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Transcript of James F. Shanley, Ph.D.

Date: June 28, 2024

Case: Hesai Technology Co., Ltd. -v- Ouster, Inc. (PTAB)

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Conducted on June 28, 2024

1 (1 to 4)

1	UNITED STATES PATENT AND TRADEMARK OFFICE	1	A P P E A R A N C E S:	3
2	BEFORE THE PATENT TRIAL AND APPEAL BOARD	2		
3	-----x	3	ATTORNEYS FOR PETITIONER:	
4	HESAI TECHNOLOGY CO., LTD.,	4	FISH & RICHARDSON, P.C.	
5	Petitioner, Case No.	5	60 South Sixth Street, Suite 3200	
6	v. IPR2023-01456	6	Minneapolis, Minnesota 55402	
7	OUSTER, INC., U.S. Patent	7	(612) 278-4514	
8	Patent Owner. No. 11,178,381	8	BY: CRAIG A. DEUTSCH, ESQ.	
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11	Petitioner, Case No.	11		
12	v. IPR2023-01457	12	ATTORNEYS FOR PATENT OWNER:	
13	OUSTER, INC., U.S. Patent	13	COOLEY LLP	
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17	DEPOSITION of JAMES F. SHANLEY, Ph.D.	17	BY: PHILLIP MORTON, ESQ.	
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22	Job No. 541281	22		
2		4		
1		1	I N D E X	
2		2	Deposition of: Page	
3		3	JAMES F. SHANLEY, Ph.D.	
4		4	By Mr. Lauppe 6, 133	
5		5	By Mr. Deutsch 140	
6		6		
7	Friday, June 28, 2024	7		
8	9:01 a.m.	8		
9		9	E X H I B I T S	
10		10	No. Page	
11	DEPOSITION of JAMES F. SHANLEY,	11	Exhibit 1 Declaration of James F.	
12	Ph.D., held at Fish & Richardson, P.C., One	12	Shanley, Ph.D., in re:	
13	Marina Park Drive, Boston, Massachusetts,	13	U.S. Patent No.	
14	pursuant to notice, before Michael D.	14	11,178,381 10	
15	O'Connor, Registered Merit Reporter,	15	Exhibit 2 Declaration of James F.	
16	Certified Realtime Reporter, Certified	16	Shanley, Ph.D., in re:	
17	Realtime Captioner.	17	U.S. Patent No.	
18		18	11,190,750 15	
19		19	Exhibit 3 U.S. Patent 11,178,381 31	
20		20	Exhibit 4 U.S. Patent 11,190,750 46	
21		21	Exhibit 1005 U.S. Patent 10,203,399 57	
22		22	Exhibit 1007 U.S. Patent 7,787,105 108	

5 1 E X H I B I T S (Cont'd) 2 No. Page 3 Exhibit 1008 U.S. Patent 8,736,818 108 4 Exhibit 1009 U.S. Patent Application 5 Publication 2016/0274223 82 6 Exhibit 1012 U.S. Patent Application 7 Publication 2017/0040368 98 8 Exhibit 1013 U.S. Patent Application 9 Publication 2014/0211194 78 10 Exhibit 1111 Translator's Certificate 11 of Translation 82 12 13 14 15 16 17 18 19 20 21 22	7 1 that I had, yes. 2 Q. Let me clarify. Sorry. 3 So then that was the matter 4 related to the '405 patent; is that correct? 5 A. Yes. 6 Q. So if I refer to the '405 or '405 7 IPR, will you understand what I mean by that? 8 A. Yes. 9 Q. Do you stand by the testimony that 10 you gave in the '405 IPR? 11 MR. DEUTSCH: Objection. Scope. 12 A. Yes, to the best of my knowledge. 13 Q. And you said you have been deposed 14 before. How many times have you been deposed 15 recently? 16 A. I think four. Four or five. 17 Q. How did you prepare for today's 18 deposition? 19 A. Read the material and consulted 20 with counsel. 21 Q. How many hours did you spend 22 consulting with counsel?
6 1 P R O C E E D I N G S 2 3 JAMES F. SHANLEY, Ph.D. 4 5 having been satisfactorily identified by the 6 production of his driver's license, and duly 7 sworn by the Notary Public, was examined and 8 testified as follows: 9 10 EXAMINATION 11 BY MR. LAUPPE: 12 Q. Good morning, Dr. Shanley. 13 A. Did morning. 14 Q. Can you please state your name for 15 the record. 16 A. James F. Shanley. 17 Q. And have you been deposed before, 18 Dr. Shanley? 19 A. Yes. 20 Q. And were you deposed in the 1421 21 matter? 22 A. If that was the last deposition	8 1 A. I don't – probably several. 2 Q. And do you understand that today's 3 deposition relates to two IPRs? 4 A. Yes. 5 Q. Okay. And those IPRs are those 6 related to the '381 patent and the '750 patent; 7 is that correct? 8 A. Yes. 9 Q. For the record, so if I refer to 10 U.S. Patent No. 11,178,381 as the '381 patent, 11 is that okay for today? 12 A. Yes. 13 Q. And then same for if I refer to 14 the 11,190,750 patent as the '750 patent, will 15 you understand that today? 16 A. Yes. 17 Q. Okay. So if I refer to the '381 18 patent IPR, you understand what I mean by that 19 is the IPR we're discussing today as to the 20 '381 patent? 21 A. Yes. 22 Q. And if I refer to the '750 IPR,

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9 1 you understand that as well? 2 A. Yes. 3 Q. Okay. Thank you. 4 MR. LAUPPE: I would like to 5 introduce as the first exhibit today 6 Exhibit 1 from the '381 patent IPR, 7 which is your declaration in that 8 proceeding. 9 10 11 12 13 14 15 16 17 18 19 20 21 22	11 1 That Claim 12 should read Claim 12 from the 2 patent and not from -- this is Claim 11. The 3 quote, the words are Claim 11. 4 Q. Understood. 5 A. Okay. And Claim 13, the same 6 problem, is that the optical system is Claim 7 11, but Claim 13 should be from the patent 8 Claim 13. 9 So in other words, somehow the 10 Claim 11 got pasted into Claim 12, and Claim 11 13, and the right Claim 12 should be there and 12 the right Claim 13 should be there. 13 Q. So is there any correction you 14 would like to make to your analysis? 15 A. No. The analysis is fine. 16 Q. Okay. And do you have any other 17 corrections or changes to Exhibit 1? 18 A. There was another one, which was a 19 figure, but it slips my mind right now. 20 Q. Dr. Shanley, does your 21 declaration, Exhibit 1 in the '381 IPR, state 22 all of the opinions you intend to provide in
10 1 (Document marked as Exhibit 1 2 for identification) 3 Q. Did you draft Exhibit 1, Dr. 4 Shanley? 5 A. The drafting was a product of mine 6 and counsel's input. We worked together in 7 formulating the document. 8 Q. Do you have any corrections or 9 changes to Exhibit 1? 10 A. I believe there is in the claims, 11 in the latter part. I believe it has to do 12 with Claim 11 of the Imai portion. In the 13 paragraph below, it is correct, but the claim 14 that's quoted should be 12 and 13 instead of 15 what was quoted, respectively. 16 Q. I'm sorry, Dr. Shanley, could you 17 point me to what page you're referring to? 18 A. Yeah. I believe it's 128. It 19 says Claim 12 and Claim 13. And if you go to 20 the patent, it really should read -- okay, 21 let's go to Item 3, and it says, "Claim 12: 22 The optical system according to Claim 10."	12 1 that proceeding? 2 A. For the most part, yes. 3 Q. And can you clarify what you mean 4 by "for the most part"? 5 A. There's always, you know, I 6 haven't pinpointed that correct -- there's one 7 more correction in here, which, you know, 8 escapes me right now, but in addition to, you 9 know, corrections, it's -- yes. 10 But I also state that we could 11 further -- I believe in my last page, all the 12 statements that I have in here are my belief 13 and the belief to be what I state. 14 Q. Did you choose the alleged prior 15 art referenced in Exhibit 1? 16 A. It was mutually chosen by both of 17 us. I presented a lot of items, and we parade 18 through the items, and actually chose the ones 19 that we felt were relevant. 20 Q. And just to clarify, by "we" and 21 "both of us," do you mean you and counsel? 22 A. And counsel.

