UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

SIONYX, LLC and PRESIDENT AND FELLOWS OF HARVARD COLLEGE,	)	
Plaintiffs,	)	
v.	)	**Civil Action No. 15-13488-FDS**
HAMAMATSU PHOTONICS K.K.; HAMAMATSU CORPORATION; OCEAN OPTICS, INC.; and DOES 1 THROUGH 10,	)	
Defendants.	)	

MEMORANDUM AND ORDER ON CLAIM CONSTRUCTION

SAYLOR, J.

This is a dispute between a Massachusetts technology company and a Japanese optical-device manufacturer involving an alleged misappropriation of technology and a related patent-ownership claim. Plaintiffs SiOnyx, LLC and the President and Fellows of Harvard College have brought suit against Hamamatsu Photonics K.K. ("HPK"); HPK's North American subsidiary, Hamamatsu Corporation ("HC"); Ocean Optics, Inc.; and ten unnamed customers. The second amended complaint asserts claims for correction of patent inventorship pursuant to 35 U.S.C. § 256 for nine patents assigned to HPK, patent infringement pursuant to 35 U.S.C. § 271, and breach of contract.

The parties' allegations hinge in part on the construction of the claims in twelve patents, three of which are assigned to Harvard or SiOnyx and nine of which are assigned to HPK. The Court conducted a *Markman* hearing on the construction of the relevant claims on June 22, 2017.

The parties have submitted proposed constructions for 17 terms: (1) "average," (2) "height," (3) "base," (4) "protrude above the semiconductor surface," (5) "width," (6) "undulating topography," (7) "at least a portion [of the surface layer] exhibiting an undulating topography," (8) "so as to generate," (9) "selected to," (10) "charge carriers," (11) "photosensitive imager device/photosensitive imager array," (12) "coupled to/coupling to," (13) "positioned to interact with electromagnetic radiation/in a position to interact with electromagnetic radiation," (14) "electrical transfer element/transfer element," (15) "positioned to maintain the electromagnetic radiation in the semiconductor substrate," (16) "irregular asperity," and (17) "optically exposed."

I. Background

A. Factual Background

Plaintiff SiOnyx, LLC is a limited liability company that develops technology to improve the performance of photoelectric devices. (Second Am. Compl. ¶¶ 1, 36–37, "SAC"). Plaintiff President and Fellows of Harvard College is an educational institution and charitable organization located in Cambridge, Massachusetts. (*Id.* ¶ 2). Dr. Eric Mazur is a professor of physics and applied physics at Harvard. (*Id.* ¶ 9). Dr. James Carey, III received his Ph.D. in applied physics from Harvard in 2004. (*Id.* ¶ 11).

Defendant Hamamatsu Photonics K.K. ("HPK") is a Japanese company that manufacturers optical devices, including photodiodes. (*Id.* ¶¶ 3, 54). Defendant Hamamatsu Corporation ("HC") is a subsidiary corporation based in New Jersey. (*Id.* ¶ 4).

This dispute concerns a technology for creating "black silicon," a substrate that improves the ability of silicon photoelectric devices to absorb near-infrared light. (*Id.* ¶ 36). Photoelectric devices, such as those used in digital cameras, often use silicon semiconductor technology to

convert electromagnetic radiation, such as light, into an electrical signal that can be read as an image. (Guidash Decl. ¶ 17). Historically, silicon semiconductors have had difficulty absorbing long-wavelength electromagnetic radiation, such as near-infrared and infrared radiation, because such radiation must be absorbed deeply in the silicon. (*Markman* Hearing Transcript at 12–13, "Tr."). One way of addressing that problem is to use thicker silicon, but that solution is problematic in other ways. (*Id.* at 17). Black silicon addresses that problem by employing a textured surface characterized by a plurality of approximately micrometer-sized needlelike spires. (SAC ¶ 44). The spires cause incident electromagnetic radiation to refract and redirect, causing photons to travel a longer distance, resulting in thin silicon that responds more like thick silicon. (Tr. at 17–18).

In 2006, Carey and Mazur co-founded SiOnyx in order to develop and commercialize black-silicon technology. (SAC ¶¶ 9, 11). Shortly thereafter, SiOnyx contacted HPK to explore whether HPK would be interested in using black silicon to improve the performance of its photodiode devices. (*Id*. ¶ 53). SiOnyx and HPK began to explore joint-development opportunities, and in January 2007, entered into a mutual non-disclosure agreement to facilitate the exchange of information. (*Id*. Ex. 10). Ultimately, the companies did not pursue any joint-development opportunity. Instead, in January 2008, HPK terminated the relationship, stating that it preferred to develop its own methods. (*Id*. Ex. 11).

B. Patents at Issue

Harvard is the named assignee on two patents related to black-silicon technology: U.S. Patent Nos. 7,884,446 ("the '446 patent") and 8,080,467 ("the '467 Patent"). (*Id*. ¶¶ 47–48). The '446 patent and the '467 patent are exclusively licensed to SiOnyx. (*Id*. ¶ 18). SiOnyx is the named assignee on one patent related to black silicon: U.S. Patent No. 8,680,591 ("the '591

Patent").

HPK is the named assignee on nine patents that disclose inventions similar to those disclosed in the Harvard and SiOnyx patents. Those are U.S. Patent Nos. 8,564,087 ("the '087 Patent"), 8,742,528 ("the '528 Patent"), 8,916,945 ("the '945 patent"), 8,629,485 ("the '485 Patent"), 8,884,226 ("the '226 Patent"), 8,994,135 ("the '135 Patent"), 9,190,551 ("the '551 Patent"), 9,293,499 ("the '499 Patent"), and 9,614,109 ("the '109 Patent").

1. The '446 Patent

The '446 patent is entitled "Femtosecond Laser-Induced Formation of Submicrometer Spikes on a Semiconductor Substrate." ('446 patent). It was issued on February 8, 2011. (*Id*.). It names Eric Mazur and Mengyan Shen as the inventors and Harvard as the assignee. (*Id*.).

The '446 patent is generally directed to "methods for generating submicron-sized features on a semiconductor surface by irradiating the surface with short laser pulses." (*Id.* col. 1 ll. 50–53). At the time the patent was issued, a number of other techniques were known for generating micrometer-sized structures on semiconductor substrates. (*Id.* col. 1 ll. 38–39). The '446 patent distinguishes itself from those earlier inventions by claiming to form features, such as spikes, that are "substantially smaller in size than those generated by previous techniques." (*Id.* col. 1 ll. 56–59). The features have an average height of less than about micrometer and an average width between about 100 nanometers to 500 nanometers. (*Id.* col. 8 ll. 34–36).

In one aspect, the patent provides a method for generating those features by "placing at least a portion of a surface of the substrate in contact with a fluid, and exposing that portion to one or more short laser pulses"—in a pulse width range of, for example, "about 50 femtoseconds to about a few nanoseconds." (*Id.* col. 2 ll. 1–9).

2. The ’467 Patent

The ’467 patent is entitled “Silicon-Based Visible and Near-Infrared Optoelectric Devices.” (’467 Patent). It was issued on December 20, 2011. (*Id.*). It names Mazur and Carey as the inventors and Harvard as the assignee. (*Id.*).

The ’467 patent is directed to methods of fabricating semiconductor devices that provide enhanced responsivity to long-wavelength electromagnetic radiation. (*Id.* col. 1 ll. 27–30; *id.* col. 2 ll. 44–47; Kruglick Decl. ¶ 52). The claimed method is comprised of two steps: (1) irradiating a silicon substrate with temporally short laser pulses while exposing the substrate to a substance so as to generate surface inclusions, and (2) “annealing [the] substrate at an elevated temperature and for a duration selected to enhance a density of charge carriers in [the] surface layer.” (’467 patent col. 22 ll. 39–49). The irradiation step results in improved absorptance of long-wavelength radiation, while the annealing step counteracts damage to the crystalline lattice of the semiconductor wafer caused by irradiation. (Kruglick Decl. ¶¶ 52, 53). Applying that method to a silicon wafer “can considerably enhance the responsivity of a photodetector that employs that wafer.” (*Id.* col. 16 ll. 63–66).

3. The ’591 Patent

The ’591 patent is entitled “Photosensitive Imaging Devices and Associated Methods.” (’591 patent). It was issued on March 25, 2014. (*Id.*). It names Homayoon Haddad, Jutao Jiang, Jeffrey McKee, Drake Miller, Leonard Forbes, and Chintamani Palsule as the inventors and Sionyx, Inc. as the assignee. (*Id.*).

