11[b] (“MgO(001) limitations”). The Petition never established *prima facie* obviousness for either ground because it never alleged, and cited no *evidence* establishing, that POSAs would have reasonably expected either ground's process to achieve MgO(001) on the amorphous CoFeB that replaces Bowen's/Nagahama's crystalline(001) lower electrode. POR, 19-21; *id.*, 12-29.

-01493 Sur-reply, 9

It is undisputed that the Petition mapped the MgO(001) limitations to unmodified Bowen/Nagahama and never addressed how or why its combinations' manufacturing methods—that remove the crystalline(001) layer on which MgO(001) formed in Bowen/Nagahama—allegedly would have yielded MgO(001). Petition, 33 (1[e]: “*Bowen taught... this limitation*”), 57 (1[e]: “*Nagahama taught... this limitation*”); POR, 12-29. It also is undisputed that Ground 1's assertion that POSAs had reason to replace Bowen's single-crystal MgO(001) with polycrystalline MgO(001) (Petition, 33) says nothing about why polycrystalline MgO(001) allegedly would have formed in Ground 1's combination. POR, 12-29. As Petitioner admits, polycrystalline MgO(001) formed in Nagahama on a *crystalline(001)* electrode. Petition, 57 (*citing* EX1027, [0073]).

Even if the Petition is read as having alleged POSAs would have reasonably expected MgO(001) to form on amorphous CoFeB in its combinations (it did not), it is undisputed that no evidence the Petition cited to meet the MgO(001) limitations establishes that. POR, 12-29.

-01493 Sur-reply, 9-10

**Petitioner's New Reply Arguments Cannot Fix
Each Petition's Failure to Make A *Prima Facie* Case of
Obviousness And Should Not Be Considered**

Trial Practice Guide Requires Striking Petitioner's New Arguments In Each Case: 134 Patent (-01447)



Consolidated Trial Practice Guide

Generally, a reply or sur-reply may only respond to arguments raised in the preceding brief. 37 C.F.R. § 42.23, except as noted above. "Respond," in the context of 37 C.F.R. § 42.23(b), does not mean proceed in a new direction with a new approach as compared to the positions taken in a prior filing. While replies and sur-replies can help crystalize issues for decision, a reply or sur-reply that raises a new issue or belatedly presents evidence may not be considered. The Board is not required to attempt to sort proper from improper portions of the reply or sur-reply.

Examples of indications that a new issue has been raised in a reply include new evidence necessary to make out a *prima facie* case for the patentability or unpatentability of an original or proposed substitute claim, such as newly raised rationale to combine the prior art references that was not expressed in the petition. See *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1369–70 (Fed. Cir. 2016) (holding that the Board did not err in refusing the reply brief as improper under 37 C.F.R. § 42.23(b) because petitioner relied on an entirely new rationale to explain why one of skill in the art would have combined the references at issue). It is also improper for a reply to present new evidence (including new expert testimony) that could have been presented in a prior filing, for example newly cited prior art references intended to "gap-fill" by teaching a claim element that was not present in the prior art presented with the petition. See *Genzyme Therapeutic Prods. Ltd. v. Biomarin Pharm. Inc.*, 825 F.3d 1360, 1365–69 (Fed. Cir. 2016) (proper for Board to rely on prior art references submitted with petitioner's reply to establish the state of the art at the time of the invention in response to patent owner arguments).

-01447 IPB Motion to Strike

2. The Reply Never Defends the Petition's Arguments and Instead Advances New Arguments Based on New Evidence

The POR explained that the Petition: (1) failed to acknowledge the impact that removing from Bowen and Nagahama the crystalline(001) underlayer would have had on a POSA's expectation of how the MgO layer would form and (2) failed to submit any evidence establishing that POSAs would have reasonably expected MgO to form as crystalline(001) on amorphous CoFeB. POR, 22-27 (Ground 1), 19-21 (Ground 2). The only proper reply would have been for Petitioner to explain where the Petition allegedly did so.

Instead of defending the Petition's showing, the Reply advances three new arguments, alleging: (1) Parkin discloses "forming an MgO(100) tunnel over an amorphous CoFeB" (Reply, 2-5) and (2) prior art allegedly disclosing MgO(001) formed on *different* amorphous substrates gave POSAs a reasonable expectation of success that MgO(001) would form on amorphous CoFeB (*id.*, 5-8), so (3) POSAs "would have reasonably expected success in growing MgO(001) on amorphous ... CoFeB" (*id.*, 5-9). See also *id.*, 12-13 (same new arguments for Ground 2).

-01447 Paper 31, 3-4

Trial Practice Guide Requires Striking Petitioner's New Arguments In Each Case: 167 Patent (-01493)



Consolidated Trial Practice Guide

Generally, a reply or sur-reply may only respond to arguments raised in the preceding brief. 37 C.F.R. § 42.23, except as noted above. "Respond," in the context of 37 C.F.R. § 42.23(b), does not mean proceed in a new direction with a new approach as compared to the positions taken in a prior filing. While replies and sur-replies can help crystalize issues for decision, a reply or sur-reply that raises a new issue or belatedly presents evidence may not be considered. The Board is not required to attempt to sort proper from improper portions of the reply or sur-reply.

Examples of indications that a new issue has been raised in a reply include new evidence necessary to make out a *prima facie* case for the patentability or unpatentability of an original or proposed substitute claim, such as newly raised rationale to combine the prior art references that was not expressed in the petition. See *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1369–70 (Fed. Cir. 2016) (holding that the Board did not err in refusing the reply brief as improper under 37 C.F.R. § 42.23(b) because petitioner relied on an entirely new rationale to explain why one of skill in the art would have combined the references at issue). It is also improper for a reply to present new evidence (including new expert testimony) that could have been presented in a prior filing, for example newly cited prior art references intended to "gap-fill" by teaching a claim element that was not present in the prior art presented with the petition. See *Genzyme Therapeutic Prods. Ltd. v. Biomarin Pharm. Inc.*, 825 F.3d 1360, 1365–69 (Fed. Cir. 2016) (proper for Board to rely on prior art references submitted with petitioner's reply to establish the state of the art at the time of the invention in response to patent owner arguments).

-01493 IPB Motion to Strike

2. The Reply Makes New Arguments Based on New Evidence

The POR explained that the Petition: (1) never alleged that forming MgO on amorphous CoFeB would achieve polycrystalline MgO(001) (POR, 19-21); and (2) cited no evidence that a POSA reasonably expected MgO(001) would form on amorphous CoFeB (POR, 12-27). The only proper reply would have shown where the *Petition* allegedly did so. Instead the Reply makes *new* arguments: (1) Parkin discloses forming MgO(001) "over" amorphous CoFeB (Reply, 5-7); and (2) prior art disclosing that MgO(001) formed on *different* substrates provided a reasonable expectation that MgO(001) would form on amorphous CoFeB (*id.*, 7-10).

-01493 Paper 30, 4

3. New Arguments Cannot Establish *Prima Facie* Obviousness

The *Petition* must make its case "with particularity." 35 U.S.C. §312(a)(3); see also 37 C.F.R. §§42.22 (requiring a "detailed explanation") and 42.104(b)(5) (*Petition* must identify supporting evidence). The Reply impermissibly "proceed[s] in a new direction" by "rais[ing] a new issue" and relying on "new evidence" in an attempt to belatedly demonstrate the reasonable expectation of success necessary to establish *prima facie* obviousness. TPG, 73-74. That is clearly improper.

-01493 Paper 30, 8

Petitioner's New Reply Arguments Fail If Considered

Parkin Does Not Disclose Forming MgO(001) on Amorphous CoFeB

Petitioner's Sole Alleged Example of Forming MgO(001) on Amorphous CoFeB Is Parkin

Petitioner's Expert Dr. Bokor

Q. Dr. Bokor, did you look for any prior art example that expressly disclosed, explicitly disclosed forming 001 magnesium oxide on amorphous cobalt iron boron?

* * *

Q. Can you cite any example other than exhibit -- your description of Exhibit 1062, Parkin?

A. That's the main thing that I relied on. I don't have any other examples of that specific thing to point to.

EX2085 94:7-95:12, cited -01447 Paper 31, 8-9; Sur-reply, 16;
-01493 Paper 30, 8-9; Sur-reply, 18

-01493 Sur-reply

C. No Prior Art Reference Formed MgO(001) on CoFeB

Bokor found no other prior art allegedly teaching MgO(001) formed on amorphous CoFeB (EX2085, 95:7-97:1) and admitted the *sole basis* for his opinion that this was known was his contention that Parkin's Fig. 11 interface layer 520 was "optional" (EX2085, 114:17-23, 117:15-120:4). Because Parkin's Fig. 11

-01493 Sur-reply, 18

-01447 Sur-reply

C. No Prior Art Reference Formed MgO(001) on CoFeB

Bokor said Parkin Fig. 11 was the *sole* basis for his opinion that it was known to form an MgO(001) barrier on amorphous CoFeB. EX2085, 95:7-97:1 ("I don't have any other examples"), 114:17-23, 117:15-120:4. Given Parkin's

-01447 Sur-reply, 16

-01447 IPB Motion to Strike

Parkin - Bokor admitted Parkin Fig. 11 is the only prior art he alleges taught

MgO(001) on CoFeB. EX2085, 108:4-109:6, 94:4-95:9 ("I don't have any other examples"). Bokor's testimony is refuted by Parkin disclosure Bokor *ignored*. Fig.

-01447 Paper 31, 8-9; see also -01493 Paper 30 (same)

Objective Evidence Refutes Petitioner's Contention That Parkin Taught Dr. Yuasa's Inventions

-01493 IPB Motion to Strike

refute Bokor's assertion that Fig. 11's MgO(001) is formed on CoFeB. Parkin's work was as well-known in the field as the inventor Yuasa's. Reply, 27 (Parkin's work cited over four thousand times). Everyone knew their different contributions. The POR cites papers acknowledging Parkin's contributions yet attributing to Yuasa the discovery that MgO(001) could form on amorphous CoFeB. Bokor admitted (EX2085, 125:7-129:11) that EX2022 acknowledged Parkin but praised the "significance" of Yuasa's method that formed "(001) MgO texture" on CoFeB. EX2022, 106-107, 111; POR, 62. EX2023 acknowledged Parkin yet praised Yuasa's "novel idea[]" that formed MgO on "CoFeB amorphous" rather than crystalline(001) electrodes and showed "[u]pon annealing CoFeB and MgO can be crystallized." EX2023, 2; POR, 62-63; EX2085, 129:13-137:15. The Reply's arguments rest on Bokor fabricating a "teaching" in Parkin no one has ever seen.

-01493 Paper 30, 9

-01447 Sur-reply

Gao (EX2022) - Petitioner never disputes another employee—after discussing Parkin's work—praised the "significance" of Yuasa's CoFeB/MgO/CoFeB MTJ which had "strong (001) MgO texture" formed on CoFeB rather than on a crystalline(001) underlayer. POR, 64-65; EX2022, 106-107, 111; EX2085, 125:7-129:11 (admitting same).

TDK (EX2023) - Petitioner never disputes TDK—after discussing Parkin's work—praised Yuasa's "novel idea[]" that formed "simple CoFeB amorphous magnetic electrodes" rather than a more complicated crystalline(001) underlayer and showed "[u]pon annealing CoFeB and MgO can be crystallized." POR, 65; EX2023, 2; EX2085, 129:13-137:15, 138:22-139:15 (conceding this made adopting MgO MTJs "much easier" for reasons EX2023 explains).

-01447 Sur-reply, 28-29

Parkin does not teach forming MgO(001) on amorphous CoFeB (*supra* §V.B) which Park, Gao and TDK praised Yuasa for. Gao and TDK acknowledged Parkin's work (EX2022, 107 (ref. 9); EX2023, 2 (ref. 19)) but credited Yuasa, not Parkin, with forming MgO(001) on amorphous CoFeB. Parkin's disclosure of

-01447 Sur-reply, 29

Petitioner's Employees and Others Acknowledge Parkin but Credit Dr. Yuasa for Inventing CoFeB/MgO/CoFeB MTJs

EX1044 (Butler), EX1046 (Mathon),
EX1026 (Bowen)

2001

167 (EX1013) /
134 (EX1005)

2004

EX2006
(APL2005)

2005

EX2005 (Park)

2006

EX2022 (Gao)

2018

EX2023 (TDK)

2023

year

Park

In 2001, a series of theoretical calculations predicted extremely high TMR ratios for Fe/MgO/Fe MTJs, where the tunnel barrier is a crystalline MgO layer with (001) texture^{13,14}. The study argued that a
* * *
could become highly spin-dependent. In 2004, two independent experimental investigations, one using a molecular beam epitaxy (MBE) thin-film growth technique and the other using a conventional sputtering technique with specialized underlayer texturing, showed greater than 180% and 220% TMR ratios at room temperature, respectively^{18,19}. Encouraged by these two studies, a surge in research

The development of CoFeB/MgO/CoFeB tunnel junctions by Anelva²¹ provides a practical solution to overcome this difficulty. In this technique, a (CoFe)₈₀B₂₀/MgO/(CoFe)₈₀B₂₀ multilayer is deposited using conventional sputtering. At 20% B content, the as-deposited

19. Parkin, S. S. P., et al, Nat. Mater. (2004) 3, 862

EX2005 reference [21] is EX2006 (APL2005)

-01493 POR, 62;
-01447 POR, 64
EX2005, 38-39, 45, cited: -01493 POR, 37, 62 ; Sur-reply 27-29
-01447 POR, 64; Sur-reply, 29

Gao

based on this theoretical prediction.⁸ Parkin et al.⁹ demonstrated an MR ratio of 220% with fully integrated polycrystalline TMR stack of CoFe/MgO/CoFe. This result motivated many
* * *
Djayaprawira et al^{10,11} reported, in 2005, an even higher TMR ratio of 230% with a CoFeB/MgO/CoFeB MTJ. The significance of

EX2022, 107, 110, cited -01493 Sur-reply, 28-29;
-01447 Sur-reply, 29

EX2022 reference [10] is EX2006 (APL2005)

-01493 POR, 62, citing EX2022, 110;
-01447 POR, 64 (same)

TDK

[18,9]. Parkin et al. showed 220 % in highly oriented (001) CoFe/MgO/CoFe MTJs within the same year, and demonstrated that high TSP can be preserved with crystalline MgO barriers. [19]. In particular, Djavaprawira et al. obtained 230 % TMR with sputtered CoFeB/MgO/CoFeB MTJs. Their results are of significant technology importance for the magnetic recording head industry because they deposited MTJs with standard spin-valve structure technology performed at room temperature. They used a conventional sputtering method instead of an MBE system; and they achieved a giant TMR ratio with simple amorphous CoFeB ferromagnetic electrodes, instead of strenuously high temperature deposition with single crystal structures. [20] Their work made the

EX2023, 2, 7, cited -01493 Sur-reply, 28-29;
-01447 Sur-reply, 29

EX2023 reference [20] is EX2006 (APL2005)

-01447 POR, 65, citing EX2023, 7;
-01493 POR, 63 (same)

Dr. Yuasa's Inventions Received Sustained Praise from **Petitioner's Own Employees**



Zheng Gao
Western Digital

Djayaprawira et al.¹⁰ reported, in 2005, an even higher TMR ratio of 230% with a CoFeB/MgO/CoFeB MTJ. The significance of this work was not only the high MR ratio, but also that it was a fully integrated film directly produced from sensor deposition sputtering tool. Instead of a single crystalline or polycrystalline ferromagnetic layer, amorphous (*a*)-CoFeB was used to promote strong (001) MgO texture in the as-deposited state; post annealing transforms *a*-CoFeB layer from amorphous to a (001)-textured polycrystalline CoFe layer, templated from the (001)MgO layer, giving rise to the orientation relationship (001)[100]_{CoFe}//(001)[110]_{MgO} in each grain as shown in **Figure 2**.¹² In 2006, the same group reported that the MgO layer can be thinned down to the 0.4 Ω μm² range while maintaining an MR of around 50%.¹³ This *RA* range was desired for read head application.