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13 1 Q. Okay. Who first identified the 2 prior art in your declaration, Exhibit 1? 3 A. As I stated before, it was both of 4 us mutually and identified a lot of prior art, 5 and we went through and mutually agreed on what 6 the prior art should be. 7 Q. Which of the prior art references 8 in Exhibit 1 were you aware of before being 9 engaged in this case? 10 A. The majority of them. 11 Q. Were there any that you weren't 12 aware of prior to being engaged for this case? 13 A. If I -- 14 MR. DEUTSCH: Objection to form. 15 A. If I take a minute, I'll look at 16 the references here. No. The only access I 17 didn't have was to the documented translations 18 of the Imai patent. 19 Q. And when were you engaged for the 20 '381 patent IPR? 21 A. Approximately -- I can't give you 22 an exact date, but I would put it in the --	15 1 preliminary response in the '381 patent IPR? 2 A. Basically I think we have. 3 Q. What do you mean by "basically"? 4 A. I really don't remember. 5 Q. Okay. Did you review the 6 institution decision in the '381 patent IPR? 7 A. The things that I remember are all 8 in my list of exhibits on the document we have. 9 Q. Okay. I'm going to introduce your 10 declaration in the '750 patent IPR. 11 MR. LAUPPE: This is Exhibit 2. 12 (Document marked as Exhibit 2 13 for identification) 14 Q. Dr. Shanley, did you draft Exhibit 15 2, which is your declaration in the '750 patent 16 IPR? 17 A. The same thing as the other 18 exhibit, we co-developed the material in this 19 document. 20 Q. And do you have any corrections or 21 changes to Exhibit 2? 22 A. Not that I know of.
14 1 let's see, probably April/May timeframe, I 2 think, something in April, May, June, something 3 in that timeframe. 4 Q. And do you mean April, May, June 5 of this year, 2024? 6 A. 2023. 7 Q. How many hours have you worked on 8 the '381 patent IPR proceeding to date? 9 A. I can't give you a number. I'd 10 have to look at my documentation on that. 11 Q. Do you have an approximate idea? 12 A. Not at this point. I could pull 13 my information up, but I don't have that at 14 hand right now. 15 Q. Did you review the Patent Owner 16 preliminary response in the '381 patent IPR? 17 A. The things that I reviewed are all 18 in my exhibit list here. 19 Q. Understood. But I think at the 20 time of your declaration, the Patent Owner 21 preliminary response hadn't been filed yet. So 22 have you since reviewed the Patent Owner	16 1 Q. And does your declaration, Exhibit 2 2, state all of the opinions you intend to 3 provide in the '750 patent IPR? 4 A. To this point, yeah. But there 5 may be more, depending on how the case goes. 6 Q. And where did you get the alleged 7 prior art referenced in Exhibit 2? 8 A. As I stated previously, most of -- 9 MR. DEUTSCH: Objection. Form. 10 Asked and answered. 11 A. As I stated previously, most of 12 the patents were initially formulated by myself 13 and counsel. 14 Q. How many hours have you worked on 15 the '750 patent IPR proceeding to date? 16 A. I would have to go back and look 17 at my records. I don't really recollect. 18 Q. And did you review the Patent 19 Owner preliminary response in the '750 patent 20 IPR? 21 A. Whatever is in the references 22 here, if that's there, then I reviewed it. If

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17 1 not, I can't comment on that. 2 Q. Okay. Let's go back to Exhibit 1, 3 which is your declaration in the '381 patent 4 IPR. 5 A. Mm-hmm. 6 Q. And can you go to Paragraph 9 of 7 your declaration. 8 A. Okay. 9 Q. Do you see where you say in 10 Paragraph 9, "Through my working experiences 11 with various companies over the years, I was 12 also personally involved designing and building 13 a number of LiDAR systems"? 14 A. Yes. 15 Q. What systems were those? 16 A. First I built a lab system at 17 Honeywell working with C02 laser in a 18 heterodyne mode? Do you want me to go through 19 the litany of companies? 20 Q. Yes, please. 21 A. I worked with various other 22 companies while I was at Honeywell developing	19 1 I also had as part of that group 2 when GE merged with RCA a facility in Elmsford, 3 New York primarily devoted to fabrication of 4 diode lasers, and in addition GE had a facility 5 in Syracuse, New York which I worked very 6 closely with in fabrication of diode lasers. 7 The goal there was to get arrays of diode 8 lasers to replace the gas laser in C02 and also 9 to replace the neodymium YAG solid-state laser 10 and the other winds measurement system. 11 I must back up a minute. At 12 Honeywell, I was heavily involved in photodiode 13 and detector fabrication for LiDAR systems. At 14 GE I was involved in working with E Labs to 15 fabricate photodiodes based on my designs, 16 which I carried over from Honeywell. 17 And then going on to 18 McDonnell-Douglas, I was heavily involved in 19 many things there, including LiDAR systems for 20 both satellite and terrestrial applications. 21 These involved both solid-state lasers and 22 diode lasers.
18 1 systems that were helicopter base for Nape of 2 the Earth, wire avoidance. 3 I worked with companies involved 4 with space-based systems, and some of the 5 things involved both helicopter cruise missile 6 while I was at Honeywell. 7 And then at General Electric, we 8 actually had several groups, one of which was 9 doing a C02 laser radar from the technology I 10 initiated at Honeywell, and we built up a 11 trailer system involving a C02 system for wind 12 velocity measurements, and actually took that 13 to Tabletop Mesa in Colorado and NOAA to 14 actually measure and verify wind velocities. 15 This is a prelude for a satellite program. 16 I also had another group which I 17 -- that was involved in solid-state LiDAR 18 systems using neodymium YAG lasers, and this 19 was involved with another space-based 20 application that approached wind velocity 21 measurements, and that group came to me from 22 RCA Astro Electronics.	20 1 Some of the programs we worked 2 with MOLA, Mars Observer Laser Altimeter, with 3 NASA, near asteroid rendezvous with NASA. I 4 was involved in satellite communications and 5 the satellite communications involved 6 satellite-to-satellite laser communication, and 7 the satellite to satellite involved both 8 acquisition and tracking, and we were working 9 on in addition to supplying high power laser 10 diodes and looking at that technology to 11 replace the solid-state lasers in crosslink 12 communications in space, I had a group of 13 people working on these objects. 14 There are approximately 100 people 15 involved in diode laser fabrication, and that 16 group actually fabricated the diode pump arrays 17 for laser -- Livermore's National Ignition 18 Facility, NIF. 19 So there's a lot of laser 20 technology going on here, and I had some of the 21 premiere diode laser people in the world, Dan 22 Botez and Peter Zory. Peter Zory was at GE and