The ’591 patent is generally directed to photosensitive devices and associated methods. (*Id.* abstract). The ’591 patent discloses, in one aspect, “a photosensitive imager device” that can include “a semiconductor substrate having multiple doped regions forming at least one junction,

a textured region coupled to the semiconductor substrate and positioned to interact with electromagnetic radiation, and an electrical transfer element coupled to the semiconductor substrate and operable to transfer an electrical signal from the at least one junction." (*Id.* col. 1 ll. 34–42). The textured region increases the absorption of long-wavelength electromagnetic radiation, allowing a relatively thin piece of silicon to behave as if it were thicker. (Guidash Decl. ¶ 25; '591 patent col. 5 ll. 45–47).

4. The HPK Patents

HPK is the named assignee on nine patents at issue in this litigation: the '087, '528, '945, '485, '226, '135, '551, '499, and '109 patents. Those patents were issued between October 22, 2013, and April 4, 2017, and claim priority to earlier Japanese patent applications. They list various individuals affiliated with Hamamatsu as inventors, but do not include Mazur or Carey as named inventors.

The HPK patents generally concern the formation of an "irregular asperity" on a semiconductor substrate in photoelectric devices. (*See, e.g.*, '528 patent abstract). They also concern the application of a "thermal treatment" to the semiconductor surface after the irregular asperity is formed. (*See, e.g.*, '945 patent abstract).

II. Legal Standard

The construction of claim terms is a question of law, which may in some cases rely on underlying factual determinations. *Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 135 S. Ct. 831, 835, 837–38 (2015); *Markman v. Westview Instruments*, 517 U.S. 370, 372 (1996) ("[T]he construction of a patent, including terms of art within its claim, is exclusively within the province of the court.").

In *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (*en banc*), the Federal Circuit

clarified the proper approach to claim construction and set forth principles for determining the hierarchy and weight of the definitional sources that give a patent its meaning. The guiding principle of construction is "the meaning that the term would have to a person of ordinary skill in the art in question at the time of . . . the effective filing date of the patent application." *Id.* at 1313. Courts thus seek clarification of meaning in "the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art." *Id.* at 1314 (quoting *Innova/Pure Water, Inc. v. Safari Water Filtration Sys., Inc.*, 381 F.3d 1111, 1116 (Fed. Cir. 2004)).

A. The Words of the Claim

The claim construction analysis normally begins with the claims themselves.[1] The claims of a patent "define the invention to which the patentee is entitled the right to exclude." *Phillips*, 415 F.3d at 1312 (citing *Innova*, 381 F.3d at 1115).

A court may construe a claim term to have its plain meaning when such a construction resolves a dispute between the parties. *See O2 Micro Int'l Ltd. v. Beyond Innovation Tech. Co.*, 521 F.3d 1351, 1361 (Fed. Cir. 2008); *see also U.S. Surgical Corp. v. Ethicon, Inc.*, 103 F.3d 1554, 1568 (Fed. Cir. 1997) ("Claim construction is a matter of resolution of disputed meanings

[1] In *Phillips*, the Federal Circuit discredited the practice of starting the claim construction analysis with broad definitions found in dictionaries and other extrinsic sources:

> [I]f the district court starts with the broad dictionary definition . . . and fails to fully appreciate how the specification implicitly limits that definition, the error will systematically cause the construction of the claim to be unduly expansive. The risk of systematic overbreadth is greatly reduced if the court instead focuses at the outset on how the patentee used the claim term in the claims, specification, and prosecution history, rather than starting with a broad definition and whittling it down.

415 F.3d at 1321. Of course, if no special meaning is apparent after reviewing the intrinsic evidence, claim construction might then "involve[] little more than the application of the widely accepted meaning of commonly understood words." *Id.* at 1314.

and technical scope, to clarify and when necessary to explain what the patentee covered by the claims, . . . [but] is not an obligatory exercise in redundancy.").

In some instances, it is the arrangement of the disputed term in the claims that is dispositive. "This court's cases provide numerous . . . examples in which the use of a term within the claim provides a firm basis for construing the term." *Phillips*, 415 F.3d at 1314. For example, because claim terms are normally used consistently throughout the patent, the meaning of a term in one claim is likely the meaning of that same term in another. *Id.* In addition, "the presence of a dependent claim that adds a particular limitation gives rise to a presumption that the limitation in question is not present in the independent claim." *Id.* at 1315.

B. The Specification

"The claims, of course, do not stand alone." *Id.* "Rather, they are part of a fully integrated written instrument, consisting principally of a specification that concludes with the claims." *Id.* (citations and quotations omitted). For that reason, the specification must always be consulted to determine a claim's intended meaning. The specification "is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term." *Id.* (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)).

"In general, the scope and outer boundary of claims is set by the patentee's description of his invention." *On Demand Mach. Corp. v. Ingram Indus., Inc.*, 442 F.3d 1331, 1338 (Fed. Cir. 2006); *see also Phillips*, 415 F.3d at 1315–17 ("[T]he interpretation to be given a term can only be determined and confirmed with a full understanding of what the inventors actually invented and intended to envelop with the claim." (quoting *Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1250 (Fed. Cir. 1998))). "[T]he specification may reveal a special definition

given to a claim term by the patentee that differs from the meaning it would otherwise possess." *Phillips*, 415 F.3d at 1316. It may also reveal "an intentional disclaimer, or disavowal, of claim scope by the inventor." *Id.* Therefore, the claims are to be construed in a way that makes them consistent with, and no broader than, the invention disclosed in the specification. *On Demand*, 442 F.3d at 1340 ("[C]laims cannot be of broader scope than the invention that is set forth in the specification."); *Phillips*, 415 F.3d at 1316 ("[C]laims must be construed so as to be consistent with the specification, of which they are a part." (quoting *Merck & Co. v. Teva Pharm. USA, Inc.*, 347 F.3d 1367, 1371 (Fed. Cir. 2003))).

Nevertheless, courts must be careful to "us[e] the specification [only] to interpret the meaning of a claim" and not to "import[] limitations from the specification into the claim." *Id.* at 1323. A patent's "claims, not specification embodiments, define the scope of patent protection." *Kara Tech. Inc. v. Stamps.com Inc.*, 582 F.3d 1341, 1348 (Fed. Cir. 2009); *see also Martek Biosciences Corp. v. Nutrinova, Inc.*, 579 F.3d 1363, 1381 (Fed. Cir. 2009) ("[E]mbodiments appearing in the written description will not be used to limit claim language that has broader effect."). "In particular, [the Federal Circuit] ha[s] expressly rejected the contention that if a patent describes only a single embodiment, the claims of the patent must be construed as being limited to that embodiment." *Phillips*, 415 F.3d at 1323. This is "because persons of ordinary skill in the art rarely would confine their definitions of terms to the exact representations depicted in the embodiments." *Id.*

Although this distinction "can be a difficult one to apply in practice[,] . . . the line between construing terms and importing limitations can be discerned with reasonable certainty and predictability if the court's focus remains on understanding how a person of ordinary skill in the art would understand the claim terms." *Id.* "The construction that stays true to the claim

language and most naturally aligns with the patent's description of the invention will be, in the end, the correct construction." *Id.* at 1316 (quoting *Renishaw*, 158 F.3d at 1250).

C. The Prosecution History

After the specification and the claims themselves, the prosecution history is the next best indicator of term meaning. The prosecution history "consists of the complete record of the proceedings before the PTO and includes the prior art cited during the examination of the patent." *Id.* at 1317. "Like the specification, the prosecution history provides evidence of how the PTO and the inventor understood the patent." *Id.* "[T]he prosecution history can often inform the meaning of the claim language by demonstrating how the inventor understood the invention and whether the inventor limited the invention in the course of prosecution, making the claim scope narrower than it would otherwise be." *Id*.

However, "because the prosecution history represents an ongoing negotiation between the PTO and the applicant, rather than the final product of that negotiation, it often lacks the clarity of the specification and thus is less useful for claim construction purposes." *Id.* As a result, courts generally require that "a patent applicant . . . clearly and unambiguously express surrender of subject matter" to disavow claim scope during prosecution. *Voda v. Cordis Corp.*, 536 F.3d 1311, 1321 (Fed. Cir. 2008) (quoting *Sorensen v. Int'l Trade Comm'n*, 427 F.3d 1375, 1378–79 (Fed. Cir. 2005)).