EX2022, 106-107, cited : -01493 POR, 62; Sur-reply, 28
-01447 POR, 64-65; Sur-reply, 28-29

Dr. Bokor Agrees:

Q. And a POSA would have understood that the technique described in Yuasa's APL 2005 performing a CoFeB/MgO/CoFeb MTJ was consistent with providing a fully integrated film directly produced from sensor deposition sputtering tools; right?

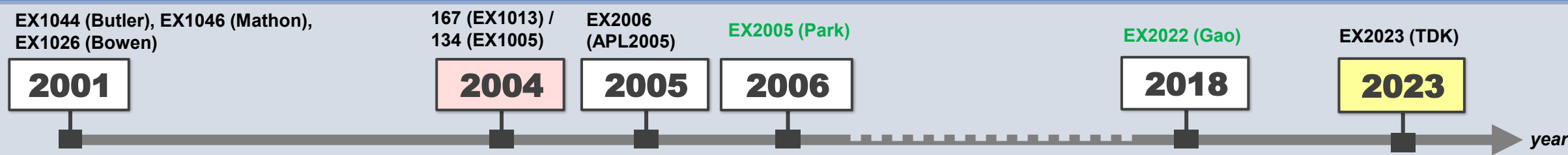
A. I think that is probably correct.

EX2085, 127:18-128:1, cited : -01493 Sur-reply, 28; -01447 Sur-reply, 28-29

EX2022 reference [10] is EX2006 (APL2005)

-01493 POR, 62, citing EX2022, 110;
-01447 POR, 64 (same)

Dr. Yuasa's Inventions Received Praise from **Petitioner's** Competitors



Dr. Bokor Agrees:

Q. Okay. And so this -- this whole sentence here, "Their work made the technology transition from aluminum oxide to magnesium oxide barrier much easier thanks to the use of simple CoFeb magnetic electrodes to preserve magnesium oxide structure from being impacted by fcc underlayers and free layer structures." Do you agree with that statement?

A. Okay. Yeah. I'll agree with that.

EX2085, 137:4-15, cited -01493 Sur-reply, 28; -01447 Sur-reply, 29

EX2023 reference [20] is EX2006 (APL2005)

-01447 POR, 65, citing EX2023, 7;
-01493 POR, 63 (same)

experimental works. In 2004, Yuasa et al. demonstrated giant TMR ratios of up to 180 % in single-crystal Fe/MgO/Fe MTJs deposited by MBE [18,9]. Parkin et al. showed 220 % in highly oriented (001) CoFe/MgO/CoFe MTJs within the same year, and demonstrated that high TSP can be preserved with crystalline MgO barriers. [19]. In particular, Djavaprawira *et al.* obtained 230 % TMR with sputtered CoFeB/MgO/CoFeB MTJs. Their results are of significant technology importance for the magnetic recording head industry because they deposited MTJs with standard spin-valve structure technology performed at room temperature. They used a conventional sputtering method instead of an MBE system; and they achieved a giant TMR ratio with simple amorphous CoFeB ferromagnetic electrodes, instead of strenuously high temperature deposition with single crystal structures. [20] Their work made the technology transition from Al2O3 to MgO barrier much easier thanks to the use of simple CoFeB amorphous magnetic electrodes to preserve MgO structure from being impacted by FCC underlayers and free layer structures. Upon annealing CoFeB and MgO can be crystallized to BCC structures. After demonstrating superior performance compared to Al2O3 TMR as shown in Fig. 2, MgO TMR became the state-of-art technology for all future spintronic devices including HDD recording read heads.

EX2023, 2, cited -01493 POR 38, 62-63, 67;
-01447 POR, 70

The Examiner Allowed the Claims over Parkin

-01493 Sur-reply

Petitioner’s *only* response alleges Parkin “already disclosed” CoFeB/MgO/CoFeB “*MTJs*” —not MTJ *manufacturing methods*—“rendering Park/Gao/TDK incapable of showing non-obviousness.” Reply, 26. Petitioner provides no analysis and cites no evidence supporting its assertion that Parkin teaches claim 1.⁶ Reply, 23-28. The Examiner disagreed. EX1013, 2 (code(56), considering EX1062).

-01493 Sur-reply, 28-29

167 Patent code(56) References Cited

7,270,896 B2 9/2007 Parkin ← **Parkin EX1062**

EX1013, code(56) at 2, cited -01493 Sur-reply, 29

-01447 Sur-reply

Petitioner’s *only* response – alleging Parkin “already disclosed” CoFeB/MgO/CoFeB MTJs “rendering these references [Park, Gao and TDK] incapable of showing non-obviousness” (Reply, 26) – fails. Petitioner provides no analysis and cites no evidence supporting its assertion that Parkin teaches claim 1.¹⁰ Reply, 23-27. The Examiner disagreed. EX1005, 2-3 (Parkin considered).

-01447 Sur-reply, 29

134 Patent code(56) References Cited

7,270,896 B2 9/2007 Parkin ← **Parkin EX1062**

EX1005, code(56) at 2, cited -01447 Sur-reply, 29

**Petitions Did Not Argue Or Show That
Parkin Fig. 3A “Inverted” Electrodes Show
Forming MgO(001) on Amorphous CoFeB**

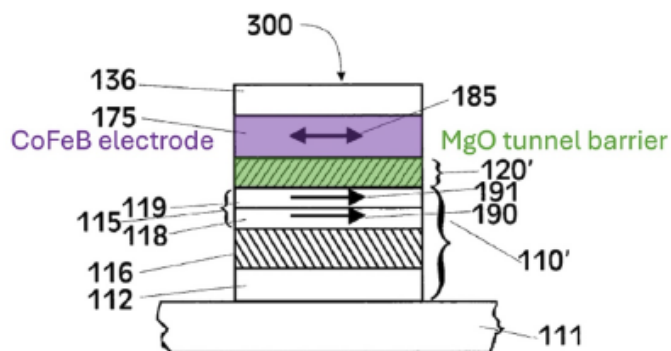
-01447: Petition Cites “Inverted” Fig. 3A Embodiment For Electrode Limitation 1[e] Not the MgO(001) Limitation 1[d]

-01447 Petition (Ground 1)

6. Claim 1[e]: “at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.”

-01447 Petition, 34

Alternatively, this limitation is also obvious over Bowen in view of Parkin. EX1024 ¶¶144-50. Parkin taught a ferromagnetic “CoFeB layer 175,” as shown in Fig. 3A below:



EX1062 at Fig. 3A (annotated), 19:16 (describing “the CoFeB layer 175” in Fig. 3A); EX1024 ¶144. Parkin’s CoFeB layer 175 adjoins the “MgO crystalline layer 120” in Figure 3A. EX1062 at 19:16-17.

-01447 Petition, 39

As explained for Bowen and Sunai, one of skill would have been motivated to replace either or both of Bowen’s electrodes with CoFeB to increase TMR and lower H_f and H_c . 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 ¶146; *KSR*, 550 U.S. at 416 (“combination of familiar elements” is obvious). Parkin itself teaches that the top and bottom electrodes in Figure 3A may be “inverted.” EX1062 at 17:7-10.

-01447 Petition, 39-40

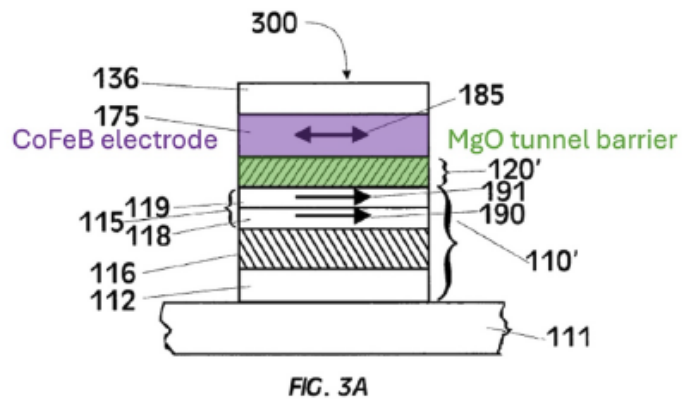
-01493: Petition Cites “Inverted” Fig. 3A for Forming Lower Electrode (1[a]) Not for Forming MgO Layer (1[b]) or Achieving MgO(001) (1[e])

-01493 Petition (Ground 1)

2. Claim 1[a]: “forming a first CoFeB layer that is amorphous;”

-01493 Petition, 22

Alternatively, this limitation is also obvious over Bowen in view of Parkin. EX1024 ¶¶131-36. Parkin taught forming an “amorphous ferromagnetic layer 175” that “may be comprised of 75 Å thick $(\text{Co}_{73}\text{Fe}_{27})_{74}\text{B}_{26}$ ” as shown in Fig. 3A below:



EX1062 at Fig. 3A (annotated), 17:42-44; *see also id.* at 19:16-17; EX1024 ¶131. Parkin taught that this “layer is formed by magnetron sputtering in a pure argon plasma where a target of composition $(\text{Co}_{70}\text{Fe}_{30})_{80}\text{B}_{20}$ is used.” EX1062 at 17:44-46. One of skill knew that CoFeB would be deposited as an amorphous layer. EX1062

at 17:40-50 (deposition of “amorphous ferromagnetic layer 175”); EX1030 ¶¶24-28; EX1055 at Abstract; EX1056 at Abstract; EX1024 ¶¶130-31.

As explained for Bowen and Sunai, one of skill would have been motivated to replace either or both of Bowen’s electrodes with CoFeB to increase TMR and lower H_f and H_c . EX1055 at 2270; EX1056 ¶¶67-68; EX1035 at 3274; EX1024 ¶132; KSR, 550 U.S. at 416. Parkin itself teaches that the top and bottom electrodes in Figure 3A may be “inverted.” EX1062 at 17:7-10.

-01493 Petition, 27

-01493 Petition, 26

Parkin Fig. 3A “inverted embodiment” Does Not Describe Forming MgO(001) on Amorphous CoFeB

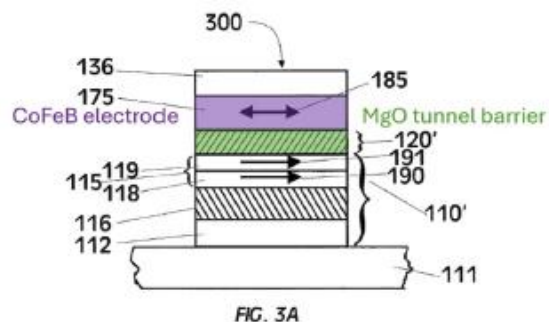
-01447 Sur-reply, 10-13

-01493 Sur-reply, 13-16

-01447 Reply

But the Petition demonstrated that Parkin showed an MgO(100) layer formed atop a CoFeB electrode and plainly met its burden for Grounds 1-2. Pet., 39-41, 60-61. Parkin indisputably disclosed forming MgO(100) atop an amorphous CoFeB

-01447 Reply, 2



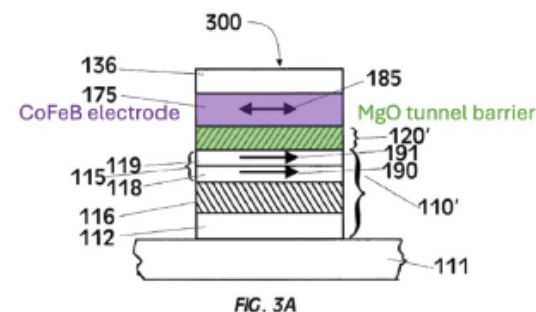
-01447 Reply, 2

The Petition showed the CoFeB storage layer 175 is beneath the MgO(100) layer in Parkin’s inverted embodiment. Pet., 40 (Ground 1 quoting EX1062, 17:7-10), 60 (Ground 2 referencing Ground 1 discussion). The Board agreed that “[w]ith this inversion” in Parkin, “layer 175 would then be located on substrate 111.” ID, 28.

-01447 Reply, 3

-01493 Reply

Parkin plainly disclosed forming MgO(100) atop an amorphous CoFeB electrode. Parkin’s Figure 3A taught a CoFeB layer 175 above a “highly (100) textured MgO layer”:



Pet., 26-28 (citing EX1062, Fig. 3A, 19:16-17); see also EX1062, 9:58-10:2 (using polycrystalline or single-crystal MgO), 18:49-51 (“highly textured (100) MgO tunnel barriers”); EX1024 ¶¶131-35; EX2018, 134:1-138:11; EX1101, 156:17-157:14 (Ross admitting Parkin’s disclosure). Parkin explained that its electrodes may be “inverted”: the lower reference electrode 115 in FIG. 3A “may be formed from one or more ferromagnetic layers 118 and 119,” or “[t]he MTJ device of FIG. 3A may also be *inverted*, such that the reference ferromagnetic electrode is formed above the tunnel barrier and *the storage layer is formed beneath the tunnel barrier.*” EX1062, 17:19-20, 17:7-10; see Pet., 27.

-01493 Reply, 6-7

Experts Agree That Inverting “Electrodes” In Parkin Fig. 3A Says Nothing About the Composition of the Layers That Form Those Electrodes

-01493 Reply

example, Parkin. EX1062, 17:7-10; *supra* §II.C. IPB agrees Parkin’s MTJ taught an “amorphous CoFeB electrode 175” in Figure 3A, POR, 15 (citing EX1062, Fig. 3A), and does not dispute that Parkin taught a lower CoFeB electrode when Figure 3A was inverted, EX1062, 17:7-20; *supra* §II.C. Everyone agrees that Parkin’s

Reply, 15

-01493 Sur-reply

Both experts refute Petitioner’s (mis)reading of Parkin’s “inverted” Fig. 3A. EX2085, 43:24-44:10 (*Bokor* admitted: “in that sentence [Parkin] is not describing the composition of the layers”), 42:8-43:9, 44:15-45:24; EX1101, 159:4-9 (Parkin “merely says the device may be inverted. It doesn’t give any further details”), 160:18-161:5 (“we don’t know which of the layers are actually flipped”).

-01447 Sur-reply, 12;
-01493 Sur-reply 14 (similar)

Petitioner’s Expert Dr. Bokor

Q. In Parkin, Exhibit 1062, column 17, line 7 through 10... Parkin is not describing the composition of those layers or the ferromagnetic electrode or the storage layer, is he?

A. In that sentence, he is not describing the composition of the layers.

EX2085, 43:24-44:14, cited -01447 Sur-reply, 13; -01493 Sur-reply, 15

Parkin (EX1062)

operation of the device. The MTJ device of FIG. 3A may also be inverted, such that the reference ferromagnetic electrode is formed above the tunnel barrier and the storage layer is formed beneath the tunnel barrier.

10

EX1062, 17:7-10

IPB’s Expert Dr. Ross

Q. Okay. And so in order -- in your mind, in order for Parkin to properly teach this, he would have had to explain how he knew that MgO(001) would grow on an amorphous cobalt iron boron layer, correct?

A. I don’t know what Parkin knew about this other than what’s in the patent. And he just says the structure may be inverted. This is a very incomplete description. For example, we don’t know which of the layers are actually flipped, every single one of them or just the storage in the reference electrode. So the person of skill in the art would not know how the MgO would grow in this inverted structure.