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21 1 Dan Botez was at McDonnell-Douglas working on 2 that technology, and we were also working on 3 detectors and detector arrays. We worked with 4 several companies to develop alternate 5 photo-detection techniques. 6 I also was heavily involved with 7 personnel during that period of time at Lincoln 8 Labs monitoring the technology that was going 9 on there in the technology development. 10 And then, of course, consulting in 11 various things peripheral to this. Consulted 12 with Scram Technologies on building a handheld 13 LiDAR designator system which involved 14 solid-state devices, and that was built in our 15 Korean facility with Dong Ho Kim. So that's a 16 summary. 17 And then I was also involved in a 18 deposition involving laser radars for 19 altimeters, replacing the mechanical altimeters 20 on airplanes which was being built by two 21 companies, one of which was Honeywell. 22 Q. Just a few things I would like to	23 1 change. I mean, it's basic. It's 60 years 2 old. But the sources and components do. 3 The point was we were always 4 looking for the holy grail to replace 5 solid-state and gas lasers with diode laser 6 arrays, so you would get the high power. And 7 so that was the really goal for the whole 8 evolution, so it would make these systems much 9 better. 10 Q. Why would replacing solid-state 11 and gas lasers with diode arrays make these 12 systems better? 13 MR. DEUTSCH: Objection. Scope. 14 A. It would fulfill a lot of your 15 system requirements of costs, volume, weight, 16 power, size. 17 Q. You said solid-state lasers were 18 based on solid-state materials. Can you 19 elaborate on that? 20 A. Single crystal solid-state which 21 are usually doped with some species which 22 causes laser action, and you would have to pump
22 1 follow up on there. You just mentioned CO2 2 lasers? 3 A. Yes. 4 Q. Can you describe what CO2 lasers 5 are? 6 A. Yeah. Basically it's a gas laser. 7 What you're doing is getting the lasing action 8 by using -- the lasers were about this big, and 9 the gas was confined to a ceramic layer inside. 10 Basically you cited various levels. 11 I won't go into how a laser works. 12 Just very quickly, you pump up several levels, 13 and then you stimulate the downward radiation 14 and it bounces back and forth until you get an 15 amplification, and that's a gas laser. 16 Then there are solid-state lasers 17 which are solid-state materials, but it's the 18 same game, but you have to use silvered 19 mirrors. The whole goal is to replace those 20 lasers. 21 The whole chronology of this thing 22 is that the basic physics in LiDARs don't	24 1 them with flash lamps or diode lasers or 2 something like that. 3 Q. When you refer to diode lasers, 4 what are diode lasers? 5 A. They're some type of solid-state 6 P-N junction device. 7 Q. Are you familiar with vertical 8 cavity surface emitting lasers or VCSELs? 9 A. Yes. In fact, my group actually, 10 at GE and McDonnell-Douglas, were working on 11 how to design VCSELs and how to implement, and 12 a lot of that had to do with structural and how 13 do you fabricate the correct structures in the 14 cavity and turning mirrors, and things like 15 that, because it solved so many problems. 16 Q. Are VCSELs diode lasers? 17 A. Basically, yes. 18 Q. You were discussing CO2 lasers, 19 solid-state lasers, diode lasers. Can you 20 describe where VCSELs fit into that picture 21 that you described? 22 MR. DEUTSCH: Objection. Form.

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25 1 A. Yeah. They're a type of laser; 2 okay? So depending upon what you want to do, 3 the idea – okay. This is a long story, but 4 I'll make it very short. 5 When designing a laser system, you 6 have to look at what wavelength of light you 7 want, what material is best to give you that 8 particular wavelength, because not all 9 materials give you this continuous tunability 10 of wavelength, and what structure you want to 11 use, and the cost. 12 Now, gas lasers are like CO2, and 13 that operates at 10.6 microns. Helium neon, 14 which operates at visible wavelengths, and 15 there are a bunch of gas lasers that operate at 16 all of these different wavelengths, but the 17 technology is you have to seal the gas in a 18 tube and pump it electrically. 19 Then you have solid-state lasers, 20 like neodymium YAG or erbium-doped fibers or 21 things like, and they're solid state because 22 they are solid materials, and have a	27 1 Whereas with a VCSEL, now, in this 2 layer that you've grown, you have all of these 3 junctions, and if you do the correct surface 4 edges down to the junction in the correct 5 stacking of material on top of that, they get 6 the reflectors, Bragg reflectors and coatings 7 right, you then get a beam that comes from the 8 surface, and then your beam is spherical so you 9 don't have to correct it. 10 And then you can just take this 11 wafer and dice it. And the nice thing about 12 the VCSEL is that you can readily fabricate 13 arrays on this surface, whereas with the edge 14 emitters, you have to stack the bar. So if you 15 want an end-by-end array, you have to get end 16 surface emitters in this direction, which is 17 cleaved, and then you have to stack the bars 18 one on top of the other until you get that 19 end-by-end array. 20 Whereas with the surface emitter, 21 you've got it already coming out of your 22 process.
26 1 crystalline structure, and so you want to be 2 able to pump that crystalline structure in the 3 correct energy configuration to get an output. 4 And then you have these tiny 5 little guys – and YAGs can be about this big. 6 CO2 and gas lasers, probably about like this, 7 and then you have the tiny diode lasers. 8 The diode lasers come in two 9 forms. They come in surface emitters and edge 10 emitter. A surface emitter, you take a crystal 11 and you form your diode, and basically you grow 12 them, and you grow the layers to give you the 13 diode. 14 And then in an edge emitter, what 15 you have to do is you have to cleave the 16 crystal and you get this bar, and in the bar 17 you've got all of these little junctions that 18 are edge emitters. 19 And then with the edge emitters, 20 the edge emitters emit an elliptical beam. And 21 so you have to correct that beam, because you 22 want a spherical beam.	28 1 Q. Sorry, remind me, where did you 2 work on VCSELs? 3 A. I had groups both at GE and 4 McDonnell-Douglas. McDonnell-Douglas, there 5 were two parts to that group. One was in St. 6 Louis and the other one was in Elmsford, New 7 York. 8 Q. And just for the court reporter's 9 benefit, I'm going to be probably saying the 10 word VCSEL a fair number of times, and when I 11 say that, it's an acronym, V-C-S-E-L, which 12 refers to vertical cavity surface emitting 13 lasers. 14 You said you worked on VCSELs at 15 GE and McDonnell-Douglas. Did you use VCSELs 16 in a system? 17 MR. DEUTSCH: Objection. Scope. 18 A. They weren't ready at that point. 19 There were material and etching considerations 20 that were going on. These are in development 21 from 1974 on. 22 Q. And you just said, referring to