D. Extrinsic Sources

Extrinsic evidence consists of "all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, and learned treatises." *Phillips*, 415 F.3d at 1317 (quoting *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 980 (Fed. Cir. 1995)). It "can help educate the court regarding the field of the invention and can help the court determine

what a person of ordinary skill in the art would understand claim terms to mean." *Id.* at 1319. However, extrinsic evidence suffers from a number of defects, including its independence from the patent, potential bias, and varying relevance. *Id.* at 1318–19. Such evidence is therefore "unlikely to result in a reliable interpretation of patent claim scope unless considered in the context of the intrinsic evidence," and courts may consider, or reject, such evidence at their discretion. *Id.* at 1319.

III. Analysis

There are 17 terms at issue in the patents:

Term	**Plaintiffs' construction**	**Defendants' construction**	**Patent Number**
"Average"	"a single value that summarizes or represents the general significance of a set of unequal values"	"a sum of all (heights/widths) of all features divided by the number of features," or indefinite	'446
"Height"	"separation between base and tip"	"a linear dimension of a feature measured from a tip to a base that is defined by the lowest point in the trough directly adjacent to the feature"	'446
"Base"	plain and ordinary meaning	"lowest point in the trough directly adjacent to a feature"	'446
"Protrude above the semiconductor surface"	"extend above the original surface of the semiconductor"	*see* "Height"	'446
"Width"	"diameter of a cross-section of a spike, substantially parallel to the substrate surface, at a location half way between the base and the tip"	"a largest linear dimension, taken substantially parallel to the substrate surface, of a cross-section of a feature at a location half way between a base and a tip of the feature"	'446
"Undulating topography"	"arrangement of features of varying heights and widths"	"variations in height"	'446
"At least a portion [of the surface	plain and ordinary meaning in view of plaintiffs'	"the textured region having variations in height"	'446

layer] exhibiting an undulating topography"	proposed construction of "undulating topography"		
"So as to generate"	plain and ordinary meaning	"for the purpose of generating"	'467
"Selected to"	plain and ordinary meaning	"intentionally chosen"	'467
"Charge carriers"	"electrons or holes"	"electrons or holes contributed by the surface inclusions"	'467
"Photosensitive imager device/ photosensitive imager array"	"sensor that converts incident radiation into a digital image"	"a device that absorbs and detects electromagnetic radiation/an array of the photosensitive imager devices"	'591
"Coupled to/ coupling to"	"in contact with, directly or indirectly"	"affixed or joined to"	'591
"Positioned to interact with electromagnetic radiation/in a position to interact with electromagnetic radiation"	"located to provide enhanced response to and/or filtering of electromagnetic radiation"	"located on the substrate for the purpose of receiving electromagnetic radiation"	'591
"Electrical transfer element/transfer element"	"component of integrated circuitry used to read or transfer charge or signal from a photosensitive pixel"	"an electrical conductor for transferring an electrical signal from one component to another"	'591
"Positioned to maintain the electromagnetic radiation in the semiconductor substrate"	"positioned on the device in a region other than the radiation incident surface to reflect or retain the electromagnetic radiation in the substrate"	"located for the purpose of reflecting electromagnetic radiation back toward the semiconductor substrate"	'591
"Irregular asperity"	"surface characterized by features of various sizes"	"surface roughness with random variations in characteristics"	HPK patents
"Optically exposed"	plain and ordinary meaning	"in contact with ambient gas or covered by an optically transparent film"	HPK patents

A. <u>The '446 Patent</u>

There are seven terms at issue in the '446 patent: (1) "average," (2) "height," (3) "base," (4) "protrude above the semiconductor surface," (5) "width," (6) "undulating

topography," (7) "at least a portion [of the surface layer] exhibiting an undulating topography." Those terms appear in claims 1, 5, 6, 8, 9 and 11. Their use in claims 1, 5, 6, and 11 is illustrative. Claim 1 recites:

> A semiconductor substrate, comprising
>
> > a surface layer having **at least a portion exhibiting an undulating topography** characterized by a plurality of submicron-sized features having an **average height** less than about 1 micrometer and an **average width** in a range of about 100 nm to about 500 nm.

'446 patent col. 8 ll. 31–36 (emphasis added). Claim 5 recites:

> The semiconductor substrate of claim 1, wherein said submicron-sized features comprise spikes extending from a **base** to a tip separated from the **base** by a distance less than about 1 micrometer.

Id. col. 8 ll. 44–47 (emphasis added). Claim 6 recites:

> The semiconductor substrate of claim 5, wherein said spikes **protrude above the semiconductor surface** by a distance in a range of about 100 nm to about 300 nm.

Id. col. 8 ll. 48–50 (emphasis added). Claim 11 recites:

> The semiconductor substrate of claim 1, wherein said submicron-sized features have an **average width** in a range of about 100 nm to about 300 nm.

Id. col. 8 ll. 63–65 (emphasis added).

1. <u>Average</u>

Term	**Plaintiffs' construction**	**Defendants' construction**
"Average"	"a single value that summarizes or represents the general significance of a set of unequal values"	"a sum of all (heights/widths) of all features divided by the number of features," or indefinite

The parties dispute whether the term "average" is used in the patent to connote a representative value among a set of unequal values, or whether it is a calculable figure equaling the arithmetic mean.[2]

Neither party has argued that "average" has any special or idiosyncratic meaning in the art. Where the "claim language as understood by a person of skill in the art [is] readily apparent even to lay judges, . . . claim construction . . . involves little more than the application of the widely accepted meaning of commonly understood words." *Phillips*, 415 F.3d at 1314. Under such circumstances, it may be appropriate to consult general-purpose dictionaries. *Id.*

The parties advance different methods for calculating "average" as used in the claims. Plaintiffs contend that pursuant to the ordinary meaning of the term, "average" may be calculated by at least three methods: finding the arithmetic mean, the median, and the mode. Kruglick Decl. ¶ 35; Tr. 82–83. They further contend that the key concept concerning the term "average" is that it connotes a varied, as opposed to a homogenous, set. Defendants contend that the most common understanding of the term is that it equals the arithmetic mean. Def. Opening *Markman* Brief at 7, ECF 176. Both parties point to the same Merriam-Webster dictionary definition in support of their proposed definitions. *Id.* Ex. 2–3; Kruglick Decl. ¶ 35.

The Merriam-Webster dictionary definition of "average," when used as a noun, has a primary definition of "a single value (such as a mean, mode, or median) that summarizes or represents the general significance of a set of unequal values," and a secondary definition of "an estimation of or approximation to an arithmetic mean." Def. Opening *Markman* Brief Ex. 2–3. However, the term "average" as used in the claims is not a noun; it is an adjective. The primary

[2] Arithmetic mean is calculated by "dividing the sum of a set of terms by the number of terms." *Arithmetic Mean*, MERRIAM-WEBSTER.COM, https://www.merriam-webster.com/dictionary/arithmetic%20mean (last visited Sept. 6, 2017).

definition of "average" when used as an adjective is "equaling an arithmetic mean." *Id*. Other courts have found that the plain and ordinary meaning of "average," at least when used as an adjective, is "arithmetic mean." *See Biopolymer Eng'g, Inc. v. Immunocorp,* 2007 WL 4562592, at *11 (D. Minn. Dec. 21, 2007) ("As to 'average,' its ordinary meaning is an arithmetic mean."). Therefore, the definition to which both parties point provides strong evidence that "average" means "arithmetic mean."

The specification and claim terms provide further support for the conclusion that "average" signifies a single calculable figure, rather than a general linguistic concept connoting typicality among a varied set. The specification uses both the words "typical" and "average" to describe the height and width of features under different circumstances. *See '*446 patent col. 6 ll. 11–13 (describing certain figures as depicting spikes with "a typical height of about 500 nm and a typical diameter of about 200 nm"). The use of the term "typical" in the specification suggests that the patentee knew how to clearly connote typicality among a varied set where that was meant. In addition, the claims specify a numerical range within which the average height and width of features falls. *See id.* col. 8 ll. 31–36 (defining the average height of the features is "less than about 1 micrometer" and the average width of the features is "in a range of about 100 nm to 500 nm"). That context further supports the conclusion that "average" is used according to its ordinary meaning to identify a single calculable figure, rather than the concept of typicality.

Accordingly, the term "average" will be construed to mean "arithmetic mean."