EX1101, 160:12-161:5, cited -01447 Sur-reply, 13; -01493 Sur-reply, 15

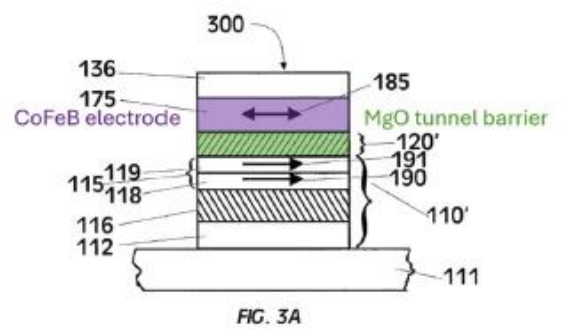
Petitions Never Argued That Parkin Fig. 11 Shows Forming MgO(001) on Amorphous CoFeB

-01447: Petitioner's Reply Arguments on "Inverted" Fig. 3A Concern MgO(001) Limitation 1[d] But Cite Petition Argument About Electrode Limitation 1[e]

-01447 Reply

But the Petition demonstrated that Parkin showed an MgO(100) layer formed atop a CoFeB electrode and plainly met its burden for Grounds 1-2. Pet., 39-41, 60-61. Parkin indisputably disclosed forming MgO(100) atop an amorphous CoFeB

-01447 Reply, 2



-01447 Reply, 2

The Petition showed the CoFeB storage layer 175 is beneath the MgO(100) layer in Parkin's inverted embodiment. Pet., 40 (Ground 1 quoting EX1062, 17:7-10), 60 (Ground 2 referencing Ground 1 discussion). The Board agreed that "[w]ith this inversion" in Parkin, "layer 175 would then be located on substrate 111." ID, 28.

-01447 Reply, 3

-01447 Petition

-01447 Pet. 39-41 are Limitation 1[e] (pp. 34-41)

6. Claim 1[e]: "at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy."

-01447 Petition, 34

B. Claim 2: "The magnetoresistive device according to claim 1, wherein said second ferromagnetic material layer is also crystallized and comprises CoFeB alloy."

-01447 Petition, 41

-01447 Pet. 60-61 are Limitation 1[e] (pp. 56-61) (Ground 2)

6. Claim 1[e]: "at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy."

-01447 Petition, 56

B. Claim 2: "The magnetoresistive device according to claim 1, wherein said second ferromagnetic material layer is also crystallized and comprises CoFeB alloy."

-01447 Petition, 61

-01447 Reply

The parties agree the Board correctly found that IPB's arguments about Parkin's "inverted" Figure 11 showed an "amorphous" "storage layer formed beneath the tunnel barrier" of MgO(100). ID, 28 (citing POPR, 47); POPR, 47

-01447 Reply, 3

-01447: The Board Recognized That -01447 POPR Argument About Fig. 11 Concerned Electrode Limitation 1[e] Not MgO(001) Limitation 1[d]

-01447 Reply

The parties agree the Board correctly found that IPB's arguments about Parkin's "inverted" Figure 11 showed an "amorphous" "storage layer formed beneath the tunnel barrier" of MgO(100). ID, 28 (citing POPR, 47); POPR, 47

-01447 Reply, 3

134 Patent claim 1

1[d] wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and

EX1005 claim 1 (-01447-Pet., xiv)

1[e] at least said first ferromagnetic material layer is crystallized and comprises CoFeB alloy.

EX1005 claim 1 (-01447-Pet., xiv)

-01447 Institution Decision

v. Limitation 1[d]

Petitioner asserts, in part, that Bowen teaches that its "tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented" by its disclosure of single-crystal epitaxially grown structures and its Fe(001)/MgO(001)/FeCo(001) epitaxial tunnel junctions structure. Pet. 32–33 (citing Ex. 1026, Abstract, 1655; Ex. 1025 ¶ 124).

Patent Owner presents no arguments specific to limitation 1[d] at this stage of the proceeding. *See generally* Prelim. Resp. We determine that, on

-01447 Paper 10 at 14, cited -01447 Sur-reply, 13-14

Patent Owner also argues that the claimed "first ferromagnetic material layer" has a specific position and Parkin's CoFeB layer does not meet the limitation, which requires that the "first ferromagnetic material layer [be] deposited on a substrate." Prelim. Resp. 44–49. Patent Owner

-01447 Paper 10 at 27

Patent Owner argues that Parkin's "references to the 'reference ferromagnetic electrode' and the 'storage layer' refer to the functions of those layers, not the material," and "[i]t is neither explicit nor inherent in Parkin that the ferromagnetic layer formed below the tunnel barrier is formed of crystalline CoFeB." Prelim. Resp. 47. Patent Owner then refers to Parkin's description of Figure 11 in the inverted form, with the storage

-01447 Paper 10 at 28, cited -01447 Reply, 3

-01447: Petitioner's Fig. 11 Argument Depends Entirely on Its Contention That CoFe(001) Layer 520 is "Optional"

-01447 Reply

Indeed, Parkin's Figure 11 confirms Figure 3A's "inverted" embodiment expressly discloses an MgO(100) layer over an amorphous CoFeB layer. Figure 11 shows the storage and reference electrodes in Figures 3A-3B's devices "inverted." EX1062, 22:29-33. "[S]torage magnetic electrode 510 is formed on the underlayer 512 by deposition of a layer 515 comprising an amorphous ferromagnetic alloy" of "CoFeB." EX1062, 22:56-58, 22:62-63. The CoFe "interface layer 520" is optional. EX1062, 22:66-67. An "MgO tunnel barrier 540" is formed atop storage layer 510, EX1062, 23:6, and a "reference magnetic electrode 560" is placed atop the MgO. EX1062, 23:15.

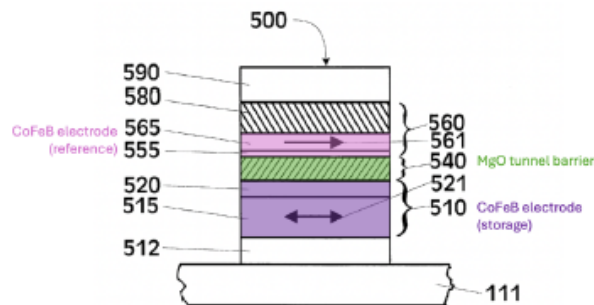


FIG. 11

EX1062, Fig. 11 (annotated).

-01447 Reply, 4; see also -01493 Reply, 7

Parkin (EX1062)

The storage magnetic electrode 510 is formed on the underlayer 512 by deposition of a layer 515 comprising an amorphous ferromagnetic alloy. The electrode may be formed from a wide variety of amorphous ferromagnetic materials but particularly the family of 3d transition metal ferromagnetic alloys combined with glass forming elements, such as B, Hf, Zr and Si. In FIG. 11 a layer 515 of CoFeB is deposited which is 60 Å thick. The composition of the layer as determined by RBS analysis is $\text{Co}_{57}\text{Fe}_{23}\text{B}_{20}$ (or $(\text{Co}_{60}\text{Fe}_{40})_{80}\text{B}_{20}$ where a sputtering target with a nominal composition of $\text{Co}_{59.5}\text{Fe}_{25.5}\text{B}_{15}$ was used). An interface layer 520 of a crystalline CoFe alloy may also be used. In

EX1062, 22:56-67, cited -01447 Sur-reply, 14; -01493 Sur-reply, 14-15

Petitioner's Expert Dr. Bokor

Q. And now I'm asking you to tell me what are the things that led you to this conclusion, other than you already told us that you think layer 520 is optional

* * *

A. But sitting here right now, I can't answer the question about what else I may have relied on for the conclusionary statement that was in my declaration.

EX2085, 118:19-120:4, cited -01447 Sur-reply, 13; -01493 Sur-reply, 15

Dr. Bokor Admits That If CoFe(001) Layer 520 Is Not Optional, Then Fig. 11 Does Not Disclose Forming MgO(001) on Amorphous CoFeB

Petitioner's Expert Dr. Bokor

Q. So in Figure 11, if layer 520 is not optional, then you agree that Figure 11 does not describe forming 100 magnesium oxide on CoFeB; right?

A. Yes. I'll have to agree with that.

EX2085, 114:17-23, cited -01447 Sur-reply, 16; -01493 Sur-reply, 18

Dr. Bokor Admits Parkin Could Be Interpreted As Saying An Alloy Other Than CoFe May Be Used For Layer 520

-01447 Sur-reply

First, Parkin's disclosure that "[a]n interface layer 520 of a crystalline *CoFe* alloy may be used" (Parkin, 22:66-67) does not say **interface layer 520** is "optional." It says **interface layer 520** "may be" *CoFe*. Stating **interface layer 520** "may be" *CoFe* comports with Parkin's disclosure that another crystalline(001) layer "may be formed from *Co₇₀Fe₃₀*" (*id.*, 13:10-13). Parkin's teaching that the crystalline(001) layer can be "formed from" different crystalline(001) materials never says **interface layer 520** is optional. EX2085, 52:3-20 (Bokor conceded POSAs could read Parkin as saying "an interface layer of something else may also be used"); 53:3-14 (similar).

-01447 Sur-reply, 15

Parkin

orientation. The layer **115** is preferably formed from a bcc alloy formed from one or more of Co and Fe. For example, layer **118** may be formed from Fe or *Co₈₄Fe₁₆* and layer **119** may be formed from *Co₇₀Fe₃₀*. The crystallographic texture

EX1062, 13:10-13

composition of *Co_{59.5}Fe_{25.5}B₁₅* was used). An interface layer **520** of a crystalline CoFe alloy may also be used. In

EX1062, 22:66-67

Petitioner's Expert Dr. Bokor

Q. Another alloy could be used for layer 520; right?

A. Well, what it says is an interface layer may also be used. Interface layer 520 could -- is described as crystalline cobalt iron alloy. So crys- -- I suppose -- I think a person of ordinary skill would understand that an interface layer of crystalline cobalt iron alloy or some -- an interface layer of something else may also be used. But I also think a person of ordinary skill reading this would understand that this layer 520 might be absent. It says it may also be used, which means it might -- it may also not be used. So the interface layer 520 is optional. And it is optionally composed of crystalline cobalt iron alloy. That's the way I read that sentence.

EX2085, 52:3-20, cited -01447 Sur-reply, 15

In -01493 Petitioner Never Argues That CoFe(001) Layer 520 is “Optional”

-01493 Reply

As IPB admits in the copending '134 IPR (IPR2024-01447, Paper 8, 47), Parkin's Figure 11 confirms Figure 3A's "inverted" embodiment expressly discloses an MgO(100) layer over an amorphous CoFeB layer:

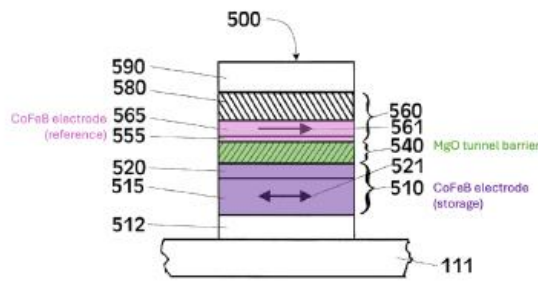


FIG. 11

EX1062, 22:29-63, 23:6-23:15, Fig. 11 (annotated); see also EX2018, 134:1-138:11.

-01493 Reply, 7

-01493 Sur-reply

3. Petitioner Mischaracterizes Fig. 11

The Petition never cited Parkin Fig. 11 or argued that crystalline(001) CoFe interface layer 520 is optional. *Supra* §V (Petition's arguments). The Reply also never argues that layer 520 is optional but cites new Bokor evidence alleging this. Reply, 7 (*citing* EX2018, 134:1-138:11). That argument cannot be incorporated by reference into the Reply. 37 C.F.R. §42.6(a)(3). This impermissible new argument should not be considered. Paper 30. If considered, it fails.

-01493 Sur-reply, 16

-01493 Sur-reply

Despite the Reply's color annotation misrepresenting CoFe(001) layer 520 as "CoFeB" (Reply, 7), bottom electrode 510 in Fig. 11 (annotated below) has amorphous CoFeB layer 515 and crystalline(001) Co₇₀Fe₃₀ interface layer 520. EX1062, 22:56-23:1, 3:24-37. MgO tunnel barrier 540 is "formed according to the methods described in" EX2080 ("835-Application) and EX2081("246-Application") which form MgO(001) on a crystalline(001) layer like interface layer 520. EX1062, 23:6-11, 3:24-37; EX2080, 35:12-18; EX2081, 91:5-21.

-01493 Sur-reply, 16

-01493 Sur-reply

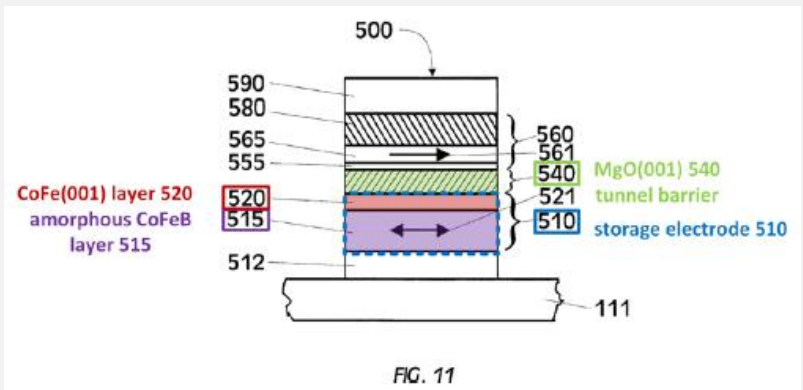


FIG. 11

-01493 Sur-reply, 17

-01493 Reply

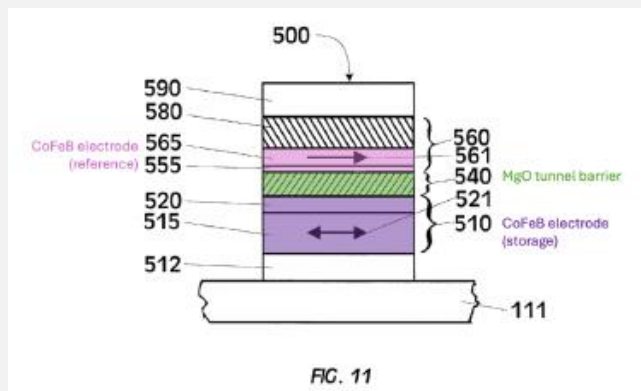


FIG. 11

-01493 Reply, 7

Parkin Teaches Forming MgO(001) Barrier 540 on Crystalline(001)

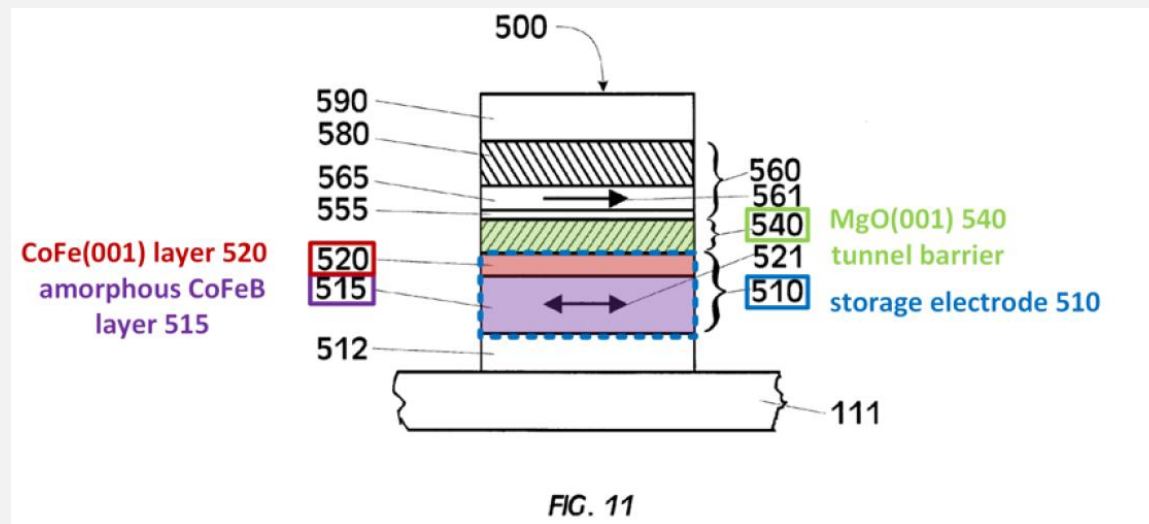
Parkin (EX1062)

U.S. patent application Ser. No. 10/824,835 to Parkin
titled “MgO tunnel barriers and method of formation” (filed 25
Apr. 14, 2004), which is hereby incorporated by reference,
discloses a method of forming a tunnel barrier comprised of
magnesium oxide (MgO) with which magnetic tunnel junc-
tions can be deposited which exhibit tunneling magnetore-
sistance values of more than 100% at low bias. The tunnel 30
barrier is formed by first depositing a thin layer of Mg using,
for example, magnetron or ion beam sputter deposition
followed by a layer of Mg deposited in the presence of
oxygen. In addition, Parkin discloses methods of forming
highly oriented crystalline MgO tunnel barriers by forming 35
the MgO barrier on a ferromagnetic electrode comprised of
a Co—Fe alloy, which is bcc and (100) textured. The CoFe
electrode is formed on a (100) oriented antiferromagnetic
layer of fcc IrMn which itself is grown highly oriented by
forming this layer on suitable underlayers, for example, a 40
combination of a TaN layer followed by a Ta layer.