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29 1 VCSELs, they weren't ready at that point. What 2 was that point that you were referring to? 3 A. This is up until -- well, ready 4 meaning you could do one or two devices, you 5 could show lab queens, but for mass production 6 and putting into your product line to get 7 realizable power out, they were immature at 8 that point. 9 If you could get them, they were 10 very, very expensive, so they couldn't meet the 11 system needs. 12 Q. Just to repeat, what was that 13 point that we're discussing here? 14 MR. DEUTSCH: Same objection. 15 Scope. 16 A. This was in the '90s, early 2000s. 17 Q. So what made VCSELs immature for 18 mass production purposes in the 2000s? 19 MR. DEUTSCH: Objection. Scope. 20 A. Just the price. As time went on, 21 it was really price and manufacturing 22 capability.	31 1 A. There were several. I worked on 2 loads much them, and they were rotating 3 mirrors, they were swivel bases, they were 4 three dimensional, Gimball systems, space-based 5 systems, multi-platform, different types of 6 systems, depending upon what the system 7 requirement was. 8 MR. LAUPPE: I'm going to 9 introduce an exhibit. This is the '381 10 patent. I see we have another collision 11 of exhibit numbers, so let's mark this 12 as Exhibit 3. So this will be the '381 13 patent. This is Exhibit 1001 in the 14 '381 patent IPR. 15 (Document marked as Exhibit 3 16 for identification) 17 Q. Dr. Shanley, let's turn to Claim 1 18 of the '381 patent, which is between Columns 16 19 and 17. 20 Do you see where Claim 1 starts at 21 the bottom of Column 16? 22 A. Yes.
30 1 Q. And what were the reasons for 2 price being an issue for VCSELs in that period? 3 MR. DEUTSCH: Objection. Scope. 4 A. No processes were put in place to 5 upscale them, and the market was limited. 6 Q. So you worked on various LiDAR 7 systems. Have you ever used VCSELs in a LiDAR 8 system? 9 A. No. 10 Q. Did any of the LiDAR systems you 11 worked on use single photon avalanche diodes or 12 SPADs? 13 MR. DEUTSCH: Objection. Form. 14 Scope. 15 A. No. 16 Q. Did any of the LiDAR systems you 17 worked on rotate? 18 MR. DEUTSCH: Objection. Form. 19 Scope. 20 A. Yes. 21 Q. Was that rotation via a rotating 22 mirror?	32 1 Q. And then if you turn to the next 2 page, looking at Column 17, starting at line 6, 3 do you see where it says, "A plurality of 4 pixels arranged behind the bulk imaging optic, 5 wherein each pixel in the plurality of pixels 6 has a field of view coincident with an emission 7 region of a corresponding optical emitter"? 8 A. Yes. 9 Q. What is your understanding of what 10 the word "coincident" means here? 11 MR. DEUTSCH: Objection. Form. 12 Scope. 13 A. I think if we go to my 14 declaration, and I think specifically if we go 15 to Page 49 in my declaration, and we look at 16 Figure 4, and we go to 51 and look at Figure 8, 17 I believe that what I state in referencing that 18 patent is what I believe the sentence in the 19 claim section of '381 states. 20 Q. So let's start, then, with Figure 21 4, and I believe this is for the Retterath 22 system, right? Is that correct?

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33 1 A. Of Retterath. 2 Q. So what in Figure 4 shows "wherein 3 each pixel in the plurality of pixels has a 4 field of view coincident with an emission 5 region of a corresponding optical emitter"? 6 MR. DEUTSCH: Objection. Form. 7 A. So if we look at the vector 8 annotated by 120, and we look at the text, it 9 says, "Each beam is emitted along a unique 10 vector that is angularly spaced from the other 11 vectors in the array." And then if we go to 12 Figure 8 and we look at the corresponding 13 vector 220 in the photodetector area, and it 14 says, "Each detector defines a field of view 15 that receives light beams 210 along a unique 16 vector 220." 17 So 220 each detector element 200 18 has an optimal receive coincident axis along 19 which the maximum optical energy will be 20 transferred. 21 So I think that answers your 22 question.	35 1 Q. A vector refers to a direction; is 2 that correct? 3 MR. DEUTSCH: Objection. Form. 4 Scope. 5 A. A field of view refers to a vector 6 which defines the field of view. And I believe 7 I further amplified that by saying each 8 detector of detector elements has an optimal 9 receive detector vector coincident along which 10 the maximum optical energy will be transferred. 11 Q. So looking at Figure 8, the vector 12 is element 220, correct? 13 A. Yes. 14 Q. So element 220 shows the direction 15 of a column of light; is that correct? 16 A. It shows the direction of the 17 light, yes. 18 Q. But the vector doesn't reflect the 19 area of the field of view, does it? 20 MR. DEUTSCH: Objection. Form. 21 A. I think it's pretty clear from the 22 figures of what's happening, and it defines the
34 1 Q. So your understanding of the word 2 "coincident" is that it refers to the vector of 3 a light beam; is that correct? 4 MR. DEUTSCH: Objection. Form. 5 Scope. 6 A. The vector defines the -- as it 7 says here, "Each detector defines a field of 8 view," and that vector defines that field of 9 view. So each emitter has a vector defining a 10 field of view, if you will, which corresponds 11 to the field of view 220, which the vector 220 12 defines in the detection portion of this 13 circuit. 14 So you have a one-to-one 15 correspondence. 16 Q. In the vectors; is that correct? 17 MR. DEUTSCH: Objection. Form. 18 A. In "each detector 200 defines a 19 field of view that receives light beams along a 20 unique vector." 21 So those vectors define that field 22 of view.	36 1 direction of the field of view of that 2 particular element as stated in Paragraph 86. 3 Q. So you've pointed to two figures, 4 Figure 4, which is in Paragraph 82 of your 5 declaration, and then Figure 8 in Paragraph 85, 6 and between those two figures, what is it that 7 is coincident? 8 MR. DEUTSCH: Objection. Form. 9 Scope. 10 A. It's showing the one-to-one 11 relationship of an emitter element to a 12 detector element, and it's showing that each 13 emitter element has a corresponding one-to-one 14 mapping into each detector element. 15 Q. Let's turn to another portion of 16 Claim 1 of the '381 patent. So if you go back 17 to the '381 patent, and this is Exhibit 3, can 18 you turn to Column 17, Line 15. This is the 19 last limitation in Claim 1. 20 Do you see that? 21 A. Yes. 22 Q. Do you see where it says, "An