2. <u>Height and Base</u>

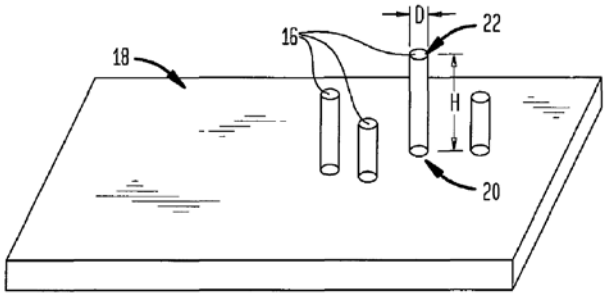
Term	**Plaintiffs' construction**	**Defendants' construction**
"Height"	"separation between base and tip"	"a linear dimension of a feature measured from a tip to a base that is defined by the lowest point in the trough directly adjacent to the feature"

"Base"	plain and ordinary meaning	"lowest point in the trough directly adjacent to a feature"

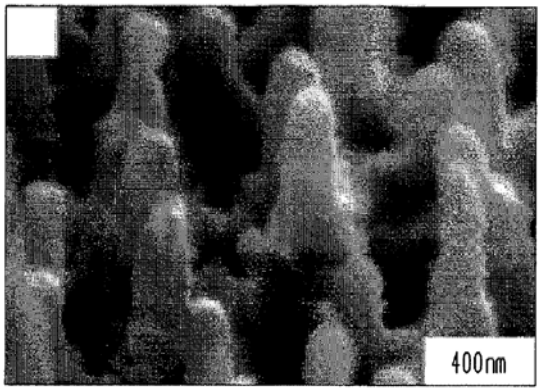
It appears that there are no substantive differences between plaintiffs' and defendants' positions concerning the proper construction of the terms "height" and "base."

The parties agree that "height" is measured by finding the separation between the base of the feature and the tip. That definition is consistent with the ordinary meaning of the term and the specification. *See* '446 patent col. 1 ll. 61–62 (speaking of "the average height of the spikes (i.e., the average separation between the base and the tip)"). The dispute concerns "how to select the base from which to measure." Def. Rebuttal *Markman* Brief at 7, ECF 189. Plaintiffs contend that the term "base" needs no additional construction, as a person of ordinary skill in the art would understand the term in context. Defendants contend that "base" should be defined by the lowest point of the nearest surrounding trough.

The meaning of "base" would be obvious if the features emerged from an even plane, as the schematic in figure 2 of the patent depicts:

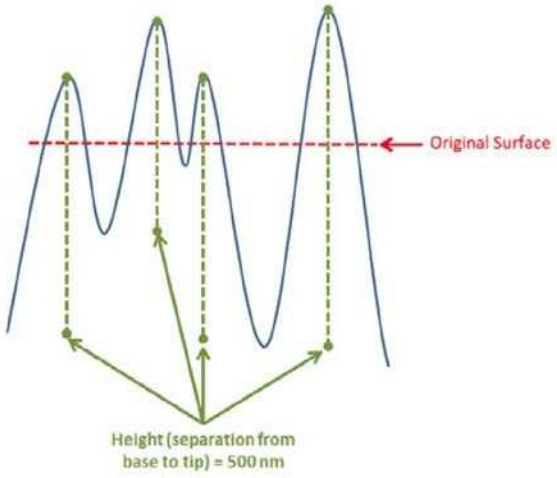


'446 patent fig. 2. In figure 2, "20" represents the base, 22 represents the tip, and "H" represents the "height" defined as the "separation between . . . base and . . . tip." *Id.* col. 4 ll. 28–29. However, the invention is more complicated than the schematic depicts. Electron micrograph images of the features contained in the patent consistently depict features that emerge from uneven troughs such as those shown in figure 5A:



’446 patent fig. 5A.

While the patent itself does not provide guidance as to how to select the relevant base from that uneven surface, the prosecution history does. During *inter partes* review of the ’446 patent, Harvard submitted a schematic illustrating the proper reference point for the “base.”



Def. Opening *Markman* Brief, Ex. D at 13. From that schematic, it is clear that Harvard understood the height of the feature to be defined by three relevant points: (A) the point at the tip of the feature, (B) the lowest point of the nearest surrounding trough, and (C) a third point defined by a right angle between (A) and (B). At the *Markman* hearing, counsel for both sides agreed that the third point (C) is the proper reference point from which to measure height. Tr. 88–89.

Therefore, it appears that the parties do not have substantive disagreement concerning the correct construction of the terms "base" and "height." The parties appear to agree that the "base" is the plane substantially parallel to the substrate surface that is part of the feature through which the lowest point of the nearest surrounding trough passes. That definition is consistent with the embodiments in the specification and the prosecution history.

Accordingly, the term "base" will be construed to mean "the plane substantially parallel to the substrate surface that is part of the feature and that passes through the lowest point of the nearest surrounding trough." The term "Height" will be construed to mean "separation between the base and the tip."

3. Protrude Above the Semiconductor Surface

Term	Plaintiffs' construction	Defendants' construction
"Protrude above the semiconductor surface"	"extend above the original surface of the semiconductor"	*see* "Height"

The parties dispute whether "protrude above the semiconductor surface" is synonymous with the "height."

There is a presumption in claim construction that different terms have different meanings. *See CAE Screenplates Inc. v. Heinrich Fiedler GmbH & Co.*, 224 F.3d 1308, 1317 (Fed. Cir. 2000). From that presumption, it follows that the patentee intended a different meaning by the term "height," as used in independent claim one, than the term "protrude above the semiconductor surface," as used in dependent claim six.

The conclusion that those terms have different meanings is supported by the specification. The specification describes the spikes depicted in figures 5A, 5B, and 5C as having a "typical height of about 500 nm" and states that they "protrude up to about 100 nm above the original surface of the wafer." '446 patent col. 6 ll. 12–14. The patent also provides

an example of a semiconductor substrate surface. It states that "a solid compound, e.g., sulfur powder, is applied to at least a portion of a semiconductor substrate surface (e.g., a surface of a silicon wafer)." *Id.* col. 4 ll. 59–61. A silicon wafer is the smooth original surface made of crystalline silicon that is transformed into the textured surface described by the '446 patent. Tr. 10, 31. Figure 3 also suggests that the semiconductor surface is a precursor, or "original" state. '446 patent fig. 3. That figure depicts an "exemplary embodiment of a method . . . for changing topography of a semiconductor surface." *Id.* col. 3 ll. 31–34. Therefore the specification repeatedly and consistently uses the term "semiconductor surface" to mean the "original surface of the semiconductor."

Accordingly, the term "protrude above the semiconductor surface" will be construed to mean "extend above the original surface of the semiconductor."

4. Width

Term	Plaintiffs' construction	Defendants' construction
"Width"	"diameter of a cross-section of a spike, substantially parallel to the substrate surface, at a location half way between the base and the tip"	"a largest linear dimension, taken substantially parallel to the substrate surface, of a cross-section of a feature at a location half way between a base and a tip of the feature"

The parties dispute two issues concerning the construction of the term "width": (1) whether it must be measured as the "diameter of a cross-section" or the "largest linear dimension," and (2) whether it necessarily is measured in a spike.

a. Largest Linear Dimension

The schematic depicted in figure 2 (shown above) depicts regularly shaped columns. The specification describes the width of one of those columns as "defined by a diameter D of a cross-section, e.g., one substantially parallel to the substrate surface, at a location half way between the base and the tip." 446 patent col. 4 ll. 28–32. Therefore, the specification indicates that the

width of a feature should be measured by its diameter, which is ordinarily understood to mean "the length of a straight line through the center of an object or space." *Diameter*, *MERRIAM-WEBSTER.COM*, https://www.merriam-webster.com/dictionary/diameter (last visited Sept. 6, 2017).

The inquiry does not end there, however, because the specification contemplates at least some features that are irregularly shaped. *See* '446 patent figs. 5A–6B. Irregularly shaped objects have a potentially infinite number of diameters. The specification provides further guidance for selecting the proper diameter measure in the case of irregularly shaped features. It says, "[i]n case of irregularly shaped spikes, the width can correspond, *e.g.*, to the largest linear dimension of such a cross-section of the spike." *Id.* col. 4 ll. 32–34; *see also id.* col. 1 ll. 63–66 ("the spikes can have an average width—defined, for example, as the average of the largest dimensions of cross-sections of the spikes at half way between the base and the tip"). The largest linear dimension of a cross-section of a spike also constitutes a diameter of the spike. Defining "width" according to the "largest linear dimension" specifically, as opposed to "diameter" generally, provides the additional specificity needed in the case of irregularly shaped features.

b. Spike

Plaintiffs contend that "width" necessarily measures "spikes." However, importing the word "spike" into the construction of "width" does not appear necessary, as the claims already define what is being measured—the features. There is some dispute whether the terms "feature" and "spike" are coextensive. For example, defendants point to the fact that claims 5 and 6 use the term "spike," as opposed to "feature," which is used in claims 1, 7, and 11, suggesting that "feature" is broader than "spike." *Innova*, 381 F.3d at 1119 ("[W]hen an applicant uses different

terms in a claim it is permissible to infer that he intended his choice of different terms to reflect a differentiation in the meaning of those terms."). Even assuming that plaintiffs' argument that they are coextensive is correct, including "spike" in the definition of "features" would unnecessarily repeat what is being measured. Therefore, it is not necessary to include the term "spike" in the construction of "width."

c. Conclusion

Accordingly, "width" will be construed to mean "the largest linear dimension, taken substantially parallel to the substrate surface, of a cross-section of a feature at a location half way between the base and the tip."