EX1062, 3:24-41, cited -01493: Sur-reply, 3, 8, 14, 16, 18
-01447: Sur-reply, 2, 11, 16-17

A MgO tunnel barrier 540 is then formed according to the
methods described in U.S. patent applications Ser. No.
10/824,835 to Parkin titled “MgO tunnel barriers and
method of formation” (filed Apr. 14, 2004) and Ser. No.
10/646,246 to Parkin titled “MgO tunnel barriers and 10
method of formation” (filed Aug. 22, 2003). First a layer of

EX1062, 23:6-11, cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13



EX1062, Fig. 11 (annotated), cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13

Parkin Teaches Templating to Form MgO(001) Barrier 540 in Fig. 11

Parkin (EX1062)

Ser. No. 10/824,835 (EX2080)

Growth of IrMn on Ta leads to a (100) growth texture for the face-centered cubic (fcc) IrMn layer. The fcc lattice may be slightly distorted due to in-plane compression or expansion of the fcc lattice. The lower ferromagnetic electrode may be formed from a bilayer 115 of Co₈₄Fe₁₆ (layer 118) and Fe (layer 119). The Co₈₄Fe₁₆ layer 118 grows (100) oriented on top of the (100) textured IrMn layer 116. Then the Fe layer 119, which is grown on top of the (100) oriented Co₈₄Fe₁₆ layer 119, is bcc and also grows (100) oriented. By preparing a (100) oriented bcc template layer of Fe, the MgO deposited on top of this layer also grows (100) oriented. Thus, for this combination of layers, the MgO barrier 120' that is formed also grows textured in the (100) direction, thereby leading to high TMR. By changing the layer 112 or by changing the antiferromagnetic layer 116, the texture of the lower ferromagnetic electrode can be varied. For example, by using

EX2080, 35:10-18, cited -01493: EX2085 (Bokor Dep. Tr.), 75:2-16; Sur-reply, 14;
-01447: EX2085 (Bokor Dep. Tr.), 75:2-16; Sur-reply, 11

Parkin (EX1062)

alloys as described in U.S. patent application Ser. No. 10/824,835 to Parkin titled "MgO tunnel barriers and method of formation" (filed Apr. 14, 2004) and Ser. No. 10/646,246 to Parkin titled "MgO tunnel barriers and method of formation" (filed Aug. 22, 2003), which are hereby incorporated by reference. This surprising and unex-

EX1062, 19:1-6, cited -01493: Sur-reply, 3
-01447: Sur-reply, 2

A MgO tunnel barrier 540 is then formed according to the methods described in U.S. patent applications Ser. No. 10/824,835 to Parkin titled "MgO tunnel barriers and method of formation" (filed Apr. 14, 2004) and Ser. No. 10/646,246 to Parkin titled "MgO tunnel barriers and method of formation" (filed Aug. 22, 2003). First a layer of

EX1062, 23:6-11, cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13



Parkin Teaches Templating to Form MgO(001) Barrier 540 in Fig. 11

Parkin (EX1062)

Ser. No. 10/646,246 (EX2081)

5 The magnitude of the TMR is most sensitive to the nature of the layer 112. It seems very clear that the layer or layers 112 are preferably chosen so that the IrMn layer and the ferromagnetic pinned layers grow textured in the (100) orientation and that the ferromagnetic layer is preferably formed in the bcc crystal structure. High TMR values (compared to those possible with prior art Al₂O₃ tunnel barriers) are found for Co_{1-x} Fe_x alloys with more than about 8 atomic % Fe or for pure Fe underlayers. Ni—Fe alloys which are fcc (e.g. for permalloy, Ni₈₁Fe₁₉) give TMR values no higher than those found for prior art Al₂O₃ tunnel barriers. The method for forming MgO tunnel barriers described herein can be used for a wide variety of ferromagnetic underlayers and capping layers, with TMR values typically at least as high as those found for prior art Al₂O₃ tunnel barriers for otherwise the same structures. However, significantly enhanced TMR values compared to those for prior art Al₂O₃ tunnel barriers are found only when the texture of the ferromagnetic layer 119 and that of the MgO tunnel barrier 120' is predominantly (100). There are a wide variety of layers which give rise to (100) texture, and many of these can be used with the method of formation of the MgO tunnel barrier described herein for forming MTJs with increased TMR compared to comparable MTJs with prior art Al₂O₃ barriers.

EX2081, 91:5-21, cited -01493 Sur-reply, 16, 18;
-01447 Sur-reply, 14, 16

Parkin (EX1062)

alloys as described in U.S. patent application Ser. No. 10/824,835 to Parkin titled "MgO tunnel barriers and method of formation" (filed Apr. 14, 2004) and Ser. No. 10/646,246 to Parkin titled "MgO tunnel barriers and method of formation" (filed Aug. 22, 2003), which are hereby incorporated by reference. This surprising and unex-

EX1062, 19:1-6, cited -01493: Sur-reply, 3
-01447: Sur-reply, 2

A MgO tunnel barrier 540 is then formed according to the methods described in U.S. patent applications Ser. No. 10/824,835 to Parkin titled "MgO tunnel barriers and method of formation" (filed Apr. 14, 2004) and Ser. No. 10/646,246 to Parkin titled "MgO tunnel barriers and method of formation" (filed Aug. 22, 2003). First a layer of

EX1062, 23:6-11, cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13

Petitioner's Expert Admits He Reviewed the 10/824,835 (EX2080) and 10/646,246 (EX2081) Applications That Parkin Incorporated By Reference

Petitioner's Expert Dr. Bokor

Q. A magnesium oxide tunnel barrier 540 is then formed according to the methods described in U.S. patent application serial number 10/824,835 to Parkin and serial number 10/646,246 to Parkin. Correct?

A. That's what it says, yes.

Q. And you reviewed those applications; right?

A. Once upon a time. I have reviewed those applications actually. But I don't have them memorized. I can't answer questions about them off the top of my head, if that's where we're going to go.

EX2085, 55:5-17, cited -01447 Paper 41, 2; -01493 Paper 42, 2

Parkin (EX1062)

A MgO tunnel barrier 540 is then formed according to the methods described in U.S. patent applications Ser. No. 10/824,835 to Parkin titled "MgO tunnel barriers and method of formation" (filed Apr. 14, 2004) and Ser. No. 10/646,246 to Parkin titled "MgO tunnel barriers and method of formation" (filed Aug. 22, 2003). First a layer of

EX1062, 23:6-11, cited -01493: Sur-reply, 16-17
-01447: Sur-reply, 12-13

Dr. Bokor Knew Fig. 11 Uses the '835-Application's Method to Form MgO(001) Barrier 540 Using a Crystalline(001) Underlayer—When He Formed His Opinions

Q. All right. So the reason we've been discussing this patent application is because Parkin says, "Magnesium oxide tunnel barrier 540 that is shown in the embodiment in Figure 11 is formed according to the methods described in patent application 10/824,835." Right?

A. That's what it says.

Q. Okay. And we went through that application. And that application describes forming magnesium oxide on textured polycrystalline or single crystal ferromagnetic underlayers; right?

A. Right.

EX2085, 107:16-108:4, cited -01493 Sur-reply, 18; -01447 Sur-reply, 16

Q. So Parkin is saying a POSA that is seeking to maximize TMR would use a bcc magnetic material for a ferromagnetic underlayer; right?

A. Yeah. That's what it is saying here, yeah.

EX2085, 67:7-12, cited -01493 Sur-reply, 18; -01447 Sur-reply, 16

Q. Did you consider this description that we just read of forming a magnesium oxide on a ferromagnetic underlayer selected to be bcc and at least partially 100 oriented to improve the performance of the tunnel barrier when you formed the opinion that Parkin describes forming magnesium oxide on amorphous CoFeB?

A. I -- I guess I would have to say I considered it. I certainly was aware of it when I formed my opinion.

EX2085, 61:12-22, cited -01493 Sur-reply, 18; -01447 Sur-reply, 16

Dr. Bokor Admits That EX2080 Describes Forming MgO(001) Barrier on a Crystalline(001) Template Layer

Petitioner's Expert Dr. Bokor

Q. Okay. So now if you can go to page 35, at line 10.

A. Okay.

Q. It says that the lower ferromagnetic electrode may be formed from a bilayer 115 of cobalt sub 84, iron sub 16, parenthesis, layer 118, and iron, parenthesis, layer 119; right?

A. That's what it says.

Q. Okay. So iron is not amorphous CoFeB, is it?

THE WITNESS: I'll agree with that.

EX2085, 74:6-17, cited -01447 Paper 41, 2; -01493 Paper 42, 2

Q. "Then the iron layer 119, which is grown on top of the 100 oriented cobalt sub 84, iron sub 16, layer 119, is bcc and also grows 100 oriented." Right?

A. You read it correctly.

Q. All right. So bcc 100 iron is not amorphous CoFeB, is it?

THE WITNESS: That's true.

EX2085, 75:2-10, cited -01447 Paper 41, 2; -01493 Paper 42, 2

Parkin (EX1062)

Ser. No. 10/824,835 (EX2080)

Growth of IrMn on Ta leads to a (100) growth texture for the face-centered cubic (fcc) IrMn layer. The fcc lattice may be slightly distorted due to in-plane compression or expansion of the fcc lattice. The lower ferromagnetic electrode may be formed from a bilayer 115 of Co₈₄Fe₁₆ (layer 118) and Fe (layer 119). The Co₈₄Fe₁₆ layer 118 grows (100) oriented on top of the (100) textured IrMn layer 116. Then the Fe layer 119, which is grown on top of the (100) oriented Co₈₄Fe₁₆ layer 119, is bcc and also grows (100) oriented. By preparing a (100) oriented bcc template layer of Fe, the MgO deposited on top of this layer also grows (100) oriented. Thus, for this combination of layers, the MgO barrier 120' that is formed also grows textured in the (100) direction, thereby leading to high TMR. By changing the layer 112 or by changing the antiferromagnetic layer 116, the texture of the lower ferromagnetic electrode can be varied. For example, by using

EX2080, 35:10-18, cited -01493: EX2085 (Bokor Dep. Tr.), 75:2-16; Sur-reply, 14; -01447: EX2085 (Bokor Dep. Tr.), 75:2-16; Sur-reply, 11

Dr. Bokor Admits That EX2080 Describes Forming MgO(001) Barrier on a Crystalline(001) Template Layer

Petitioner's Expert Dr. Bokor

Q. Okay. And then the next sentence, "By preparing a 100 oriented bcc template layer of iron, the magnesium oxide deposited on top of this layer also grows 100 oriented." Right?

A. That's what it says.

Q. "Thus, for this combination of layers, the magnesium oxide barrier 120 prime that is formed also grows texture in the 100 direction, thereby leading to high TMR." Right?

A. You read it correctly.

EX2085, 75:12-21, cited -01447 Paper 41, 2; -01493 Paper 42, 2

Q. So you agree that at page 35, lines 10 to 18, Parkin is describing, in fact, controlling the texture of the lower ferromagnetic electrode by controlling layer 112 and its texture, which in turn controls the texture of the iridium-manganese layer 116, which in turn controls the texture of the lower ferromagnetic electrode; right?

THE WITNESS: This is -- this is a different embodiment. So yeah, that -- he's teaching that here.

EX2085, 97:16-98:1, cited -01447 Sur-reply, 11; -01493 Sur-reply, 14

Parkin (EX1062)

Ser. No. 10/824,835 (EX2080)

Growth of IrMn on Ta leads to a (100) growth texture for the face-centered cubic (fcc) IrMn layer. The fcc lattice may be slightly distorted due to in-plane compression or expansion of the fcc lattice. The lower ferromagnetic electrode may be formed from a bilayer 115 of Co₈₄Fe₁₆ (layer 118) and Fe (layer 119). The Co₈₄Fe₁₆ layer 118 grows (100) oriented on top of the (100) textured IrMn layer 116. Then the Fe layer 119, which is grown on top of the (100) oriented Co₈₄Fe₁₆ layer 119, is bcc and also grows (100) oriented. By preparing a (100) oriented bcc template layer of Fe, the MgO deposited on top of this layer also grows (100) oriented. Thus, for this combination of layers, the MgO barrier 120' that is formed also grows textured in the (100) direction, thereby leading to high TMR. By changing the layer 112 or by changing the antiferromagnetic layer 116, the texture of the lower ferromagnetic electrode can be varied. For example, by using

EX2080, 35:10-18, cited -01493: EX2085 (Bokor Dep. Tr.), 75:2-16; Sur-reply, 14; -01447: EX2085 (Bokor Dep. Tr.), 75:2-16; Sur-reply, 11

Petitioner's Expert Admits That EX2080 Describes Forming MgO(001) Barrier on a Crystalline(001) Template Layer

-01447 Sur-reply

[in] application [] 10/824,835" ("835-Application"). Parkin, 17:21-29. Parkin incorporates the '835-Application by reference and correctly characterizes it as forming **MgO** on a crystalline(001) layer. Parkin, 3:24-37 ("on a ferromagnetic electrode comprised of a **Co—Fe alloy**, which is **bcc and (100) textured**"); EX2053, ¶¶104-105; EX2080 ('835-Application), 26:5-19, 58:1-5, 25:8-10, 24:21-25:1, 27:10-18, 35:10-18, 45:19-46:12. Bokor admitted this. EX2085³, 55:1-56:15, 63:20-64:6, 65:21-68:7, 57:12-60:24, 68:18-70:19, 75:2-16, 97:16-98:1, 103:14-107:2.

-01447 Sur-reply, 11

Second, Petitioner's (mis)reading is inconsistent with Parkin's teaching that Fig. 11's MgO(001) is formed using the methods in EX2080-EX2081 (Parkin, 23:6-11) which *Parkin itself* says form MgO on a crystalline(001) layer (Parkin, 3:24-41). *Supra* §V.B.1 (EX2080 citations); EX2081, 91:5-21. Bokor admits Parkin says Fig. 11's MgO is made using the '835-Application's method that employs a crystalline(001) layer (EX2085, 107:8-108:4) and could not identify any disclosure in the '835-Application of forming MgO(001) on amorphous CoFeB (EX2085, 55:1-75:21, 100:21-108:4. The Reply and Bokor's declarations ignored the '835- and '246-Applications, which are dispositive of how Parkin says Fig. 11's MgO(001) layer is formed and refute Petitioner's assertion that Parkin formed MgO(001) on amorphous CoFeB.