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37 1 optical filter disposed in an optical path of 2 the plurality of pixels, the optical filter 3 configured to allow a set of wavelengths of 4 electromagnetic radiation, including the 5 operating wavelength, to pass through the 6 optical filter while blocking electromagnetic 7 radiation outside the set of wavelengths from 8 reaching the plurality of pixels"? 9 Do you see that? 10 A. Yes. 11 Q. What is your understanding of what 12 "blocking electromagnetic radiation" means? 13 MR. DEUTSCH: Objection. Scope. 14 A. If we go to my declaration, and if 15 we go to – and I explain a bunch of things in 16 my technical part of it. If you give me a 17 minute, I'm a little disorganized. Things got 18 out of order. 19 Q. Does it make sense to maybe -- 20 we're coming up on an hour. Does it make sense 21 to take a quick break? 22 A. Sure.	39 1 mechanisms. 2 And then if we go on to Paragraph 3 58, and that's on page – I don't understand 4 the two-page thing here, 29 and 36, but it's on 5 Page 29, the top one. So that's Paragraph 58. 6 Q. I think probably more convenient 7 to just refer to the paragraph number. 8 A. So Paragraph 58, and it goes on. 9 And on the next page, there are bullets and 10 optical filters that allow light at certain 11 wavelengths to pass through the system. So 12 they could either be narrow band or wide band, 13 and you can choose, you know, how you do that 14 filter, and there are many types of filters 15 that one can implement. 16 So that's my understanding of that 17 part of the claim. 18 Q. So this discussion here you're 19 just pointing to in Paragraph 58 about optical 20 filters, so do you see where you say "filters 21 that only allow light at certain wavelengths," 22 but the claim language here says "blocking
38 1 MR. LAUPPE: How about for the 2 court reporter and everyone to stretch 3 our legs and take a ten-minute break. 4 (Recess taken at 9:55 a.m. and 5 reconvening at 10:02 a.m.) 6 BY MR. LAUPPE: 7 Q. Dr. Shanley, I will repeat my last 8 question that was pending right before the 9 break. We were discussing this final 10 limitation in Claim 1 of the '381 patent, and I 11 asked, what is your understanding of what 12 blocking electromagnetic radiation means? 13 MR. DEUTSCH: Same objection. 14 Form. Scope. 15 A. Yeah, if we go to Page 35, 16 Paragraph 55, under "Noise and Interference," 17 and basically I go through in this section and 18 talk about unwanted light, stray light, and the 19 techniques that one may go through. So that's 20 Section 6, "Noise and Interference," and 21 Paragraph 55. If we go through Paragraph 55, I 22 talk about stray light and the various	40 1 electromagnetic radiation." 2 So what is your understanding of 3 blocking electromagnetic radiation? 4 MR. DEUTSCH: Objection. Scope. 5 A. Well, yeah, looking at – okay. 6 So we have bandpass or wide pass, low pass, 7 high pass filters. But also if we go to the 8 beginning of this section, "Noise and 9 Interference," Paragraph 55. 10 So my understanding is that 11 elements of this system, detector elements of 12 this system, are particularly sensitive to any 13 – and I go to Paragraph 56 – stray light, and 14 stray light can originate from a lot of 15 different sources. 16 So you want to block all of that 17 light from coming into the receiving section of 18 these instruments. And I cite a number of 19 different examples of where this stray light or 20 electromagnetic radiation can be coming from. 21 It could be scattered light. It 22 could be sun, just a whole bunch of things

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41 1 listed. So you actually need to filter that 2 out, and that particularly is done with several 3 different methods, and that's my understanding 4 of that particular part of the claim. 5 Q. So you just said that you need to 6 block stray light in this system, correct? 7 MR. DEUTSCH: Objection. Form and 8 scope. 9 A. Unwanted light, yes. 10 Q. So what does it mean to block 11 unwanted light? 12 MR. DEUTSCH: Objection. Scope. 13 A. Physically prevent it from 14 reaching the detection system. 15 Q. So let's go back to the '381 16 patent, returning to Claim 1. So do you see on 17 Column 17, starting at line 10, do you see 18 where it says, "A plurality of single photon 19 avalanche diodes (SPADs) operable to detect 20 photons emitted from its corresponding optical 21 emitter and received through the bulk imaging 22 optic after being reflected from surfaces	43 1 scene is what the detector array is going to be 2 detecting. So that's how I would define it, 3 and I think that's how the Retterath and 4 several others define it also. 5 Q. Let's turn to Claim 3 of the '381 6 patent. So let's go back to the '381 patent, 7 Exhibit 3. Claim 3 is in Column 17, starting 8 on line 28. 9 Do you see that? 10 A. Yes. 11 Q. Do you see where Claim 3 says, 12 "The optical system according to Claim 1 13 wherein the plurality of optical emitters are 14 arranged in a first arrangement and the 15 plurality of pixels are arranged in a second 16 arrangement, proportional to the first 17 arrangement." 18 Do you see that? 19 A. Yes. 20 Q. What is your understanding of the 21 meaning of the word "proportional" in that 22 claim?
42 1 within the field"? 2 Do you see that? 3 A. Yes. 4 Q. What does the phrase "after being 5 reflected from surfaces within the field" mean? 6 MR. DEUTSCH: Objection. Scope. 7 A. That's looking at the received 8 radiation from a particular point in the scene. 9 Q. So what is the scene that you just 10 referred to? 11 A. That's the object or objects that 12 you're looking at. 13 Q. And so the claim language says 14 "reflected from surfaces within the field." 15 Do you see that? 16 A. Yes. 17 Q. Is the field the same as what 18 you've mentioned as the scene? 19 MR. DEUTSCH: Objection. Form. 20 Scope. 21 A. To be perfectly precise, the 22 optical system defines the scene, and that	44 1 MR. DEUTSCH: Objection. Scope. 2 A. This says to me end-by-end array 3 similar to what Retterath is illustrating in 4 Figure 8. 5 Q. And then I'd like to turn your 6 attention to Claim 1 again of the '381 patent. 7 Do you see, starting on Column 16, line 64, 8 where it says, "A plurality of optical emitters 9 arranged behind the bulk transmitting optic and 10 configured to output electromagnetic radiation 11 of an operating wavelength through the bulk 12 transmitting optic into a field external to the 13 optical system according to an illumination 14 pattern that comprises a plurality of 15 non-overlapping emission regions." 16 Do you see that? 17 A. Yes. 18 Q. What is your understanding of the 19 term "non-overlapping emission regions"? 20 MR. DEUTSCH: Objection. Scope. 21 A. Actually, if you go to my 22 declaration, and go to Weimer's patent, and in