5. Undulating Topography

Term	Plaintiffs' construction	Defendants' construction
"Undulating topography"	"arrangement of features of varying heights and widths"	"variations in height"

The parties dispute whether the term "undulating topography" requires variation in both height and width, or variation in height alone.

Plaintiffs contend that claim 1 contemplates variation in both height and width, because the embodiments in the specification consistently and repeatedly depict features of varied height and width. The patent contains multiple figures that depict electron micrographs of the features. *See* '446 patent figs. 5A, 5B, 5C, 6A, 8B, 7A–7J. In each of the images, the features exhibit varying heights and widths. For example, figure 5A (shown above) depicts features that are narrower in some instances, and wider in others. *See* '446 patent fig. 5A. Plaintiffs' definition is therefore supported by every teaching in the specification, suggesting that plaintiffs' construction is the correct one. *See Irdeto Access, Inc. v. Echostar Satellite Corp.*, 383 F.3d 1295, 1303 (Fed. Cir. 2004) (holding that the use of a term "repeatedly, consistently, and exclusively," in one

manner in the specification may narrow the construction of a claim term).

Defendants contend that the plain meaning of "undulating topography" concerns only heights and not width. They point to figure 2 (shown above) of the '446 patent, which is a schematic representation of a semiconductor surface that appears to depict features of the same widths. *See* '446 patent fig. 2. Defendants' reliance on figure 2 is misplaced. The specification states that the spikes shown in that figure "are shown only for illustrative purposes and are not intended to indicate actual density, size or shape." *Id.* col. 4 ll. 23–28. Therefore, figure 2 provides limited information as to the relative widths of features.

Defendants further contend that because the specification indicates how to measure width "in case of irregularly shaped spikes," it implies the converse: that there must also be features of "regular dimensions." Def. Opening *Markman* Brief at 3 (quoting '446 col. 4 ll. 28–34). Whether or not that is true, it is irrelevant to the question at hand. Whether any individual feature is irregularly shaped does not affect whether the plurality of features, which characterize the "undulating topography," is comprised of features of varying widths.

Accordingly, the term "undulating topography" will be construed to mean "arrangement of features of varying heights and widths."

6. "At least a portion [of the surface layer] exhibiting an undulating topography"

Term	Plaintiffs' construction	Defendants' construction
"At least a portion [of the surface layer] exhibiting an undulating topography"	plain and ordinary meaning in view of plaintiffs' proposed construction of "undulating topography"	"the textured region having variations in height"

The parties' dispute centers on the word "portion" in the term at issue. Def. Opening *Markman* Brief at 4–5.

The patent does not indicate that the word "portion" is used with a meaning other from its ordinary meaning. Where the patent does not provide any reason to depart from the plain and ordinary meaning of a term, the ordinary meaning controls. *See Frank's Casing Crew & Rental Tools, Inc. v. PMR Techs., Ltd.*, 292 F.3d 1363, 1374 (Fed. Cir. 2002). The term "portion" can be readily comprehended by a layperson. *See O2 Micro*, 521 F.3d at 1361. In its ordinary meaning, the term at issue requires that at least a portion—that is, a part—of the surface layer must exhibit an undulating topography.

Accordingly, the term "at least a portion [of the surface layer] exhibiting an undulating topography" will be construed according to its plain and ordinary meaning.

B. <u>'467 Patent Terms</u>

There are three terms at issue in the '467 patent: (1) "so as to generate," (2) "selected to," and (3) "charge carriers." Those terms appear in claims 1, 2, 3, 6, 7, 8, and 9. Their use in claims 1, 2, 3, and 9 is illustrative. Claim 1 of the '467 Patent recites:

> A method of fabricating a semiconductor wafer, comprising:
>
> > irradiating one or more surface locations of a silicon substrate with a plurality of temporally short laser pulses while exposing said one or more locations to a substance **so as to generate** a plurality of surface inclusions containing at least a constituent of said substance in a surface layer of said substrate, and
> >
> > annealing said substrate at an elevated temperature and for a duration **selected to** enhance a density of **charge carriers** in said surface layer.

'467 patent col. 22 ll. 39–49 (emphasis added). Claim 2 of the '467 Patent recites:

> The method of claim 1, wherein said **charge carriers** comprise electrons.

Id. col. 22 ll. 50–51 (emphasis added). Claim 3 of the '467 Patent recites:

> The method of claim 1, wherein said **charge carriers** comprise holes.

Id. col. 22 ll. 52–53 (emphasis added). Claim 9 of the '467 Patent recites:

> The method of claim 1, wherein said increase in the density of **charge carriers** is

in a range of about 10 percent to about 200 percent.

Id. col. 23 ll. 3–5 (emphasis added).

1. "So As To Generate" and "Selected To"

Term	Plaintiffs' construction	Defendants' construction
"So as to generate"	plain and ordinary meaning	"for the purpose of generating"
"Selected to"	plain and ordinary meaning	"intentionally chosen"

The parties dispute whether the terms "so as to generate" and "selected to" necessarily imply that certain actions were taken with intent.

Defendants contend that the terms "so as to generate" and "selected to" have plain meanings that include an implication of intention: "for the purpose of generating" and "intentionally chosen," respectively. However, that interpretation "injects subjective notions into the infringement analysis." *Amazon.com, Inc. v. Barnesandnoble.com, Inc.*, 239 F.3d 1343, 1353 (Fed. Cir. 2001). Patent infringement is determined by whether an accused product or method reads on the claims of the patent, not by the intent of the accused infringer. *See Southwall Techs., Inc. v. Cardinal IG Co.*, 54 F.3d 1570, 1575 (Fed. Cir. 1995). Therefore, courts generally avoid assigning "a meaning to a patent claim that depends on the state of mind of the accused infringer." *Amazon.com*, 239 F.3d at 1353.

The terms "so as to generate" and "selected to" are not terms of art, and are readily understood by a lay person. Nothing in the patent claims, specification, or prosecution history suggests that those terms are used with anything other than their plain and ordinary meaning. Therefore, no additional construction is required. *See O2 Micro*, 521 F.3d at 1361 (holding that a court need not construe a claim if it is understandable to a layperson and adopting the plain and ordinary meaning would resolve the dispute).

Accordingly, the terms "so as to generate" and "selected to" will be construed according to their plain and ordinary meanings.

2. Charge Carriers

Term	Plaintiffs' construction	Defendants' construction
"Charge carriers"	"electrons or holes"	"electrons or holes contributed by the surface inclusions"

The parties agree that charge carriers are "electrons or holes," but dispute whether those electrons or holes must be "contributed by the surface inclusions."

Defendants contend that the term "charge carriers" in claim 1 refers to the particular set of electrons or holes contributed by the surface inclusions, because the surface inclusions are referred to earlier in the same claim. However, that reading is not supported by a plain reading of claim 1. Claim 1 provides a method in two steps: first, laser pulses generate "a plurality of surface inclusions containing at least a constituent of [a] substance in a surface layer of [a silicon] substrate," and then the substrate is "anneal[ed] . . . at an elevated temperature and for a duration selected to enhance a density of charge carriers in said surface layer." '467 patent col. 22 ll. 42–49. There is no language in the annealing step that refers back to the generation of surface inclusions. Therefore, nothing in the claim requires the charge carriers to be contributed by the surface inclusions. In addition, dependent claims 2 and 3 explicitly refer to "said charge carriers" in the annealing step of claim 1 as comprising electrons and holes, but do not refer to the surface inclusions.