-01447 Sur-reply, 16

**Petitioners New Reply Arguments Concerning
Forming MgO(001) on Non-CoFeB
Amorphous Substrates Fail If Considered**

Petitioner's New Reply Arguments that MgO Growth on Other Amorphous Surfaces Informed MgO Barrier Layer Formation on CoFeB Fails

1. Petitioner's New Argument and Evidence Should Not Be Considered
2. The Only Link Between The New Evidence And CoFeB is Bokor's Unreliable Naked Say-So, Which Is Inadmissible
3. Dr. Ross Explains Why There Is No Link and Her Testimony is Corroborated
4. Petitioner's Own Evidence Refutes Its New Argument

Arguments About MgO(001) Forming on Other Substrates Are Not in Petitions

-01447 Petition

5. Claim 1[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

-01447 Petition, 32; -01447 Paper 31

Further, if Sunai’s or Parkin’s CoFeB electrodes are used as described in Claims 1[e] and 2 in this Ground, one of skill would understand that the MgO could be polycrystalline or single-crystal but would still have the same (001) orientation. EX1024 ¶129; EX1062 at 9:58-10:2 (describing use of polycrystalline or single-crystal MgO), 18:49-51 (“highly textured (100) MgO tunnel barriers”); EX1005 at 4:30-32 (MgO (001), (100), (010) planes are the same).

-01447 Petition, 33-34; -01447 Paper 31

-01493 Petition

3. Claim 1[b]: “forming a magnesium oxide (MgO) layer over the first CoFeB layer;”

This limitation was taught or suggested by Bowen in view of Sunai or Parkin. EX1024 ¶¶137-40.

Bowen disclosed forming an MgO layer epitaxially over a lower ferromagnetic layer: “the *MgO barrier* is grown at 400 °C in order to obtain good crystallinity” above the “Fe bottom electrode.” EX1026 at 1655²; *see also id.* at 1655-56, Fig. 1, Abstract (describing “Fe(001)/MgO(20 Å)/FeCo(001) single-crystal epitaxial junctions”); EX1024 ¶139. As explained for Claim 1[a], one of skill would have been motivated to replace Bowen’s lower, Fe electrode with a CoFeB layer. *Supra* Claim 1[a], §VI.A.2; EX1024 ¶139.

Forming an MgO layer over a ferromagnetic layer in an MTJ was conventional. EX1013 at 1:42-46; *id.* at Figs. 8(A)-8(B); EX1045 at 8 (describing “high quality... MgO tunnel barrier”); EX1024 ¶140; *supra* §II.B.

-01493 Petition, 28-29; Paper 30

The PORs Identified this Deficiency in the Petitions

-01447 POR

A. Ground 2 Never Maps its Nagahama-Sunai/Parkin Combination to Limitation 1[d] or 3[d] that Require an MgO(001) Layer

Ground 2 alleges that Nagahama alone, *unmodified* by Sunai and/or Parkin, meets Limitations 1[d] and 3[d]. Petition, 56 and 63. Petitioner fails to even allege that *Ground 2's combination*—which modifies Nagahama based on Sunai and/or Parkin to replace Nagahama's (001)-highly-oriented lower ferromagnetic electrode with a CoFeB electrode (Petition, 56-61)—meets Limitation 1[d] or 3[d], let alone explain how or why that would have been so.

-01447 POR, 19

B. Ground 1 Fails to Show that a POSA Would Have Reasonably Expected the Bowen-Sunai/Parkin Combination to Meet the Claimed MgO(001) Layer

In Ground 1's Bowen-Sunai/Parkin Combination, the MgO layer is formed on a CoFeB layer rather than on Bowen's crystalline Fe(001) layer. Petition, 34-41 (Bowen's Fe layer is "replaced" with a CoFeB layer). Petitioner admits boron inhibits crystallization. *Id.*, 37. Petitioner fails to show that a POSA would have reasonably expected the MgO layer in its Bowen-Sunai/Parkin combination to meet the MgO(001) limitation despite being formed on a CoFeB layer. Ross, ¶101.

-01447 POR, 22

-01493 POR

- b. Petitioner does not explain the "contemplated workings of the combination" required to show a reasonable expectation of success and does not even allege that MgO deposited on amorphous CoFeB would achieve the claimed microstructure.

Second, even if the grounds were read to encompass depositing (rather than epitaxially growing) MgO on an amorphous first CoFeB layer (they do not), the Petition *does not even allege* that forming MgO on an amorphous material (e.g., the assumed CoFeB surface) would have achieved polycrystalline MgO with a microstructure meeting 1[e] or 11[b]. There is *no* "clear, evidence-supported

-01493 POR, 19

THE ONLY PROPER REPLY WOULD HAVE BEEN TO SHOW WHERE THE PETITIONS MADE THESE ARGUMENTS.

-01493 Paper 30, 4; -01447 Paper 31, 3

Replies' New Evidence Should Be Stricken

1 New Exhibits:

- Wang (EX1097)
- Inaba (EX1098)
- Tonouchi (EX1099)

2 New Bokor Testimony:

- EX2018, 134:1-138:11;
- -01447 EX1105 ¶¶6-22, 25;
- -01493 EX1105 ¶¶6-22

The Experts Agree That MgO Crystallization Depends on the Substrate Material—But Bokor Never Considered the Impact of Amorphous CoFeB

-01447 Sur-reply

In contrast, Petitioner never disputed that Ross is a world-leading expert in “materials science, thin film growth and crystal growth.” POR, 1 (citing EX2053, ¶¶2-10). Ross is unequivocal that POSAs would *not* have expected an MgO(001) barrier to form on amorphous CoFeB before Yuasa unexpectedly showed it could be done and her testimony extensively cites corroborating evidence. EX2053, ¶¶97-99, 106-171, 255-276; POR, 36-43 and 60-71.

Ross explained why Petitioner’s art disclosing crystalizing MgO on SiO₂ was not predictive of MgO crystallization on CoFeB. EX2053 ¶¶137-172. “MgO nucleation and grain growth *depended crucially* on multiple factors including” the *substrate material*. *Id.*, ¶156; POR, 39. Bokor agreed (EX2085, 154:13-155:2, 178:3-179:4) and admitted crystal growth depends “*crucially on the material of the substrate*” (*id.*, 154:13-155:2), on the “*surface energy of the substrate*” (*id.*, 158:8-18), and other parameters (*id.*, 152:17-158:18).

-01447 Sur-reply, 17-18;
-01493 Sur-reply, 19-20 (similar)

Bokor has a “*limited* understanding” of these parameters impacting crystal formation. EX2085, 156:23-157:11. In opining that POSAs would have reasonably expected MgO(001) to form on amorphous CoFeB, he did “not undertake[] a detailed analysis of the mechanism involved and all the different parameters” (*id.*, 152:17-153:15) and admitted he did not even *understand* many of the factors (*id.*, 185:10-186:3). Bokor conceded he did not consider the impact that *a different material, i.e., amorphous CoFeB*, would have had on the crystallization of MgO. *Id.*, 179:7-22, 176:10-178:4, 172:7-176:23 (admitting he did not even know what kind of bond MgO would form with CoFeB).

-01447 Sur-reply, 18;
-01493 Sur-reply, 20 (similar)

The Experts Agree That MgO Crystallization Depends on the Substrate Material

IPB's Expert Dr. Ross

164. A POSA knew that without a lattice match providing epitaxy the MgO nucleation at the amorphous surface interface would most likely have resulted in random grain orientation in the MgO. The process of MgO nucleation and grain growth depended crucially on multiple factors including the materials, surface morphology, deposition technique, deposition temperature, substrate temperature, deposition rate, and growth time. EX2048, 203. Atoms arrive on the surface, move on the surface by diffusion, and eventually form a nucleus or are incorporated into a growing grain. EX2048, 199. The sticking probability of atoms on a pre-existing nucleus depends among other factors on the orientation of the nucleus. Thus nuclei with different orientations grow at different rates and the texture of the film can evolve with thickness as the grains grow. The initial texture (if any) and the final texture depend on multiple growth and substrate factors. POSAs could not predict what crystal orientations would form on an amorphous CoFeB layer in the thicknesses typical for an MTJ barrier (i.e., less than 10 nm), or even within the first 30 nm of the film.

-01493 EX2053 ¶¶164;
-01447 EX2053 ¶¶155-156 (similar)

Petitioner's Expert Dr. Bokor

Q. Do you agree that the process of magnesium oxide nucleation in grain growth depends crucially on the material of the substrate?

A. Sure. It can -- it can depend on the material. Yes.

EX2085, 154:23-155:2, cited -01447 Sur-reply, 17-18; -01493 Sur-reply, 19-20 (similar)

Dr. Ross Explained Why A POSA Would Not Have Expected MgO(001) to Form on Amorphous CoFeB

IPB's Expert Dr. Ross

156. The process of MgO nucleation and grain growth depended crucially on multiple factors including the materials, surface morphology, deposition technique, deposition temperature, substrate temperature, deposition rate, and growth time. EX2066, 129-133, 144, 150; EX2065, S120. Atoms arrive on the surface, move on the surface by diffusion, and eventually form a nucleus or are incorporated into a growing grain. EX2048, 199. The sticking probability of atoms on a pre-existing nucleus depends among other factors on the orientation of the nucleus. Thus nuclei with different orientations grow at different rates and the texture of the film can evolve with thickness as the grains grow. The initial texture (if any) and the final texture depend on multiple growth and substrate factors. POSAs could not predict what crystal orientations would form on an amorphous CoFeB layer in the thicknesses typical for an MTJ barrier (i.e., less than 10 nm), or even within the first 30 nm of the film.

157. For thin films of the type used in MTJ devices, if the MgO layer is formed on an amorphous surface the surface effects from that amorphous surface impact crystallization in ways that produce random crystal orientations. EX2067, 621-623-25. That is why all the prior art references that relate to MTJ devices—Wulff and Yoon do not—taught that an MgO(001) layer be formed on a crystalline (001) underlayer to guide the formation of a thin film MgO(001) layer.

158. When there is no epitaxy from a lattice match the factors affecting orientation of grains in thin films on the order of 15-20 atomic layers thick, e.g., a 2 nm MgO barrier layer in an MTJ, are significantly different from the factors relevant to the orientation of films that are much thicker like those in Yoon and Wulff.

-01447 EX2053, ¶¶156-158, cited -01447 POR, 39

Dr. Ross Explained Why A POSA Would Not Have Expected MgO(001) to Form on Amorphous CoFeB

IPB's Expert Dr. Ross

159. A POSA would not have been able to predict what crystal orientations would form (nucleate) on an amorphous surface in the thicknesses used for MTJ barriers (*i.e.*, less than 10 nm) because it was known that initial crystal formation on amorphous substrates results in randomly oriented islands of crystals which may evolve into a preferred texture as the film grows thicker. EX2065 (Petrov), S118, S126; EX2067, 621-623-25. In a study of the crystalline structure of thin films of MgO deposited on amorphous substrates, IBM found that “[f]ilms [of MgO] thinner than ~500 Å [50 nm] show a random orientation.” EX2067, 625; *see*

160. “Near the substrate, the microstructure consists of randomly oriented small grains” and “[o]rientation selection during coarsening is incomplete, thus crystallites are nearly random or only weakly textured.” EX2065, S119-20; EX2067, 625 (“owing to the more or less random arrangement of the substrate atoms, no preferred orientation is induced” in the thin MgO films). Thicker films where a preferred crystalline orientation eventually formed away from the substrate do not reflect the orientation within the first 50 nm of the film – let alone within the first 10 nm. EX2067, 623 (IBM’s study indicates that MgO growth on

161. Furthermore, it was known that many variables affect crystal growth. Different combinations of temperature and growth rate could produce amorphous, polycrystalline or single crystals. EX2066 (Krikorian), 129-131, 150. Some materials have a weak interfacial interaction between the deposited material and surface and those materials can grow preferentially as (100)-oriented as the deposited material becomes thicker (more than 50 nm). EX2068, 349. But that is not true of MgO. *Id.*

162. Because of the above differences, most notably the substantial differences in MgO thickness, a POSA would have not reasonably expected success in making a crystalline MgO layer for an MTJ (of less than 10 nm) on an amorphous surface based on Wulff or Yoon’s thick-film results. Thus, a POSA would not have had a reasonable expectation that depositing MgO on amorphous CoFeB would have yielded a MgO(001) layer in Bowen’s or Nagahama’s MTJ.

-01447 EX2053, ¶¶159-162, cited -01447 POR, 39-40

Dr. Bokor Admits He Is “No Expert,” “No Crystal Grower”

Petitioner’s Expert Dr. Bokor

Q. And what if you had a crystalline layer where the lattice constant was different from the material that you hoped to crystallize on top of it?

A. Well, that’s a – that’s a very broad question. It’s – it’s – it’s a thick topic. How you -- how crystal layers grow one on top of each other when there is not commensurate lattice constants, there’s a – there’s a huge literature on that. I have – I’m somewhat familiar on it. But I’m no expert. I’m no crystal grower. And so the question of what happens in that scenario, I can’t really answer sitting here today. The answer to that, I – I’m sure -- I could prepare, you know, a whole course on that, frankly. That’s – that’s a very active -- continues to be a very active area of research, growth of crystals...

Q. Are you familiar with the concept of a composite material in the context of semiconductor fabrication?

A. Not in any detail. I’m not a materials scientist and, you know, at best I’m an amateur consumer of material science. So, you know, generally speaking I’m familiar with the term, but the details I’m not an expert in. It’s a whole field of material – I’m aware there’s a large field of material science called composite materials. I’m not -- I’m not – I’m not particularly well versed in that field.

-01447 EX2059, 42:6-21, cited -01447 POR,

EX2018, 77:9-78:3, cited -01447 POR 2; -01447 Sur-reply, 3;
-01493 POR 21; -01493 Sur-reply, 4

Dr. Bokor Admitted that Growing Crystalline MgO is Very “Complicated”

Petitioner’s Expert Dr. Bokor

Q. But you agreed with the proposition that grain formation and magnesium oxide film in nucleation depends on factors such as the material of the substrate and the diffusivity of the atom that arrives on the substrate; right?

A. I think what I testified is I agree that the deposition of a thin film can depend on those factors.

Q. And –

A. How strongly they depend on those factors varies a lot from system to system. It depends on other parameters, like temperature, gas pressure. It is a very complicated -- I certainly agree it is a very complicated business. And I’m not prepared -- I feel completely qualified to study up and testify about this topic. But I’m not prepared today to do that. I did not --

EX2018, 178:5-179:6, cited -01447 Sur-reply, 8-10;
-01493 Sur-reply, 4, 10, 12

Q. So, Dr. Bokor, if it was known in the art that magnesium oxide would form with a 100 orientation on any amorphous substrate, why would it be necessary to talk about surface deformations at all to explain that result?

A. I don’t know. I mean, this is speculation. You know, this -- this type of materials growth and analysis is a really complicated business. You know, one thing that I like about the Petroff reference that Dr. Ross cited was that if you read that reference, you get a really good sense for how complicated this business is. And the literature is full of statements, reports that are, you know, such as this Tonouchi, where people observe things and they’re not able to really explain them all the way down to the absolute, you know, littlest

EX2085, 201:14-202:7, cited -01447 Sur-reply, 8-10, 23;
-01493 Sur-reply, 10, 12, 24

Dr. Bokor Admitted MgO Crystal Growth Depends on Many Factors

Petitioner's Expert Dr. Bokor

Q. Do you agree that the process of magnesium oxide nucleation in grain growth on a surface depends crucially on multiple factors?