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45 1 my declaration, if you look at Figure 3A, 2 combine that with Retterath, you can actually 3 see the figure showing non-overlapping regions 4 between the detector, the scene, and the 5 emitter and detectors. 6 Q. Can you point me to a paragraph 7 number in your declaration, sir? 8 A. Sorry. 102, Paragraph 102. You 9 can see both the emitter and the detector bulk 10 optics. 11 And if you go back to paragraph -- 12 let's see, Paragraph 84, one sees in that 13 example also a bulk optic in the detector 14 array, as well as the emitter array with the 15 bulk optic. 16 Q. So just taking these in turn, 17 going back to Paragraph 102 of your 18 declaration, in explaining your understanding 19 of what "non-overlapping emission regions" 20 means, you pointed me to Figure 3A. 21 So is Figure 3A -- strike that. 22 Does Figure 3A provide your	47 1 do you see where Claim 44 recites, "A plurality 2 of pixels arranged behind the bulk imaging 3 optic, wherein each pixel in the plurality of 4 pixels comprises a plurality of single photon 5 avalanche diodes (SPADs) and has a field of 6 view that is non-overlapping beyond a threshold 7 distance in a field external to the optical 8 imaging system with fields of view of all other 9 pixels in the plurality of pixels, and wherein 10 the plurality of pixels includes at least a 11 first pixel and a second pixel." 12 Do you see that claim language? 13 A. Yes. 14 Q. So what does the term "a field of 15 view that is non-overlapping beyond a threshold 16 distance" mean in this claim? 17 MR. DEUTSCH: Objection. Scope. 18 A. I think we covered that just 19 previously, but in my declaration, and we can 20 go to the same figures. Let me pull that up 21 for a minute. If we look at Paragraph 85 in 22 the '750 declaration. Is that what we're
46 1 understanding of what "non-overlapping emission 2 regions" are? 3 MR. DEUTSCH: Objection, form. 4 Objection, scope. 5 A. It's an example. 6 Q. Do you have any other basis for 7 your understanding of what "non-overlapping 8 emission regions" are? 9 A. I think it's all through my 10 declaration. Retterath has examples. Weimer 11 has examples. One can also go to Imai and 12 Higashi all have examples. 13 MR. LAUPPE: I'm going to 14 introduce now the '750 patent, and this 15 will be Exhibit 4. 16 (Document marked as Exhibit 4 17 for identification) 18 Q. And when you're settled, let's go 19 to Claim 44 of the '750 patent, which is 20 between Columns 21 and 22. 21 A. Okay. 22 Q. So starting on Column 21, line 42,	48 1 calling it? 2 Q. That's right. 3 A. Okay. So it would be Paragraph 4 85, Figures 6 and 10. 5 Q. And do you have any other basis 6 for your understanding of what 7 "non-overlapping" means in this claim? 8 MR. DEUTSCH: Objection. Form. 9 Scope. 10 A. So here is an example of it in 11 Figure 6 and 10 showing the emitting section 12 with the bulk option showing the received 13 section with the bulk optic and separate beams. 14 If we go to, and again, I can cite 15 the Weimer patent, and we go to that figure I 16 previously cited. Let me look through this. 17 Well, as I'm paging through, I see the Imai and 18 Higashi patents point to that bulk optic and 19 field of view. And that would be the Paragraph 20 111 and Figure 2. 21 We can actually go to the same 22 patent in 120, Figure 11. Also Figure 3A on

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49 1 paragraph -- the paragraph preceding that is 2 Paragraph 178, and on the next page is figure 3 from Weimer showing that it meets that 4 requirement also. 5 Q. Okay. Let's turn to your 6 declaration in the '381 IPR. So that's Exhibit 7 1. So let's turn to Paragraph 131 of your 8 declaration. 9 A. Okay. 10 Q. In the '381 patent IPR, you were 11 opining that it would have been obvious to 12 combine Retterath with Borowski, correct? 13 MR. DEUTSCH: Objection. Form. 14 A. Combining Retterath and Borowski, 15 yes. 16 Q. And correct me if I'm wrong, but 17 is it your view that the combination between 18 Retterath and Borowski involves each detector 19 disclosed by Retterath containing multiple of 20 Borowski's single photon avalanche diodes or 21 SPADs? 22 A. As stated, yes.	51 1 combination, would what is shown in the red box 2 in this demonstrative figure be included for 3 each single photon avalanche diode or SPAD? 4 MR. DEUTSCH: Objection. Form. 5 A. Yes. 6 Q. And so how many SPADs and 7 associated circuitry would each detector 8 contain in the combination? 9 A. If you look at -- let's see, one 10 would have several SPADs per pixel. So we can 11 have multiple SPADs for a given pixel, and each 12 of those would have quenching circuits so that 13 a pixel would have an overall output based on 14 multiple detections, and not all SPADs in that 15 pixel are operating simultaneously; some are 16 quench and some are still operating, and that's 17 the whole idea of having multi pixels -- or 18 multi-SPAD pixels. 19 Q. And so for each SPAD in a pixel, 20 you said each SPAD would have a quenching 21 circuit, correct? 22 A. Yes. You have to be able to
50 1 Q. And so that's shown in the 2 demonstrative figure in Paragraph 131, correct? 3 A. Yes. 4 Q. Do you see what's in the red box 5 in that demonstrative figure? 6 A. Yes. 7 Q. What's in the red box in that 8 demonstrative figure? 9 A. It shows a quenching circuit for a 10 single element in the array. 11 Q. Does it show anything other than a 12 quenching circuit? 13 A. Well, it shows the emitter and 14 detector sections. 15 Q. Sorry, I was unclear. So looking 16 at the red box in the demonstrative figure, do 17 you see in red you have something that reads 18 "quenching," something that reads "SPAD, TDC" 19 and "local DSP"? 20 Do you see each of those elements? 21 A. Yes. 22 Q. So in the Retterath/Borowski	52 1 quench a SPAD while another SPAD is operating. 2 So if, for example, we had this four-by-four 3 array, three of the SPADs may be quenched while 4 one is still operating, and then the others 5 come up while you quench that other that is 6 operating. So you have a pixel -- a SPAD 7 always at the -- let me get this right. So you 8 have a pixel always turned on, period. 9 Q. And then going back to the red box 10 in this demonstrative figure, would each SPAD 11 have its own TDC element? 12 A. That would -- that would -- I 13 think I show that you would have other inputs 14 into the TDC. You would have some type of 15 integrator that you're integrating the outputs 16 for each SPAD. 17 So each pixel has an integrator, 18 and how you accomplish that, where you're 19 accumulating -- okay. Let's take this. 20 So a frame comes in, and a frame 21 is a multi-pixel image, and each pixel has a 22 value, and that value comes from the