Defendants contend that the specification supports their interpretation. They point to language in the specification that begins by stating "[w]ithout being limited to any particular theory," and proceeds to describe the annealing step as freeing up donor electrons in the microstructured layer that otherwise would not substantially contribute to conduction. '467 patent col. 11 ll. 42–50. Although the charge carriers described in that passage are in the microstructured layer, which defendants contend is synonymous with the layer containing

surface inclusions, the language of that passage does not limit the term "charge carrier" to only electrons and holes contributed by the surface inclusions. In any event, the permissive language of the specification does not amount to a clear "disavowal[] of claim scope by the inventor." *Phillips*, 415 F.3d at 1316.

Accordingly, the term "charge carrier" will be construed to mean "electrons or holes."

C. The '591 Patent

There are five terms at issue in the '591 patent: (1) "photosensitive imager device/photosensitive imager array," (2) "coupled to/coupling to," (3) "positioned to interact with electromagnetic radiation/in a position to interact with electromagnetic radiation," (4) "electrical transfer element/transfer element," and (5) "positioned to maintain the electromagnetic radiation in the semiconductor substrate." Those terms appear in claims 1, 2, 3, 10, 11, 12, 13, 18, and 23. Their use in claims 1, 3, 10, 11, 13, and 23 is illustrative. Claim 1 of the '591 Patent recites:

> A **photosensitive imager device**, comprising:
>
> > a semiconductor substrate having a substantially planar surface and multiple doped regions forming a least one junction;
> >
> > a textured region coupled to the semiconductor substrate on a surface opposite the substantially planar surface and **positioned to interact with electromagnetic radiation**;
> >
> > integrated circuitry formed at the substantially planar surface; and
> >
> > an **electrical transfer element coupled to** the semiconductor substrate and operable to transfer an electrical signal from the at least one junction.

'591 patent col. 18 ll. 33–45. Claim 3 of the '591 Patent recites:

> The device of claim 1, further comprising a reflective layer **coupled to** the semiconductor substrate and **positioned to maintain the electromagnetic radiation in the semiconductor substrate**.

Id. col. 18 ll. 49–52. Claim 10 of the '591 Patent recites:

> The device of claim 1, further comprising a lens optically **coupled to** the semiconductor substrate and positioned to focus incident electromagnetic radiation into the semiconductor substrate.

Id. col. 19 ll. 7–10. Claim 11 of the ’591 Patent recites:

> A **photosensitive imager array**, comprising at least two **photosensitive imager devices** of claim 1.

Id. col. 19 ll. 11–12. Claim 13 of the ’591 Patent recites:

> A method of making a **photosensitive imager device**, comprising:
>
> > forming a textured region on a semiconductor substrate, wherein the semiconductor substrate has a substantially planar surface opposite the textured region and multiple doped regions forming a least one junction, and wherein the textured region is formed **in a position to interact with electromagnetic radiation**;
> >
> > forming integrated circuitry on the substantially planar surface; and
> >
> > **coupling** an **electrical transfer element** to the semiconductor substrate such that the electrical transfer element is operable to transfer an electrical signal from the at least one junction.

Id. col. 19 ll. 16–29. Claim 21 of the ’591 Patent recites:

> The method of claim 13, wherein the **transfer element** is selected from the group consisting of a transistor, a sensing node, a transfer gate, and combinations thereof.

Id. col. 20 ll. 19–21. Claim 23 of the ’591 Patent recites:

> A **photosensitive imager device**, comprising:
>
> > a semiconductor substrate having a substantially planar surface and multiple doped regions forming a least one junction;
> >
> > a textured region **coupled to** the semiconductor substrate on a surface opposite the substantially planar surface and **positioned to interact with electromagnetic radiation**; and
> >
> > at least 4 transistors formed at the substantially planar surface with at least one of the transistors electrically **coupled to** the at least one junction.

Id. col. 20 ll. 25–35.

1. Photosensitive Imager Device/Photosensitive Imager Array

Term	Plaintiffs' construction	Defendants' construction
"Photosensitive imager device/ photosensitive imager array"	"sensor that converts incident radiation into a digital image"	"a device that absorbs and detects electromagnetic radiation/ an array of the photosensitive imager devices"

a. "Photosensitive imager device"

The parties dispute whether the "photosensitive imager device" must convert electromagnetic radiation into a digital image.

The '591 patent is entitled "Photosensitive Imaging Devices and Associated Methods." As that title indicates, the claims of the patent are directed not to photosensitive devices generally, but to photosensitive *imager* devices. '591 patent col. 18 ll. 33; *id.* col. 19 ll. 11–16; *id.* col. 19 l. 16; *id.* col. 20 ll. 6; *id.* col. 20 l. 25. Defendants' omission of the ability to convert radiation into an image in its construction of "photosensitive imager device" would sweep in all photosensitive devices that absorb and detect electromagnetic radiation, whether or not they are imagers, such as antennae, and render the word "imager" in the claims superfluous. *See* Guidash Decl. ¶ 36; *see also Innova*, 381 F.3d at 1119. The only way to give effect to every word in the claim term is to construe "photosensitive imager device" to include that the device convert incident radiation into an image.[3]

The specification reinforces that interpretation. The background section of the specification provides examples of technologies in which "[s]ilicon imaging devices" are used, including "digital cameras, optical mice, video cameras, cell phones, and the like." '591 patent

[3] It appears that the word "sensor" in plaintiffs' definition provides no additional clarification separate from the word "device" as used in the claims. Accordingly, the Court will not adopt the nearly synonymous term "sensor" in place of "device" as plaintiffs suggest. *See U.S. Surgical Corp.*, 103 F.3d at 1568 ("Claim construction is a matter of resolution of disputed meanings and technical scope, to clarify and when necessary to explain what the patentee covered by the claims, . . . [but] is not an obligatory exercise in redundancy.").

col. 1 ll. 16–18. All of those examples convert electromagnetic radiation into a digital image. Guidash Decl. ¶ 34. By contrast, the specification does not provide any examples of imager devices that do not image. Thus the examples in the specification are consistent with the finding that an "imager device" must image.

b. Photosensitive imager array

There does not appear to be a substantive disagreement concerning the construction of "photosensitive imager array," as distinct from the term "photosensitive imager device." As used in the claims, the term "photosensitive imager array" comprises at least two "photosensitive imager devices." That term needs no further construction in light of the construction of "photosensitive imager device."

c. Conclusion

Accordingly, the term "photosensitive imager device" will be construed to mean a "device that converts incident radiation into a digital image." The term "Photosensitive imager array" needs no additional construction.

2. Coupled To/Coupling To

Term	Plaintiffs' construction	Defendants' construction
"Coupled to/ coupling to"	"in contact with, directly or indirectly"	"affixed or joined to"

The parties dispute whether "coupled to" or "coupling to" includes only a mechanical connection between two components, or whether it includes all contact, both direct and indirect.

Defendants contend that the term "coupled to" requires a mechanical link; specifically, that the components are "affixed or joined to" one another. The specification and claims suggest that such a definition is too narrow. Claim 10 describes a lens that is "optically coupled to" the semiconductor substrate. '591 patent col. 19 ll. 7–8. Claim 23 describes a transistor that is

"electrically coupled to" a junction. *Id.* col. 20 ll. 34–35. The specification provides more examples of components being optically or electrically coupled. *Id.* col. 2 ll. 22–25; *id.* col. 2 ll. 48–54. For components to be optically or electrically coupled, they need not be mechanically joined, and need not even be in direct contact. Guidash Decl. ¶ 40.

Defendants contend that where "coupled to" is not modified by the words "electrically" or "optically," it means "mechanically coupled," which they contend is the ordinary meaning of the term. However, that argument contradicts the canon of claim construction that claim terms are normally used consistently throughout the patent. *Phillips*, 415 F.3d at 1314.

In addition, defendants have not provided any expert testimony to support the definition they advance. Plaintiffs have offered expert testimony describing how a person of ordinary skill in the art would understand the terms "coupled to" and "coupling to." According to plaintiffs' expert, a person of ordinary skill in the art would understand the word "coupled" to "describe different types of connections," and that "two components . . . can be considered 'coupled' if they are connected, regardless of whether they are in direct contact." Guidash Decl. ¶ 40.

While defendants' construction is too narrow, it appears that plaintiffs' construction of "coupled to" is too broad. It appears, for example, that under plaintiffs' proposed definition, a pen lying on a desk would be "coupled to" the floor, because it is indirectly in contact with the floor through the intermediary of the desk. Plaintiffs' expert testified that a person of ordinary skill in the art would understand the term "coupled to" to mean "connected." That description is consistent with the claims and specification and is clearer than plaintiffs' proposed construction.