A. **That's a fair statement. I'll agree with that.**

EX2085, 152:20-25, cited -01447 Sur-reply, 18; -01493 Sur-reply, 20

Dr. Bokor Admitted He Has a Limited Understanding of Those Factors

Petitioner's Expert Dr. Bokor

Q. You agree that the process of magnesium oxide and grain growth depends crucially on the deposition rate?

A. I would -- like -- I think -- I think I would focus in my quibble with this sentence on the word crucially. Yes, it depends. That doesn't mean that there isn't a broad range of deposition rate that would give similar result or a broad range of any of these parameters. So that's -- that's really the way I want to answer all of these questions. Depends is rather broad. Crucially is a little too -- a little too restrictive in terms of my -- my understanding -- my limited understanding of this.

EX2085, 156:23-157:11, cited -01447 Sur-reply, 18;
-01493 Sur-reply, 20

Q. What is an interfacial free energy?

A. I'm not sure I can give you a simple explanation for that without further study.

Q. What is the surface free energy that is being referred to here?

A. Yeah. I -- I'm not prepared to give an explanation of surface free energy as we sit here right now.

EX2085, 185:10-186:3, cited -01447 Sur-reply, 18;
-01493 Sur-reply, 20

Dr. Bokor Admitted He Failed to Evaluate How Factors Crucial to Grain Formation Would Have Affected MgO Crystallizing on Amorphous CoFeB

Petitioner's Expert Dr. Bokor

Q. Okay. Do you agree that among those factors, those factors include the materials of the substrate?

A. I have not undertaken a detailed analysis of the mechanism involved and all the different parameters. I am happy to -- you know, I have given opinions based on prior art findings. I have not formed independent opinions on the mechanisms. So I don't think I can without, you know, undertaking a rather extensive independent study answer questions about the precise mechanisms for the formation of the highly oriented MgO on any particular surface. I just go by the -- the results that I have reported in my declaration.

EX2085, 153:1-17, cited -01447 Sur-reply, 18;
-01493 Sur-reply, 20

Q. So you didn't consider the -- the bonding energy -- the differences in bonding energy between cobalt iron boron and any of these other amorphous substrates with atomic magnesium or atomic oxygen that would arrive in a deposition on that substrate?

A. Let me answer the question this way: First of all, I did not undertake an independent analysis at the atomic level such as what you're describing, regarding MgO deposition on the variety of surfaces we've been discussing -- glass, silicon dioxide, soda glass, silicon nitride, cobalt iron boron. I did not undertake own independent analysis of the physics of this deposition.

EX2085, 179:7-22, cited -01447 Sur-reply, 18;
-01493 Sur-reply, 20

Dr. Bokor's New Testimony About New Evidence Is Inadmissible

Petitioner's Expert Dr. Bokor

Dr. Ross' opinion. In addition to Parkin and Nagahama, the scientific literature, including articles authored or cited by Dr. Yuasa himself, confirm that one of skill in the art would have understood that MgO grown on an amorphous substrate, such as CoFeB, would form as MgO(001) layers. Contrary to Dr. Ross' opinion, the literature describing the successful growth of MgO, including thin films less than 10 nm, confirms one of skill would have reasonably expected success in growing MgO(001) layers on amorphous substrates. I will discuss these publications below.

EX1105, ¶6, cited:
-01447 Motion to Strike (Paper 31), 1; -01447 Motion to Exclude (Paper 44), 1;
-01447 Reply, 7
-01493 Motion to Strike (Paper 30), 1; -01447 Motion to Exclude (Paper 45), 1;

-01447 Reply ISO Motion to Exclude (Paper 46), 5
-01493 Reply ISO Motion to Exclude (Paper 47), 5 (similar)

-01447 IPB Reply ISO Motion to Exclude

A. Bokor's Testimony Is Not Based on Sufficient Facts.

In EX1105 §IV (comprising ¶¶6-30), Bokor opines that a POSA “would have understood that MgO grown on an amorphous substrate, such as CoFeB, would form as MgO(001) layers.” EX1105, ¶6; Mot., 1. Bokor bases that testimony on references that studied MgO formation on materials other than CoFeB:

Reference	EX1105	Mot.	Material
Wang 1997 (EX1097)	¶¶8-11	3-4, 8	Si ₃ N ₄
Inaba (EX1098)	¶¶13-16	3-4, 6-7, 9-10	soda lime glass
Tonouchi (EX1099)	¶¶17-19	3-4, 7-10	SiO ₂ , InP, GaAs
Nagahama (EX1027)	¶¶20-22	3-4, 6-7, 9-10	amorphous MgO
Yoon (EX1040) (citing Wang 1997)	¶11	8-9	fused quartz
Wulff (EX1036) (citing Tonouchi)	¶17	8	float glass

-01447 Reply ISO Motion to Exclude (Paper 46), 2
-01493 Reply ISO Motion to Exclude (Paper 47), 2 (same)

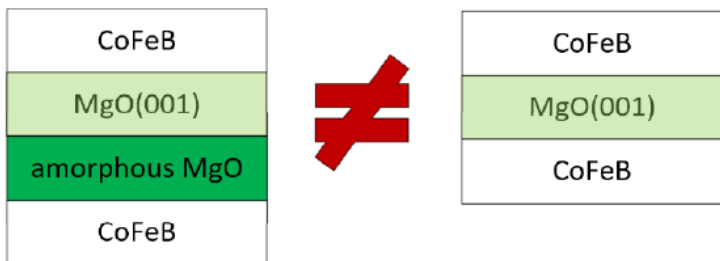
III. BOKOR'S TESTIMONY IS INADMISSIBLE.

Striking EX1105 ¶¶6-22, 25 (Paper 31) would moot IPB's Motion to Exclude.

If that evidence is not struck, then (EX1105, ¶¶6, 8-11, 13-22) are inadmissible under Rule 702. Admitting that testimony would be legal error.

The Claimed MgO(001) Barrier Layer Is Crystallized At The Interface With Each CoFeB Ferromagnetic Layer

-01447 Sur-reply



To act as an MTJ *barrier*, MgO must be crystallized at its interfaces with *both* electrodes. EX2085, 123:18-124:5 (*Bokor* admitted)⁶; EX1046, 4. *Petitioner*

-01447 Sur-reply, 21; -01493 Sur-reply, 22 (figure)

EX1046 (Mathon)

It is clear from Figs. 3 and 4 that the calculated large TMR ratio R_{TMR} in the asymptotic regime is due, entirely, to a very low spectral density of minority-spin electrons at the Γ point. To observe such a large R_{TMR} it is, therefore, essential that the Fe/MgO interface is perfect so that the theoretical minority-spin spectral density is well reproduced.

EX1046, 4, cited -01447 Sur-reply, 21; -01493 Sur-reply, 22

Petitioner's Expert Dr. Bokor

Q. So it is not only important that the ferromagnetic electrode be crystallized 100, but also that the magnesium oxide at that interface is crystallized or has a 100 texture; correct?

A. That's correct.

Q. Right at the interface?

A. Right at -- well, the MgO should be crystallized ideally all the way through. It is a thin layer, only one or two nanometers thick. The MgO ideally -- now, the patent -- Parkin does not require the MgO to be crystallized all the way through, just -- in my opinion. But yes, the MgO should be substantially crystallized.

EX2085, 123:18-124:5, cited -01447 Sur-reply, 21; -01493 Sur-reply, 22

Petitioner Mapped MgO(001) Limitations in Each Patent to Bowen and Nagahama MgO Barrier Layers

-01447 Petition

5. Claim 1[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

Bowen taught or suggested this limitation. EX1024 ¶¶123-29. As explained for Claim 1[c] in this Ground, Bowen disclosed an MgO tunnel barrier layer. *Supra* §VI.A.4; EX1024 ¶124. Bowen described a “single-crystal” MgO(001) tunnel barrier layer:

5. Claim 1[d]: “wherein said tunnel barrier layer comprises a single-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented or a poly-crystalline magnesium oxide in which (001) crystal plane is preferentially oriented, and”

Nagahama taught a polycrystalline MgO(001) tunnel barrier layer in its magnetoresistive element: “a (001)-highly-oriented MgO barrier layer.” EX1027 ¶73; EX1024 ¶¶181-82. Because single-crystal layers have the same

-01447 Petition, 32

-01447 Petition, 56

-01493 Petition

6. Claim 1[e]: “wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.”

Bowen taught or suggested this limitation. EX1024 ¶¶171-78. As explained for Claim 1[b], Bowen taught or suggested a single-crystal MgO barrier layer. *Supra* §VI.A.3; EX1026 at Abstract, 1655; EX1024 ¶172.

-01493 Petition, 33

6. Claim 1[e]: “wherein the MgO layer is poly-crystalline in which a (001) crystal plane is preferentially oriented.”

Nagahama taught or suggested this limitation. *Supra* §VII.A.3 (Claim 1[b]); EX1024 ¶¶281-83.

Nagahama taught a polycrystalline “(001)-highly-oriented MgO barrier layer” in his MTJ. EX1027 ¶73 EX1024 ¶¶282-83. Because single-crystal layers have the

-01493 Petition, 57

Nagahama (EX1027)

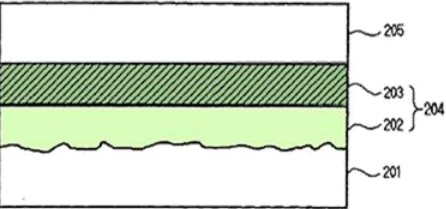
[0073] Still another magnetoresistive element was prepared which includes a (001)-highly-oriented lower ferromagnetic electrode layer, a (001)-highly-oriented MgO barrier layer, and a (001)-highly-oriented upper ferromagnetic electrode layer on the MgO double underlayer of the present invention.

Each Reply Cites Nagahama's Double Underlayer That Is Not Crystallized At the Interface with The Underlayer

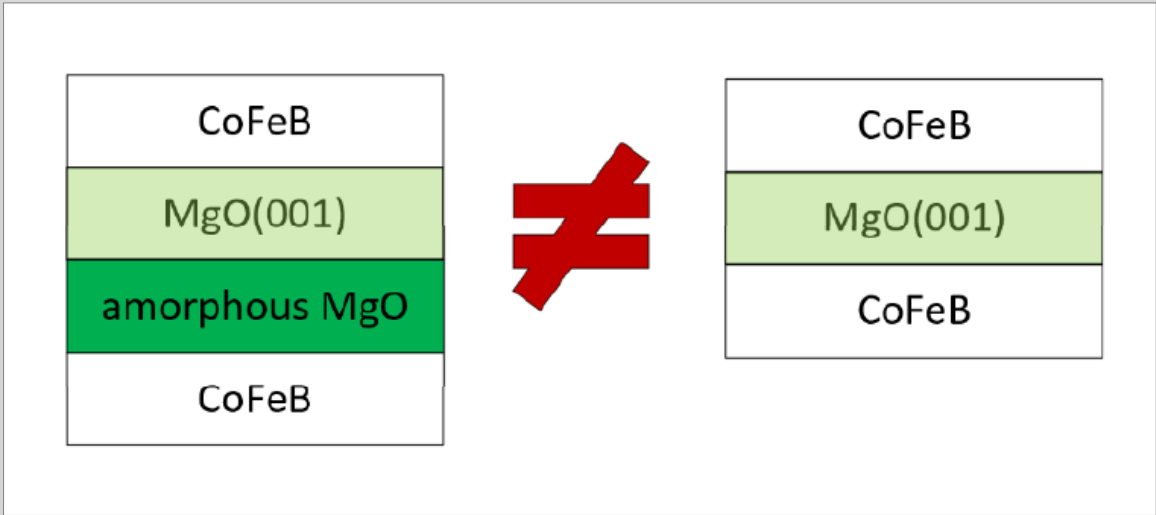
-01447 Reply

IPB and Ross admit that Nagahama taught growing MgO(001) seed layers on amorphous surfaces: “Nagahama formed a ‘MgO double underlayer’... compris[ing] an amorphous MgO [layer 202] covered by a ‘(001)-oriented highly oriented’ crystal MgO layer [203] ‘on an amorphous substrate.’” POR, 45-46 (quoting EX1027 ¶¶55-59,

FIG. 12



-01447 Reply, 6 (citing EX1105, ¶¶20-22)

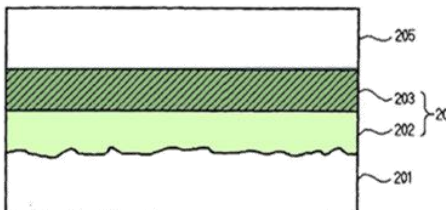


-01447 Sur-Reply, 21; -01493 Sur-Reply, 22

-01493 Reply

IPB and Ross admit that Nagahama taught growing MgO(001) seed layers on amorphous surfaces: Nagahama “form[ed] a ‘MgO double underlayer’... compris[ing] an amorphous MgO [layer 202] covered by a ‘(001)-oriented highly oriented’ crystal MgO layer [203]... ‘on an amorphous substrate.’” POR, 38-39 (quoting EX1027 ¶¶55-59,

FIG. 12



-01493 Reply, 8 (citing EX1105, ¶¶20-22)

Petitioner's Expert Dr. Bokor

structure for the rest of the MTJ. Although the MgO(001) seed layer is not a tunnel barrier layer, it proves that one of skill in the art understood that MgO(001) can be formed on any kind of substrate, and one of skill in the art would understand that MgO(001) is the same crystalline substance and structure, whether used as a seed layer or a tunnel barrier layer.

-01447 EX1105 ¶13; 01493 EX1105 ¶13

Inaba's Seed Layer Is Not Crystallized At the Interface with The Underlayer

-01447 Reply

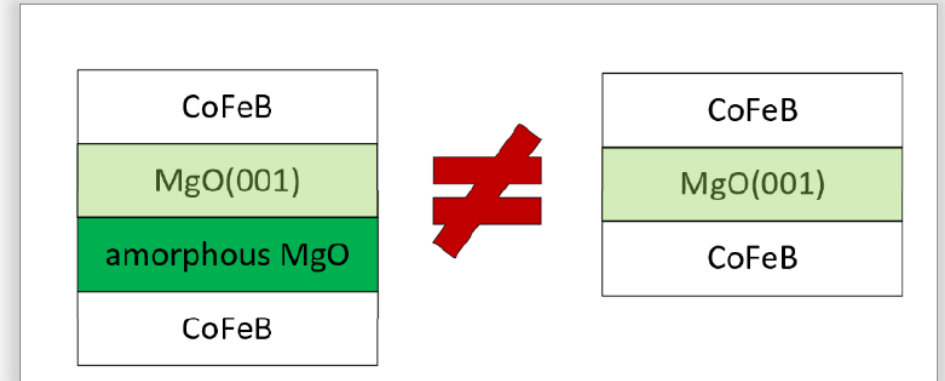
Yuasa's 2004 *Nature Materials* article (EX2008), citing Inaba 2000 (EX1098), recognized "textured Fe/MgO/Fe MTJs with (001) orientation[] [may] be prepared on *any kinds of substrates* by using a highly oriented MgO(001) seed layer." EX2008, 870 & n.21. Inaba reported, at room temperature, "prepar[ing] Co-Cr-Pt/Cr-alloy/MgO longitudinal thin film media" on thin-film "MgO seedlayers" on "glass substrates." EX1098, 2372; EX1105 ¶¶13-15. Its "10 nm-thick MgO seedlayer... shows well developed {100} texture." EX1098, 2373, Fig. 2; EX1105 ¶16.