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53 1 integration of the SPAD detections in each 2 pixel. 3 So what happens is, if this is my 4 pixel, and I've got these four SPADs, then my 5 arm represents the output from those four SPADs 6 going into the TDC. 7 Q. So the TDC is what you're 8 referring to as the integrator; is that 9 correct? 10 A. Yeah, I would integrate that. I 11 mean, you could have -- that could be 12 implemented in many different ways in CMOS, 13 depending on the person who is designing it. 14 Q. How about the local DSP showing 15 shown in the red box, would each SPAD have its 16 own local DSP? 17 A. No, I would think that you would 18 have a central DSP, and that would be some FPGA 19 or some programmable thing that you would have 20 there, initially in Xilinx and the signal 21 processing. 22 So what you're doing is processing	55 1 it's fairly obvious, probably for most of the 2 systems we discussed here, four would do it, 3 maybe more. 4 Q. So how many SPADs would be 5 sufficient for the -- strike that. 6 How many SPADs per pixel would be 7 sufficient for the Retterath system? 8 MR. DEUTSCH: Objection. Form. 9 Scope. 10 A. I don't -- I don't -- I couldn't 11 comment on that. I'd have to look at the whole 12 system requirement. But Borowski for his 13 method tends to think four, as reflected in my 14 declaration, and Imai and Higashi tend to think 15 four also. 16 Q. Can you turn to your declaration 17 for the '750 IPR, Exhibit 2. Can you go to 18 Paragraph 148. 19 A. Okay. 20 Q. Do you see in Paragraph 148 where 21 you say, "Retterath also teaches that each 22 pixel in the plurality of pixels has a field of
54 1 frame by frame by frame. As the images come 2 in, you get output from the pixel, and that 3 pixel, which consists of multiple SPADs, will 4 go into some type of accumulation, which will 5 then put into a central signal processing unit. 6 Q. So you said that, and again, 7 correct me if I'm wrong, I believe you said 8 that each pixel shown in the Retterath Figure 9 11B in this combination with Borowski would 10 have several SPADs; is that correct? 11 A. Yes. 12 Q. Okay. How many SPADs? 13 A. How many would you like? 14 MR. DEUTSCH: Objection. Form. 15 Scope. 16 A. They could be multiple. So, you 17 know, what's the minimum -- it depends on what 18 your system requirements are, and how fast 19 you're going to be processing your frames. 20 So that can be backtracked to how 21 many pixels you put in; is it four, is it six? 22 It's up to the system designer, but I think	56 1 view that is non-overlapping beyond a threshold 2 distance in a field external to the optical 3 imaging system with fields of view of all other 4 pixels in the plurality of pixels"? 5 A. Yes. 6 Q. What is the threshold distance 7 Retterath discloses? 8 A. I would have to go and look at 9 Retterath. I don't think it's absolutely 10 designed as an absolute number on it. So I 11 can't be certain. 12 Q. So you don't know what the 13 threshold distance is for Retterath? 14 MR. DEUTSCH: Objection. Form. 15 A. Do we have the Retterath patent? 16 Q. I'm sorry, absolutely. Let me 17 introduce Retterath. 18 MR. LAUPPE: This is Exhibit 1005 19 of -- it's the same exhibit number for 20 both the '381 and the '750 IPRs. So 21 let's keep it at that number. 22

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57 1 (Document marked as Exhibit 1005 2 for identification) 3 Q. You don't know what the threshold 4 distance is for Retterath; is that correct? 5 MR. DEUTSCH: Objection. Same 6 objections. 7 A. Yeah, at this point I'd have to go 8 through and look at the patent. But basically 9 my quick comment here is that it really depends 10 upon the object being detected and how that 11 system is performing. But one schooled in this 12 field knows that there's a distance, you know, 13 that this statement is true. 14 Q. But this statement doesn't include 15 what the threshold distance is, correct? 16 MR. DEUTSCH: Objection. Form. 17 A. No. I don't believe any patent 18 does. 19 Q. Sorry to make you jump around. 20 Let's turn to the '381 patent, and let's take a 21 look at Claim 7 of the '381 patent. So that's 22 Exhibit 3. Claim 7 is on Column 17 of the '381	59 1 Q. So you are pointing to Retterath's 2 waveguide structures as the aperture layer 3 comprising a thin opaque structure for Claim 7, 4 correct? 5 MR. DEUTSCH: Objection. 6 Mischaracterizes. 7 A. Yeah, I think I've stated that 8 pretty succinctly in the declaration. 9 Q. Okay. Then let's turn to 10 Retterath, which we just introduced, that was 11 Exhibit 1005. Can you turn to Figure 9? 12 MR. DEUTSCH: Hold on a second. 13 A. If you give me a minute here. Let 14 me get rid of some of this paper. 15 Q. No problem. 16 A. All set. 17 Q. If you could turn to Figure 9 of 18 Retterath, which is on Page 14. 19 A. Okay. 20 Q. Does Figure 9 show one of 21 Retterath's waveguide structures? 22 A. Yes.
58 1 patent. 2 A. Okay. 3 Q. Do you see where Claim 7 says, 4 "The optical system according to Claim 6 5 wherein the aperture layer comprises a thin 6 opaque structure"? 7 A. Yes. 8 Q. Okay. I'm going to make you jump 9 again. Sorry. Can you go to Paragraph 180. 10 This is your declaration of the '381 patent, so 11 Exhibit 1. 12 A. 180? 13 Q. Correct. 14 A. Okay. 15 Q. And if you flip to the prior page, 16 do you see that Paragraph 180 is in a section 17 related to Claim 7 of the '381 patent? 18 A. Could you repeat that? 19 Q. Of course. So Paragraph 180 20 pertains to your analysis for Claim 7 of the 21 '381 patent, correct? 22 A. Yes.	60 1 Q. Okay. So I'd kind of just like to 2 keep that figure there, and if we could look 3 back at Paragraph 180 of your declaration, 4 we'll just kind of be referring back and forth. 5 Do you see in Paragraph 180 of 6 your declaration you say, "A POSITA would have 7 recognized from Retterath's description that 8 the waveguide material 215 comprises an 9 optically opaque material that is not 10 transparent to effectuate that purpose"? 11 Do you see that? 12 A. Yes. 13 Q. So do you see, looking at Figure 9 14 of Retterath, do you see element 215? 15 A. Yes. 16 Q. So what about Retterath's 17 description would have made a POSITA that the 18 waveguide layer 215 comprises an optically 19 opaque material that is not transparent? 20 MR. DEUTSCH: Objection. Form. 21 A. Yeah, I go on in Paragraph 181 to 22 explain that he didn't explicitly disclose a

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61 1 thin opaque layer, but a POSITA would have gone 2 on to say, yes, I can do waveguide structures 3 and waveguide structures can take many 4 different forms. 5 Having done this and having 6 actually created photodetectors with various 7 masks and structures on the surface, this would 8 render itself very easily to thin film 9 techniques where you could use opaque material, 10 and part of that waveguide structure being, you 11 know, you could blacken the top part, you can 12 do all kinds of things. 13 And I think that's the thing, this 14 is a pretty obvious rendition for that figure, 15 and someone with the skills of making these 16 devices in systems would recognize that there 17 are many ways to do this, including air gap, no 18 air gap, lenses, just a multitude of ways. 19 So it's a pretty obvious thing. 20 Q. Just to clarify, you said 21 Retterath doesn't explicitly disclose a thin 22 opaque structure; is that correct?	63 1 MR. DEUTSCH: Objection. Form. 2 A. Yes. 3 Q. What is thin about element 215? 4 A. That's to be determined by the 5 designer. And so the fabrication of that layer 6 would really depend upon the characteristics 7 that the designer assigns to that array and how 8 you fabricate it. So it really comes down and 9 flows from the system. 10 The other way of looking at it is 11 that a lot of these waveguide structures and 12 structures on the devices themselves are done 13 at the manufacturer. For instance, a company 14 like Sony. 15 So they would have these SPAD 16 structures available to industry, and you would 17 have what their existing structure is, or you 18 could go to the manufacturer of the SPADs and 19 specify what you wanted and how you wanted that 20 waveguide on the surface, and they would take 21 care of the fabrication. 22 Q. So let's go back at your
62 1 A. Paragraph 181. 2 MR. DEUTSCH: Objection. 3 Mischaracterizes. 4 Q. Sorry, is it your opinion that 5 Retterath discloses explicitly a thin -- a 6 aperture layer comprising a thin opaque 7 structure? 8 A. I cite Paragraph 181 again, and it 9 states "To be clear even if Retterath did not 10 explicitly disclose a thin opaque structure," 11 it's obvious that someone skilled in the art 12 would put you or could put a structure in 13 there. 14 Now, I've fabricated a lot of 15 devices in my time with various structures on 16 the surface, and the one would go about using 17 thin film techniques and other techniques to 18 actually fabricate those waveguides. It's 19 pretty standard in the field. 20 Q. So is it your opinion that in 21 Figure 9, element 215, is the thin opaque 22 structure?	64 1 declaration, Paragraph 180. This is the 2 sentence toward the bottom of the paragraph. 3 Do you see where you say, "The 4 waveguide material 215 is formed as a layer on 5 substrate 50, which a POSITA would have 6 understood is a thin layer relative to the 7 optical system"? 8 Do you see that? 9 A. Yes. 10 Q. So why would a POSITA have 11 understood waveguide material 215 is a thin 12 layer relative to the optical system? 13 A. Being a device person and knowing 14 that there are other people like me designing 15 these systems, it's just an understood fact of 16 device technology. 17 Q. Looking at Figure 9, is layer 215 18 thin as compared to layer 50? 19 MR. DEUTSCH: Objection. Form. 20 A. I wouldn't comment on that, 21 because I don't know. And if you look at layer 22 50, you know that that's not a -- it's a