Accordingly, the terms "coupled to/coupling to" will be construed to mean "connected to/connecting to."

3. Positioned to Interact with Electromagnetic Radiation / In a Position to Interact with Electromagnetic Radiation

Term	Plaintiffs' construction	Defendants' construction
"Positioned to interact with electromagnetic radiation/in a position to interact with electromagnetic radiation"	"located to provide enhanced response to and/or filtering of electromagnetic radiation"	"located on the substrate for the purpose of receiving electromagnetic radiation"

The parties' dispute concerns whether the word "interact" in the phrase at issue requires "enhanced response" or "filtering," or is synonymous with "receiving."

The specification describes the textured region as interacting with electromagnetic radiation in a variety of ways that are not limited to an "enhanced response or filtering." It states that the "textured region can function to diffuse[,] . . . to redirect[,] . . . and to absorb electromagnetic radiation, thus increasing the quantum efficiency of the device." '591 patent col. 10 ll. 27–30. It further states that the device can be "tuned" to allow specific ranges of wavelengths to be absorbed or to be reduced or eliminated by filtering. *Id.* col. 10 ll. 37–41. That tuning can be accomplished, among other things, "through the location of the textured region within the device." *Id.* col. 10 ll. 42–43. The specification describes figure 3 in the patent as depicting a photosensitive device with textured regions located in a configuration that "allows electromagnetic radiation normally exiting through the sides of the device to be further defused [sic] and absorbed within [the] semiconductor substrate." *Id.* col. 14 ll. 63–67.

Thus, the specification provides examples where the textured region "interacts" with electromagnetic radiation in a number of different ways, including by "redirecting," "diffusing," "absorbing," and "filtering." The specification provides those forms of interaction as examples, and does not describe them as exhaustive. Therefore, even if the Court assumed that redirecting,

diffusing, and absorbing radiation constituted "providing enhanced response," as plaintiffs suggest, the specification does not require that the claim is limited to those forms of interaction. *See Specialty Composites v. Cabot Corp.*, 845 F.2d 981, 987 (Fed. Cir. 1988) ("Where a specification does not *require* a limitation, that limitation should not be read from the specification into the claims." (emphasis in original)); *Arlington Indus. v. Bridgeport Fittings, Inc.*, 632 F.3d 1246, 1256 (Fed. Cir. 2011).

Furthermore, the summary of the invention provides that "in one aspect," the textured region "facilitate[s] generation of an electrical signal from the detection of infrared electromagnetic radiation," while "[i]n another aspect, interacting with electromagnetic radiation further includes increasing the semiconductor substrate's effective absorption length as compared to a semiconductor substrate lacking textured region." '591 patent col. 1 ll. 42–48. During *inter partes* review, plaintiffs advanced the same definition of the term at issue that they advance here. The Patent Trial and Appeal Board found that the above passage from the summary of the invention suggested that "at least in one aspect, 'interact[ing] with' electromagnetic radiation includes merely generating electrons from photons, which is not an 'enhanced response' and/or 'filtering.'" Def. Rebuttal *Markman* Brief, Ex. E at 5. While that finding is not binding on this Court, the reasoning is relevant and persuasive. The specification does not use the term "interact" to refer exclusively to "enhanced response" or "filtering" and therefore does not narrow the ordinary meaning of "interact" to those functions.

Defendants contend that their construction, equating "interacting" with "receiving," comports with the plain meaning of the word "interact." However, "interact," in its ordinary usage, connotes something more than passively "receiving." As plaintiffs state, "interact" means not only to receive, but also to "to act upon." Pl. Preliminary *Markman* Brief at 36, ECF 175;

see also Interact, *MERRIAM-WEBSTER.COM*., https://www.merriam-webster.com/dictionary/interact (last visited Sept. 6, 2017) (defining "interact" as "to act upon one another"). Consistent with that definition, the patent's examples of interaction—"redirecting," "diffusing," absorbing," and "filtering"—illustrate more than passive receipt. *See* '591 patent, col. 10 ll. 27–30; *id.* col. 14 ll. 41–43.

Accordingly, the term "positioned to interact with electromagnetic radiation/in a position to interact with electromagnetic radiation" will be construed to mean "located to receive and act upon electromagnetic radiation."

4. Electrical Transfer Element/Transfer Element

Term	Plaintiffs' construction	Defendants' construction
"Electrical transfer element/transfer element"	"component of integrated circuitry used to read or transfer charge or signal from a photosensitive pixel"	"an electrical conductor for transferring an electrical signal from one component to another"

The parties dispute three issues concerning the definition of the term "electrical transfer element/transfer element": (1) whether the signal is transferred "from a photosensitive pixel," (2) whether the transfer element may transfer a "charge," as well as a signal, and (3) whether the transfer element is a "component of integrated circuitry." Def. Rebuttal *Markman* Brief at 18.

a. Source of the Signal

Plaintiffs contend that the "transfer element" must transfer a signal "from a photosensitive pixel." Independent claims 1 and 13 provide that the electrical transfer element transfers an electrical signal "from the at least one junction." The specification clearly provides that a pixel can include a junction. *See* '591 patent col. 6 ll. 1–7 ("A photosensitive pixel can include a semiconductor substrate having multiple doped regions forming at least one junction, . . . and an electrical transfer element coupled to the semiconductor substrate and operable to transfer an electrical signal from the at least one junction."). Therefore, contrary to

defendants' contention, the language of the claim does not exclude the case where the transfer element transfers a signal from the pixel generally, and more specifically, from a junction in the pixel.

The question, then, is whether the patent otherwise limits the source of the transferred signal to the "photosensitive pixel." "Electrical transfer element" is a term of art. When asked to construe a technical or scientific term, courts may consult expert evidence to ascertain "the 'true meaning of the language employed' in the patent." *Markman*, 52 F.3d at 980 (quoting *Seymour v. Osborne*, 78 U.S. (11 Wall.) 516, 546 (1871)).

Plaintiffs have provided an expert declaration stating that a person of ordinary skill in the art would understand the term "electrical transfer element" to refer to circuitry or electrical components used in photosensitive pixels. Guidash Decl. ¶ 53. Defendants have not provided any expert testimony to contradict that conclusion. *See AstraZeneca LP v. Apotex, Inc.*, 633 F.3d 1042, 1053 (Fed. Cir. 2010) ("[A] district court can not be faulted for relying on the only expert explanation of the technology that was presented." (alteration in original) (quoting *Netword, LLC v. Centraal Corp.*, 242 F.3d 1347, 1356 (Fed. Cir. 2001))). Plaintiffs' contention is further supported by consistent and repeated references to the electrical transfer element as a part of the "photosensitive pixel" or "photosensitive imager" (which can include multiple photosensitive pixels, '591 patent col. 6 ll. 7–8) in the specification. *See* '591 patent col. 1 ll. 35–40; *id.* col. 6 ll. 1–7; *id.* col. 15 ll. 36–37, 58; *id.* col. 17 ll. 20–21.

Accordingly, the term "electrical transfer element" will be construed to transfer signal "from a photosensitive pixel."

b. Transfer of a Charge

Plaintiffs contend that the "transfer element" transfers a "charge or signal," while defendants contend that it transfers a "signal" alone.

According to plaintiffs' expert, construing the "transfer element" to transfer only a signal, and not a charge, "would rule out CCDs [charge-coupled devices]," because those devices transfer a charge out of a pixel, which is then converted to a signal by output circuitry. Guidash Decl. ¶ 55. The specification explicitly provides that the invention "can be incorporated into complementary metal-oxide-semiconductor (CMOS) imager architectures or charge-coupled device (CCD) imager architectures." '591 patent col. 6 ll. 45–49.

Again, defendants have proffered no expert testimony to rebut the contention that CCDs would be excluded under their preferred definition. *See AstraZeneca LP*, 633 F.3d at 1053 (explaining that a court may rely on "uncontested expert testimony to explain how the invention described in the intrinsic record functions" in construing a term to avoid excluding an embodiment disclosed in the specification). Instead, they point to the language of claims 1 and 13, which state that the electrical transfer element is "operable to transfer an electrical signal." Although that language requires that the transfer element must be able to transfer a signal, it does not exclude the ability to transfer a charge. Therefore, it is not dispositive.