-01447 Reply, 8

Inaba (EX1098)

lattice image around the MgO seedlayer. The Co-Cr-Pt/Cr-Ti bi-layer thin film consists of columnar crystal grains grown on the MgO seedlayer. An MgO initial layer shows no clear crystallographic structure up to around a few nm from the Si substrate, while the upper part of the MgO layer shows well developed crystal grains with {100} texture. The interface between the MgO and the Cr-Ti layers is very sharp. The cross-sectional TEM data suggest that the (100)-oriented Cr-Ti columnar and the (11.0)-oriented Co-Cr-Pt crystal grains are epitaxially grown on the MgO (100) crystal grains.

EX1098, 2373, cited -01447 Reply, 8



-01447 Sur-Reply, 21

Petitioner's Expert Dr. Bokor

structure for the rest of the MTJ. Although the MgO(001) seed layer is not a tunnel barrier layer, it proves that one of skill in the art understood that MgO(001) can be formed on any kind of substrate, and one of skill in the art would understand that MgO(001) is the same crystalline substance and structure, whether used as a seed layer or a tunnel barrier layer.

-01447 EX1105 ¶13; -01493 EX1105 ¶13

Nature Materials (EX2008) Cites Inaba's Seed Layer

-01447 Reply

Yuasa's 2004 *Nature Materials* article (EX2008), citing Inaba 2000 (EX1098), recognized "textured Fe/MgO/Fe MTJs with (001) orientation[] [may] be prepared on *any kinds of substrates* by using a highly oriented MgO(001) seed layer." EX2008, 870 & n.21. Inaba reported, at room temperature, "prepar[ing] Co-Cr-Pt/Cr-alloy/MgO longitudinal thin film media" on thin-film "MgO seedlayers" on "glass substrates." EX1098, 2372; EX1105 ¶¶13-16. Its "10 nm-thick MgO seedlayer... shows well developed {100} texture." EX1098, 2373, Fig. 2; EX1105 ¶16.

-01447 Reply, 8; -01493 Reply, 9-10

-01447 Sur-reply

Yuasa Nature Materials (EX2008)/Inaba (EX1098): EX2008 characterizes Inaba as teaching that Fe(001)/MgO(001)/Fe(001) MTJs can be prepared on any substrate using an "*MgO(001) seed layer*." EX2008, 870; Reply, 8. Like Nagahama, Inaba says MgO has no crystal structure at its interface with an amorphous underlayer and only becomes crystalline at thicknesses away from the interface. EX1098, 2373 ("MgO initial layer shows *no clear crystallographic structure* up to around a few nm from the Si substrate"). Petitioner's reliance on Inaba's seed layer fails for the same reasons as Nagahama's seed layers.

-01447 Sur-reply, 22; -01493 Sur-reply, 23

Petitioner Misrepresents Wulff Restating Text From Tonouchi As An Express Teaching

-01447 Reply

Wulff 1995 also expressly taught that “[a]part from epitaxy, MgO grows with strong preferential <100> orientation *regardless of the substrate selection*.” EX1036, 148. IPB and Ross falsely claim Wulff “discuss[ed] MgO films with thicknesses of at least 100 nm,” not “10 nm thick or less as used in MTJs.” POR, 38; EX2053 ¶145. But Wulff cited Tonouchi 1987 (EX1099), confirming this property was true for 0.5-1.0-nm-thick MgO layers. EX1105 ¶17. Tonouchi confirmed MgO(100) grew “regardless of the substrate selection” and proved it for 1-nm “(100)-oriented MgO” layers grown on amorphous “oxidized Si” substrates. EX1099, 962, 964; EX1105 ¶¶17-19. Wulff’s citation to Tonouchi proved that there was no material difference between 1- and 100-nm MgO layers. EX1105 ¶¶17-19; *see* POR, 38-39; EX2053 ¶¶145-66.

-01447 Reply, 8; -01493 Reply, 10

-01447 Sur-reply

b. Wulff (EX1036)/Tonouchi (EX1099)

Petitioner’s suggestion that Wulff taught forming MgO(001) on substrates beyond the three he studied – alumina, sapphire, and float glass (EX1036, 150) – is baseless. Reply, 8, 13. Wulff’s reference to MgO growth “regardless of the substrate selection” merely summarizes Tonouchi’s results (reference “8”) in the immediately-preceding sentence. EX1036, 148.

-01447 Sur-reply, 22; -01493 Sur-reply, 23



Wulff (EX1036)

Magnesium oxide crystallizes in the rock salt structure. It has been widely used as a substrate material for the thin film growth of high-temperature superconductors because of its lattice matching to $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ and its low chemical reactivity.¹ Recently, MgO buffer layers on silicon, fused silica and sapphire have been deposited by various methods.²⁻⁵ Strong <100> orientation of MgO was observed on alumina-coated sapphire when deposited by spray pyrolysis of $\text{Mg(2,4-pentanedionate)}_2$ from alcoholic solutions at 47 °C.⁶ Berezin *et al.*⁷ prepared MgO buffer layers on sapphire at temperatures as low as 370 °C by electron-beam evaporation. Little or no diffusion occurs between the substrate and the MgO layers. At a substrate temperature of 300 °C, MgO films were deposited on several semiconductors by r.f. sputtering of a pure MgO target.⁸ Apart from epitaxy, MgO grows with strong preferential <100> orientation regardless of the substrate selection. The authors report that the substrate

EX1036, 148

8. M. Tonouchi, Y. Sakaguchi and T. Kobayashi, *J. Appl. Phys.* **62**(3), 961 (1987).

EX1036, 154

Tonouchi's Results Contradict Petitioner's Assertion That MgO(001) Grew “regardless of substrate selection”

-01447 Reply

Wulff 1995 also expressly taught that “[a]part from epitaxy, MgO grows with strong preferential <100> orientation *regardless of the substrate selection.*” EX1036, 148. IPB and Ross falsely claim Wulff “discuss[ed] MgO films with thicknesses of at least 100 nm,” not “10 nm thick or less as used in MTJs.” POR, 38; EX2053 ¶145. But Wulff cited Tonouchi 1987 (EX1099), confirming this property was true for 0.5-1.0-nm-thick MgO layers. EX1105 ¶17. Tonouchi confirmed MgO(100) grew “regardless of the substrate selection” and proved it for 1-nm “(100)-oriented MgO” layers grown on amorphous “oxidized Si” substrates. EX1099, 962, 964; EX1105 ¶¶17-19. Wulff’s citation to Tonouchi proved that there was no material difference between 1- and 100-nm MgO layers. EX1105 ¶¶17-19; see POR, 38-39; EX2053 ¶¶145-66.

-01447 Reply, 8, citing Bokor Reply Decl. (EX1105) ¶¶17-19;
-01493 Reply, 10 (same)



EcoFactor v. Google



“Where... the relevant evidence is **contrary to a critical fact upon which the expert relied, the... court fails to fulfill its responsibility as gatekeeper by allowing the expert to testify at trial.**”

EcoFactor v. Google, 137 F.4th 1333, 1346 (Fed. Cir. 2025) (en banc),
cited -01447 Paper 44, 3-4, 6-7, 9; -01493 Paper 45, 3-4, 6-7, 9,

-01447 Sur-reply

Moreover, Petitioner falsely alleges Tonouchi “confirmed MgO(100) grew ‘regardless of the substrate’” and saw “no material difference between 1- and 100-nm MgO layers.”⁷ Reply, 8. Tonouchi acknowledged the understanding (EX2053, ¶¶145-162) that sufficiently-*thick* MgO layers form crystalline(001) and investigated whether this “maintains at one monolayer of MgO deposition.” EX1099, 962.

Tonouchi deposited MgO on multiple substrates. *Id.*, 962-964. Petitioner seizes on MgO(001) forming at the surface with one (SiO₂) which Tonouchi attributed to “structural surface deformation” which would be absent in a *flat* MTJ electrode. Reply, 8; EX1099, 964; EX2085, 201:4-22 (Bokor admitted Tonouchi did not understand why crystalline MgO formed in a thin layer on SiO₂), 192:19-23 (MTJ electrode must “be very flat”). Petitioner ignores Tonouchi’s teaching that MgO(001) did not form at the surface with other substrate materials (InP, GaAs). EX1099, 963-964. Tonouchi shows that MgO(001) formation at the interface with a substrate was substrate-dependent and refutes that MgO(001) forms “regardless of the substrate.” Reply, 8.

-01447 Sur-reply, 22-23; -01493 Sur-reply, 23-24 (similar)

Wulff and Tonouchi Do Not Teach MgO(001) Grows “regardless of substrate”

Wulff (EX1036)

dionate)₂ from alcoholic solutions at 47 °C.⁶ Berezin *et al.*⁷ prepared MgO buffer layers on sapphire at temperatures as low as 370 °C by electron-beam evaporation. Little or no diffusion occurs between the substrate and the MgO layers. At a substrate temperature of 300 °C, MgO films were deposited on several semiconductors by r.f. sputtering of a pure MgO target.⁸ Apart from epitaxy, MgO grows with strong preferential <100> orientation regardless of the substrate selection. The authors report that the substrate

8. M. Tonouchi, Y. Sakaguchi and T. Kobayashi, *J. Appl. Phys.* **62**(3), 961 (1987).

EX1036, 148, 154, cited -01447 Reply, 8; -01493 Reply, 10

Tonouchi (EX1099)

Apart from the epitaxy, MgO is known to grow with strong preferential (100) orientation regardless of the substrate selection. If this characteristic feature maintains at one monolayer of MgO deposition, it will serve as a good candidate to be the substrate for the overgrowth of the epitaxial NbN.

growth on the ultrathin MgO film. Figure 4 shows the epitaxial ratio as a function of the inserted MgO film thickness.

On the other hand, using the InP and GaAs substrates, the NbN epitaxy was not achieved on MgO film less than 30 Å

EX1099, 962-963; cited -01447 Sur-reply, 22-23; -01493 Sur-reply, 23-24 (similar)

Wang-1997 (EX1097) Formed MgO on Si₃N₄ Not Amorphous CoFeB

-01447 Reply

Well before Yuasa, Wang 1997 observed “in-plane textured (100) MgO on amorphous Si₃N₄,” and their findings had “important implications” for “real manufacturing processes, including... magnetic thin films.” EX1097, Abstract; EX1105 ¶8. Wang deposited MgO thin-films and examined their crystallinity using RHEED diffraction. EX1097, 2955; EX2053 ¶179 (Ross: “RHEED is a technique that determines the surface structure of a film....”). It found “a crystalline pattern of MgO at about 20Å [2nm],” that “suggests that the MgO molecules form well-aligned small 3D crystallites right at the inception of deposition, i.e., right at the nucleation stage.” EX1097, 2955, Fig. 1(a)-(c); EX1105 ¶¶9-11.

-01447 Reply, 7

-01447 Sur-reply

c. Wang-1997 (EX1097) Fails to Support Forming MgO(001) on Amorphous CoFeB

Petitioner cites Wang-1997’s disclosure of forming MgO(001) on Si₃N₄. Reply, 7; EX1097, 2955. Wang-1997 says nothing about MgO(001) forming on any other substrate. It is undisputed that MgO crystal formation depends on many factors including the substrate material. POR, 39-42; EX2053 ¶¶156-163. Tonouchi’s finding that MgO(001) formed on one amorphous substrate but *not* on others corroborates this. *Supra* §V.D.2.b.

Bokor never considered, and *did not even understand* many of, the factors impacting MgO crystal formation. *Supra* §§V.A, V.D.1. Petitioner cites no credible evidence establishing that POSAs would have expected Wang-1997’s teaching for Si₃N₄ (which like Tonouchi’s SiO₂ is a ceramic) to be predictive of MgO(001) forming on a very different material – CoFeB (a metal).

Moreover, Wang-1997’s process is incompatible with MTJs. EX2085, 188:12-190:14, 192:19-194:8 (Bokor could not explain how Wang-1997’s ion-beam-assisted deposition could form MTJs without damaging the ferromagnetic underlayer) which Bokor admitted must “be very flat” (*id.*, 192:19-23).

-01447 Sur-reply, 23-24

Dr. Bokor Did Not Refute That Wang's Method Was Incompatible with Making MTJs

Q. The article's title begins, "Deposition of in-plane textured magnesium oxide on amorphous silicon nitride substrates by ion-beam-assisted deposition." Correct?

A. Correct.

Q. So Exhibit 1097 used 700 electron volts argon ion energies; is that right?

A. I see that, yeah.

Q. Have you ever made an MTJ using ion-beam-assisted deposition?

A. Personally, no.

Q. Do you know anyone who has?

A. Not off the top of my head.

Q. No? Okay. What would happen if you directed a 700 electron volt argon ion beam at the surface of a cobalt iron boron underlayer?

A. I don't think I can answer that. I can't answer that question.

Q. Would you expect that you would damage the surface?

A. I don't -- I don't have an expectation. I don't know the answer to that. I haven't done the experiment. I don't recall seeing any literature on that. So I can't -- I can't answer that question definitively.

Q. Okay. If you want to maintain a very flat and uniform substrate surface, under what circumstances would you ever direct an energetic ion beam at that surface?

A. As I sit here right now, I don't have an answer to that question.

Petitioner Fails to Distinguish Dr. Ross's Explanation Why POSA's Would Have Expected That MgO Would Form With Random Orientation on Amorphous CoFeB

-01447 Reply

Petrov (EX2065) and Aboelfotoh (EX2067) provide no support that MgO would be expected to exhibit “random grain orientation” on amorphous surfaces. POR, 39 (citing EX2053 ¶¶153-63). Petrov never mentions MgO. *See* EX2065, S118, S126; EX1105 ¶25; EX2053 ¶¶153-59 (citing EX2065). Aboelfotoh 1973 observed “an initial random orientation” because his “deposition rate is relatively high for those films.” EX1104, 3735; EX1105 ¶30. Aboelfotoh’s different results under specific parameters do not override the scientific consensus regarding forming MgO(001) on amorphous substrates. EX1105 ¶¶26-30. “[T]he expectation of

-01447 Reply, 9

Aboelfotoh is -01447 EX2067

-01447 Sur-reply

Indeed, Aboelfotoh (EX2067)’s findings mirror Petrov’s for MgO – MgO formed randomly on amorphous substrates and as (001) only at thicknesses away from the substrate. POR, 38-42; EX2053, ¶¶ 157-160; EX2067, 621, 623-25.

Aboelfotoh explains *why* the substrate material matters: when factors suggest a strong bond between MgO and the amorphous material surface on which it forms POSAs expected random MgO grain orientation, whereas when those factors suggest a weak bond, MgO(001) may form at the surface. EX2067, 625. Bokor never considered Aboelfotoh’s explanation, could not explain Aboelfotoh’s factors and refused to answer whether applying Aboelfotoh’s factors to CoFeB would lead POSAs to expect random grain formation at its surface rather than (001). EX2085, 173:13-180:4, 183:24-187:22.

Petitioner’s assertion that EX1104 and “the scientific consensus regarding forming MgO(001) on amorphous substrates” override Aboelfotoh’s teaching is obfuscation. Reply, 9 (*citing* EX1104 and related Bokor testimony). EX1104 confirmed Aboelfotoh’s results because MgO layers thinner than 150 nm were “amorphous” and only thicker layers had a (111) or (001)/(200)-orientation. EX1104, 3733.

-01447 Sur-reply, 26-27

In -01493 Petitioner Misrepresents Dr. Ross's Testimony About the POSA's Expectations of MgO Formation on Amorphous CoFeB

-01493 Reply

2. Yuasa And His Cited Literature Show Growing MgO(001) On Amorphous Surfaces

Yuasa and the scientific literature contradict IPB's claim that a skilled artisan would have believed growing MgO(001) on CoFeB or other amorphous surfaces was impossible. *E.g.*, POR, 22-26. Ross' refusal to address these publications, EX1101, 104:14-105:21, 109:18-110:4, 116:6-16, 124:16-125:8, 146:9-19, shows her claim that MgO forms only "random grain orientation" on amorphous surfaces to be unreliable, EX2053 ¶¶152-67; EX1105 ¶¶25-30.

-01493 Reply, 8-9

-01493 Sur-reply

3. Ross's Testimony is Corroborated and Credible

Petitioner's allegation that Ross is "unreliable" because she allegedly said "MgO forms *only* 'random grain orientation' on amorphous surfaces" (Reply, 8-9) misrepresents her testimony. Ross testified that POSAs knew MgO "would *most likely* have resulted in random grain orientation." EX2053, ¶164. Extensive objective evidence (*supra* §VI.D.2.a) and Petitioner's references Nagahama and Inaba—which taught that MgO was amorphous/non-crystalline at its interface with many substrates—corroborate her testimony. *Supra* §VI.D.2.a- VI.D.2.b.

Petitioner's assertion that **Ross's** crystal formation testimony is "unreliable" is extraordinary. Reply, 8-9. Petitioner cites Bokor's (unqualified) testimony criticizing Ross's citation to Petrov's teaching that initial crystal formation ("nucleation") on amorphous substrates is random—not (001)—and that MgO forms as (001) only at thicknesses away from the substrate, because Petrov is not specific to MgO (POR, 23-24; EX2053, ¶¶153-167; EX2065, S118, S126). Reply, 8-9 (citing EX1105, ¶25). Despite bearing the burden, Petitioner cites no evidence suggesting that POSAs expected these fundamental crystal growth dynamics to *not* apply to MgO.

--01493 Sur-reply, 25-26

In -01493 Petitioner Does Not Dispute Dr. Ross's Explanation Why Aboelfotoh Taught that MgO Would Form as Amorphous on Amorphous CoFeB

-01493 Reply

2. Yuasa And His Cited Literature Show Growing MgO(001) On Amorphous Surfaces

Yuasa and the scientific literature contradict IPB's claim that a skilled artisan would have believed growing MgO(001) on CoFeB or other amorphous surfaces was impossible. *E.g.*, POR, 22-26. Ross' refusal to address these publications, EX1101, 104:14-105:21, 109:18-110:4, 116:6-16, 124:16-125:8, 146:9-19, shows her claim that MgO forms only "random grain orientation" on amorphous surfaces to be unreliable, EX2053 ¶¶152-67; EX1105 ¶¶25-30.

-01493 Reply, 8-9

-01493 Sur-reply

Petitioner cites Bokor's (unqualified) testimony that EX1104 refuted Aboelfotoh. Reply, 9 (*citing* EX1105, ¶¶28-30). But EX1104 *confirmed* Aboelfotoh's results because MgO layers thinner than **150 nm** were "amorphous" and only thicker films had a (111) or (001)/(200)-orientation. EX1104, 3733. It is undisputed that MTJ MgO barriers were on the order of **10 nm**. EX2053, ¶164. Aboelfotoh and EX1104 show that MgO was amorphous/non-crystalline at the thicknesses required for an MTJ. Bokor's discussion of MgO crystallizing at greater thickness is irrelevant obfuscation.

--01493 Sur-reply, 27

-01493 Sur-reply

Indeed, Aboelfotoh (EX2062)'s findings mirror Petrov's for MgO: MgO formed randomly on amorphous substrates and as (001) only at thicknesses away from the substrate. POR, 23; EX2053, ¶¶162-164; EX2062, 621-625.

Aboelfotoh explains *why* the substrate material matters: when factors suggest a strong bond between MgO and the amorphous material surface on which it forms POSAs expected random MgO grain orientation, whereas when those factors suggest a weak bond, MgO(001) may form at the surface. EX2062, 625. Bokor never considered Aboelfotoh's explanation, could not explain Aboelfotoh's factors, and refused to answer whether applying Aboelfotoh's factors to CoFeB would lead POSAs to expect random grain formation at the surface rather than (001). EX2085, 173:13-180:4, 183:24-187:22.

--01493 Sur-reply, 26-27

Aboelfotoh is -01493 EX2062

Organization

1. Dr. Yuasa's Inventions: 134 Patent (-01447), 167 Patent (-01493)

2. Petitions Are Facially Defective—For Different Reasons

2.1. 134 Patent (-01447)

- a. Ground 2 maps Limitations 1[d] / 3[d] to unmodified Nagahama
- b. Ground 1 mapping for Limitations 1[d] / 3[d] is unsupported

2.2. 167 Patent (-01493)

- a. Petitioner's expert had no idea what would have happened if a POSA tried to use the process in each combination
- b. Combinations destroy the manufacturing principle in Bowen (Ground 1) and Nagahama (Ground 2)

3. Petitioner Never Shows That POSA Had A Reasonable Expectation That MgO(001) Would Form on Amorphous CoFeB

- a. Petition arguments are unsupported
- b. Reply arguments are new and should not be considered
- c. Reply arguments fail if considered

4. Secondary Considerations Confirm That the 134 and 167 Claims Are Non-Obvious

Petitioner Fails to Refute Overwhelming Secondary Considerations Evidence

IPR2024-01447 POR, 60-71; IPR2024-01447 Sur-Reply, 28-31
IPR2024-01493 POR, 56-69; IPR2024-01493 Sur-Reply, 27-30

Dr. Yuasa's Invention Was Surprising

EX2006 (APL2005)

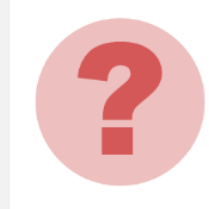
Surprisingly, the MgO layer, grown on the amorphous CoFeB layer, showed a good crystalline structure with a (001) fiber texture. The lattice image of MgO(001) can be clearly identified from the lower interface to the upper interface, indicating that the MgO(001) texture developed from the initial stage of growth, i.e., the nucleation stage. Note that MgO layer grown on amorphous Si₃N₄ substrates by ion beam assisted deposition is also (001) textured right at the inception of the deposition.¹⁴

EX2006 (APL2005) at 2, cited -01493: POR, 26-27, 59-60, 67; Sur-reply, 1, 25, 27, 30
-01447: POR, 26, 61-63, 69; Sur-reply, 24, 31

-01493 POR

structure).”). Dr. Yuasa's EX2006 paper has been cited at least 1268 times since its publication in 2005. EX2052. *See also* EX1057, 46-48 (citing EX2006 and

- 01493: POR, 26; - 01447 POR, 26 (similar)



-01493 Reply

IPB contends Yuasa's "surprising" discovery that MgO(001) could be formed on amorphous CoFeB in his APL-2005 supports its claim. POR, 26 (citing EX2006, 2). But APL-2005 refutes it by citing Wang's 1997 article (EX1097) observing successful MgO(001) growth on amorphous Si₃N₄ substrates. EX2006, 2 & n.14; EX1105 ¶¶7-8. Wang 1997 found "a crystalline pattern of MgO at about 20Å [2nm]," that "suggests that the MgO molecules form well-aligned small 3D crystallites right at the inception of [room temperature] deposition, i.e., right at the nucleation stage." EX1097, 2955, Fig. 1(a)-(c), Abstract; EX1105 ¶¶9-12; EX2053 ¶178.

- 01493: Reply, 9; - 01447: Reply, 7 (similar)

-01493 Sur-reply

d. APL (EX2006)

Petitioner's contention that Yuasa's APL paper "refutes" that MgO(001) forming on CoFeB was surprising, because APL cites Wang-1997's MgO(001) growth on amorphous Si₃N₄, is extraordinary. Reply, 9. In the *same paragraph* that cites Wang-1997, APL says: "Surprisingly, the MgO layer, grown on the amorphous CoFeB layer, showed a good crystalline structure with a (001) fiber texture." EX2006, 2. APL *confirms* Yuasa's discovery was surprising. *Infra* §VII (Petitioner never disputes this article in a *prestigious peer-reviewed journal* has been cited over a thousand times).

- 01493: Sur-reply, 25; - 01447: Sur-reply, 31 (similar)

Petitioner’s Employees and Others Acknowledge Parkin but Credit Dr. Yuasa for Inventing CoFeB/MgO/CoFeB MTJs

-01493 Sur-reply

Petitioner’s *only* response alleges Parkin “already disclosed” CoFeB/MgO/CoFeB “*MTJs*” —not MTJ *manufacturing methods*—“rendering Park/Gao/TDK incapable of showing non-obviousness.” Reply, 26. Petitioner provides no analysis and cites no evidence supporting its assertion that Parkin teaches claim 1.⁶ Reply, 23-28. The Examiner disagreed. EX1013, 2 (code(56), considering EX1062).

Parkin does not teach forming MgO(001) on amorphous CoFeB (*supra* §VI.B). Park, Gao and TDK praised *Yuasa* for this. Gao and TDK acknowledged Parkin’s work (EX2022, 107 (ref. 9); EX2023, 2 (ref. 19)) but credited *Yuasa*, not Parkin, with forming MgO(001) on amorphous CoFeB. Whether Parkin discloses individual claim *limitations*—rather than the claimed method as a whole—fails to refute nexus. *Chemours v. Daikin*, 4 F.4th 1370, 1378 (Fed. Cir. 2021).

⁶ Petitioner presented no Parkin anticipation ground.

-01493 Sur-reply, 28-29

167 Patent code(56) References Cited

7,270,896 B2 9/2007 Parkin  Parkin EX1062

EX1013, code(56) at 2, cited -01493 Sur-reply, 29

-01447 Sur-reply

Petitioner’s *only* response – alleging Parkin “already disclosed” CoFeB/MgO/CoFeB MTJs “rendering these references [Park, Gao and TDK] incapable of showing non-obviousness” (Reply, 26) – fails. Petitioner provides no analysis and cites no evidence supporting its assertion that Parkin teaches claim 1.¹⁰ Reply, 23-27. The Examiner disagreed. EX1005, 2-3 (Parkin considered). Parkin does not teach forming MgO(001) on amorphous CoFeB (*supra* §V.B) which Park, Gao and TDK praised Yuasa for. Gao and TDK acknowledged Parkin’s work (EX2022, 107 (ref. 9); EX2023, 2 (ref. 19)) but credited *Yuasa*, not Parkin, with forming MgO(001) on amorphous CoFeB. Parkin’s disclosure of individual claim limitations – not the claimed combination – fails to refute nexus.

¹⁰ Petitioner presented no Parkin anticipation ground.

-01447 Sur-reply, 29

134 Patent code(56) References Cited

7,270,896 B2 9/2007 Parkin  Parkin EX1062

EX1005, code(56) at 2, cited -01447 Sur-reply, 29

Petitioner's Employees and Others Acknowledge Parkin but Credit Dr. Yuasa for Inventing CoFeB/MgO/CoFeB MTJs

EX1044 (Butler), EX1046 (Mathon),
EX1026 (Bowen)

2001

167 (EX1013) /
134 (EX1005)

2004

EX2006
(APL2005)

2005

EX2005 (Park)

2006

EX2022 (Gao)

2018

EX2023 (TDK)

2023

year

Park

In 2001, a series of theoretical calculations predicted extremely high TMR ratios for Fe/MgO/Fe MTJs, where the tunnel barrier is a crystalline MgO layer with (001) texture^{13,14}. The study argued that a * * * could become highly spin-dependent. In 2004, two independent experimental investigations, one using a molecular beam epitaxy (MBE) thin-film growth technique and the other using a conventional sputtering technique with specialized underlayer texturing, showed greater than 180% and 220% TMR ratios at room temperature, respectively^{18,19}. Encouraged by these two studies, a surge in research

The development of CoFeB/MgO/CoFeB tunnel junctions by Anelva²¹ provides a practical solution to overcome this difficulty. In this technique, a (CoFe)₈₀B₂₀/MgO/(CoFe)₈₀B₂₀ multilayer is deposited using conventional sputtering. At 20% B content, the as-deposited

19. Parkin, S. S. P., et al, Nat. Mater. (2004) 3, 862

EX2005 reference [21] is EX2006 (APL2005)

-01493 POR, 62;
-01447 POR, 64
EX2005, 38-39, 45, cited: -01493 POR, 37, 62 ; Sur-reply 27-29
-01447 POR, 64; Sur-reply, 29

Gao

based on this theoretical prediction.⁸ Parkin et al.⁹ demonstrated an MR ratio of 220% with fully integrated polycrystalline TMR stack of CoFe/MgO/CoFe. This result motivated many * * * Djayaprawira et al^{10,11} reported, in 2005, an even higher TMR ratio of 230% with a CoFeB/MgO/CoFeB MTJ. The significance of

EX2022, 107, 110, cited -01493 Sur-reply, 28-29;
-01447 Sur-reply, 29

EX2022 reference [10] is EX2006 (APL2005)

-01493 POR, 62, citing EX2022, 110;
-01447 POR, 64 (same)

TDK

[18,9]. Parkin et al. showed 220 % in highly oriented (001) CoFe/MgO/CoFe MTJs within the same year, and demonstrated that high TSP can be preserved with crystalline MgO barriers. [19]. In particular, Djavaprawira et al. obtained 230 % TMR with sputtered CoFeB/MgO/CoFeB MTJs. Their results are of significant technology importance for the magnetic recording head industry because they deposited MTJs with standard spin-valve structure technology performed at room temperature. They used a conventional sputtering method instead of an MBE system; and they achieved a giant TMR ratio with simple amorphous CoFeB ferromagnetic electrodes, instead of strenuously high temperature deposition with single crystal structures. [20] Their work made the

EX2023, 2, 7, cited -01493 Sur-reply, 28-29;
-01447 Sur-reply, 29

EX2023 reference [20] is EX2006 (APL2005)

-01447 POR, 65, citing EX2023, 7;
-01493 POR, 63 (same)

Parkin Does Not Vitiate Nexus

-01493 Reply

d. Industry praise for APL-2005. Park (EX2005), Gao (EX2022), and TDK (EX2023) identify CoFeB-MgO-CoFeB development in the history of MTJs, POR, 62-63, but Parkin (EX1062) had already disclosed such MTJs, rendering Park/Gao/TDK incapable of showing non-obviousness, *Kao*, 639 F.3d at 1069; *see also* EX1062, 22:29-23:30, 24:24-29 (Parkin: CoFeB MTJ achieved “the highest possible TMR”).

-01493 Reply, 26

-01493 Sur-reply

Petitioner’s *only* response alleges Parkin “already disclosed” CoFeB/MgO/CoFeB “*MTJs*” —not MTJ *manufacturing methods*—“rendering Park/Gao/TDK incapable of showing non-obviousness.” Reply, 26. Petitioner provides no analysis and cites no evidence supporting its assertion that Parkin teaches claim 1.⁶ Reply, 23-28. The Examiner disagreed. EX1013, 2 (code(56), considering EX1062).

Parkin does not teach forming MgO(001) on amorphous CoFeB (*supra* §VI.B). Park, Gao and TDK praised *Yuasa* for this. Gao and TDK acknowledged Parkin’s work (EX2022, 107 (ref. 9); EX2023, 2 (ref. 19)) but credited *Yuasa*, not Parkin, with forming MgO(001) on amorphous CoFeB. Whether Parkin discloses individual claim *limitations*—rather than the claimed method as a whole—fails to refute nexus. *Chemours v. Daikin*, 4 F.4th 1370, 1378 (Fed. Cir. 2021).

⁶ Petitioner presented no Parkin anticipation ground.

-01493 Sur-reply, 28-29

167 Patent code(56) References Cited

7,270,896 B2 9/2007 Parkin ← Parkin EX1062

EX1013, code(56) at 2, cited -01493 Sur-reply, 29