Accordingly, the term "electrical transfer element" will be construed to transfer a "charge or signal."

c. Component of the Integrated Circuitry

Finally, plaintiffs contend that the "transfer element" must be a "component of the integrated circuitry." Although plaintiffs' expert states that such a construction is consistent with how a person of ordinary skill in the art would construe the term, he does not support that

contention by referring to the specification or otherwise explaining why that limitation is necessarily implied in the term "transfer element." In fact, the term "integrated circuitry" is not mentioned anywhere in the specification of the patent. That phrase appears in the patent only in claims 1 and 13, which provide, respectively, for a photosensitive imager device comprising "integrated circuitry formed at the substantially planar surface," '591 patent col. 18 ll. 41–42, and a method of making that device including "forming integrated circuitry on the substantially planar surface," *id.* col. 19 ll. 24–25. The following paragraph of each claim refers to the electrical transfer element but does not refer back to the integrated circuitry. Nothing in the patent claims or the specification requires the "electrical transfer element" to be limited to a component of the integrated circuitry. Therefore, it does not appear that limitation is appropriately read into the claim.

d. Conclusion

Accordingly, the term "electrical transfer element/transfer element" will be construed to mean "an element used to transfer charge or signal from a photosensitive pixel."

5. Positioned to Maintain the Electromagnetic Radiation in the Semiconductor Substrate

Term	Plaintiffs' construction	Defendants' construction
"Positioned to maintain the electromagnetic radiation in the semiconductor substrate"	"positioned on the device in a region other than the radiation incident surface to reflect or retain the electromagnetic radiation in the substrate"	"located for the purpose of reflecting electromagnetic radiation back toward the semiconductor substrate"

The parties agree, in substance, as to the meaning of the term "positioned to maintain the electromagnetic radiation in the semiconductor substrate." *See* Tr. 147–48. Each side advances their preferred construction on the basis that it is clearer.

It appears that plaintiffs' construction more clearly articulates the principle that the

reflective layer is not positioned on the light-incident side.

Accordingly, the term "positioned to maintain the electromagnetic radiation in the semiconductor substrate" will be construed to mean "positioned on the device in a region other than the radiation incident surface to reflect or retain the electromagnetic radiation in the substrate."

D. HPK Patents

Again, the nine HPK patents in dispute are the '087, '528, '945, '485, '226, '135, '551, '499, and '109 patents. There are two terms at issue in those patents: "irregular asperity" and "optically exposed." Both terms appear in all nine patents and are used in a similar manner in each. The use of those terms in claim 1 of the '485 patent is typical. Claim 1 recites:

> A semiconductor photodetection element comprising:
>
> > a silicon substrate which is comprised of a semiconductor of a first conductivity type, which has a first principal surface and a second principal surface opposed to each other, and which has a semiconductor region of a second conductivity type formed on the first principal surface side; and
> >
> > a transfer electrode part which is provided on the first principal surface of the silicon substrate and which transfers generated charge,
> >
> > wherein in the silicon substrate, an accumulation layer of the first conductivity type having a higher impurity concentration than the silicon substrate is formed on the second principal surface side and an **irregular asperity** is formed in a region opposed to at least the semiconductor region of the second conductivity type, in the second principal surface, and
> >
> > wherein the region where the **irregular asperity** is formed in the second principal surface of the silicon substrate is **optically exposed**.

'485 patent col. 17 l. 44–col. 18 l. 10 (emphasis added).

1. Irregular Asperity

Term	Plaintiffs' construction	Defendants' construction
"Irregular asperity"	"surface characterized by features of various sizes"	"surface roughness with random variations in characteristics"

Following the *Markman* hearing, there no longer appears to be a substantive dispute concerning the meaning of the term "irregular asperity." There are two concepts at issue: (1) randomness and (2) whether the surface is characterized by "features" or "roughness."

At the *Markman* hearing, the parties agreed that the word "irregular" in the term "irregular asperity" implies a sense of randomness. *See* Tr. 46–47.

The parties also appeared to agree that the surface must be sufficiently uneven such that it reflects, scatters, and diffuses light. *Id.* Plaintiffs initially argued for the inclusion of the word "features" in the construction of "irregular asperity," although that word does not appear anywhere in the HPK patents, and appears to be drawn from Harvard and SiOnyx's own patents. However, at the *Markman* hearing, plaintiffs agreed that the patents are directed to "either features or a roughened surface that is sufficiently rough to interact with light." *See* Tr. 49. Similarly, defendants' expert testified that "the irregular asperity [described in the HPK patents] has a topology [sic] of the size that can affect the propagation of light." Souri Decl. ¶ 13.

Accordingly, the term "irregular asperity" will be construed to mean "surface roughness that is sufficiently rough to affect the propagation of light and has random variations in characteristics."

2. Optically exposed

Term	Plaintiffs' construction	Defendants' construction
"Optically exposed"	plain and ordinary meaning	"in contact with ambient gas or covered by an optically transparent film"

The parties dispute whether the term "optically exposed" may be construed according to its plain and ordinary meaning or whether the specification requires a special construction.

Defendants do not contend that the term "optically exposed" has a special meaning to people of ordinary skill in the art. Def. Opening *Markman* Brief at 35. Rather, they contend that the patentee acted as its own lexicographer to define that term with something other than its plain and ordinary meaning. In support of that contention, they point to language in the specification that provides: "[t]hat the second principal surface . . . is optically exposed embraces, not only the case where the second principal surface . . . is in contact with ambient gas such as air, but also the case where an optically transparent film is formed on the second principal surface . . . ." '551 patent col. 12 ll. 17–22. "To act as its own lexicographer, a patentee must 'clearly set forth a definition of the disputed claim term' other than its plain and ordinary meaning." *Thorner v. Sony Comput. Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012) (quoting *CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1366 (Fed. Cir. 2002)). Here, the permissive language to which defendants point in the specification does not redefine "optically exposed," but instead provides an example of that term in context.

The plain meaning of "optically exposed" is exposed to light. Rather than disavowing that meaning, the specification is consistent with it. *See Straight Path IP Grp., Inc. v. Sipnet EU S.R.O.*, 806 F.3d 1356, 1361 (Fed. Cir. 2015).

Accordingly, the term "optically exposed" will be construed according to its plain and ordinary meaning.

IV. Conclusion

For the foregoing reasons, the disputed claim terms are construed as follows:

(1) "Average" in the '446 patent is construed to mean "arithmetic mean."

(2) “Height” in the ’446 patent is construed to mean “separation between the base and the tip.”

(3) “Base” in the ’446 patent is construed to mean “the plane substantially parallel to the substrate surface that is part of the feature and that passes through the lowest point of the nearest surrounding trough.”

(4) “Protrude above the semiconductor surface” in the ’446 patent is construed to mean “extend above the original surface of the semiconductor.”

(5) “Width” in the ’446 patent is construed to mean “the largest linear dimension, taken substantially parallel to the substrate surface, of a cross-section of a feature at a location half way between the base and the tip.”

(6) “Undulating topography” in the ’446 patent is construed to mean “arrangement of features of varying heights and widths.”

(7) “At least a portion [of the surface layer] exhibiting an undulating topography” in the ’446 patent is construed according to its plain and ordinary meaning.

(8) “So as to generate” in the ’467 patent is construed according to its plain and ordinary meaning.

(9) “Selected to” in the ’467 patent is construed according to its plain and ordinary meaning.

(10) “Charge carriers” in the ’467 patent is construed to mean “electrons or holes.”

(11) “Photosensitive imager device” in the ’591 patent is construed to mean “device that converts incident radiation into a digital image.” “Photosensitive imager array” needs no additional construction.

(12) “Coupled to/coupling to” in the ’591 patent is construed to mean “connected to/connecting to.”

(13) “Positioned to interact with electromagnetic radiation/in a position to interact with electromagnetic radiation” in the ’591 patent is construed to mean “located to receive and act upon electromagnetic radiation.”

(14) “Electrical transfer element/transfer element” in the ’591 patent is construed to mean “an element used to transfer charge or signal from a photosensitive pixel.”

(15) “Positioned to maintain the electromagnetic radiation in the semiconductor substrate” in the ’591 patent is construed to mean “positioned on the device in a region other than the radiation incident surface to reflect or retain the electromagnetic radiation in the substrate.”

(16) “Irregular asperity” in the HPK patents is construed to mean “surface roughness that is sufficiently rough to affect the propagation of light and has random variations in characteristics.”

(17) “Optically exposed” in the HPK patents is construed according to its plain and ordinary meaning.

So Ordered.

/s/ F. Dennis Saylor
F. Dennis Saylor IV
United States District Judge

Dated: September 7, 2016