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65 1 schematic SPAD. But if you looked at that 2 device, you know that that SPAD layer has got 3 all kinds of multiple layers in the junction 4 and it has grown in a certain manner. 5 So that's, you know, just 6 structurally just an overview. It just shows 7 light coming in and things like that. But a 8 person schooled in device technology would know 9 these things, and so I couldn't comment on how 10 thick or thin that layer was. 11 Q. So layer 228 in Figure 9, that's 12 thinner than element 215; is that correct? 13 MR. DEUTSCH: Objection. Form. 14 A. That's what's shown schematically. 15 Q. And what about layer 226? 16 MR. DEUTSCH: Objection. Form. 17 A. Which layer? 18 MR. DEUTSCH: Scope. 19 Q. Is layer 226, is that thinner than 20 layer 215? 21 A. I would have to go back and look 22 at what Retterath says in the patent, if you	67 1 thicknesses. So I really can't comment on 2 that. 3 The passivation layer or 4 protective layer 228, those are usually some 5 kind of – these are silicon devices. So 6 that's some kind of silicon oxide, I believe. 7 That's 228, a protective layer, but I don't 8 know what that is, because that's not on the 9 silicon itself. So 224 is a bandpass. The 10 photoreceptor is 224. The bandpass layer is 11 226. 12 So the protective layer isn't even 13 the silicon dioxide layer on the surface of 14 this, if it is a silicon device. 15 So, you know, it's hard to comment 16 on the layers, because I don't know what, you 17 know, I don't believe he – I don't know what 18 the – I would have to go back and look and see 19 what his detector comprises in terms of 20 material. So it's very difficult to tell you 21 what those layers are. 22 Q. So you can't say whether layer 226
66 1 want to take a minute and do that. He does 2 comment on that. 3 Q. Sure. I will direct you to where 4 Retterath discusses Figure 9. If you want to 5 go Column 10, starting at line 4. Feel free to 6 take a minute if you want to look at that 7 paragraph. 8 A. Column 10, line 4. 9 Q. So the question is, is layer 226 10 thinner than layer 215 in Figure 9? 11 MR. DEUTSCH: Objection. Scope. 12 A. It's really hard for me to comment 13 from a schematic like this without actual 14 drawings. I mean, you know, having – okay, so 15 226 is a bandpass filter. So the question is, 16 how many layers are put down, and what 17 materials are in that bandpass filter. So it's 18 hard to say what the thickness of that would 19 be. 20 I had a group at McDonnell-Douglas 21 that did nothing but filter and various filter 22 development and filters can have various	68 1 is thin relative to layer 215? 2 MR. DEUTSCH: Objection. 3 Mischaracterizes. 4 A. No, I wouldn't venture a guess. 5 Q. And how about layer 228, can you 6 say whether that is thin relative to layer 215? 7 MR. DEUTSCH: Objection. 8 Mischaracterizes. 9 A. It's shown in the diagram, but I 10 wouldn't guess. A lot of times you look at 11 these schematics, and they're wrong. I just 12 note that he's emphasizing the waveguide nature 13 here. So I don't know the depth or anything 14 about the waveguide material. 15 And it might be noted when you're 16 filling it and you have an opaque material, 17 there should probably be another layer on top, 18 which is a blackening layer which prevents 19 reflected light. 20 If you fill this, you could file 21 it with some dielectric material off a 22 refractive index that makes it fairly thin.

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69 1 So it's hard to quantify relative 2 thicknesses. 3 Q. Going back to the specification of 4 Retterath, if you go to Column 9. 5 A. Okay. 6 Q. So Column 9, do you see, starting 7 at line 62, Column 9 says, "Inbound optical 8 energy that is more than slightly non-parallel 9 to the receive detector vector (coincident 10 axis) 220 will be substantially blocked by the 11 detector waveguide or directed elsewhere by the 12 macro lens." 13 Do you see that? 14 A. Yes. 15 Q. What does that mean "substantially 16 blocked"? 17 MR. DEUTSCH: Objection. Scope. 18 A. I really couldn't comment on the 19 wording "substantially," but it will be blocked 20 by the detector waveguide. Some radiation 21 might get through, but if they have done their 22 optical design right, I would think that would	71 1 system. 2 And as I point out in my 3 declaration on interference effects in the 4 light coming into the receiver portion, you 5 have to do all kinds of modifications in the 6 section of my declaration on interference, in 7 the section that we previously looked at. 8 It talks about what you have to go 9 through to stop interference effects in the 10 instrument itself, and there are many things 11 you do, including a whole bunch of things. 12 So by that time, it gets to the 13 waveguide area here on the detector. There 14 shouldn't be much of a problem and the 15 waveguide would take care of it as per, you 16 know, using waveguides and I state in my 17 declaration. 18 Q. I'm going to try to demonstrate on 19 Figure 9 and also try to make this clear for 20 the record. So if this light beam shown at 21 element 220, if that were to be shifted to the 22 right, such that it has the same angle but
70 1 be very extremely small. 2 Q. So let's look back at Figure 9. 3 A. Okay. 4 Q. So is it your understanding that 5 light will only be substantially blocked by the 6 waveguide shown in Figure 9? 7 MR. DEUTSCH: Objection. Form. 8 Scope. 9 A. Well, let's see. He goes on to 10 say also that "For the purposes of present 11 invention" -- this is in Column 9, in 65, 12 starting at the bottom of the page. "For 13 purposes of the present invention, the 14 coincidence axis of a given detector is defined 15 as the center of the area of the light beam as 16 received by the detector not including any 17 modifications to the light beam due to optic 18 elements internal to the LiDAR unit." 19 I point out that the optic 20 elements, the other optic elements in the light 21 system, there's a make play between the 22 waveguide and the other elements in the optical	72 1 shifted to the right such that it hits the 2 layer 215, what is your understanding of what 3 happens to that light beam? 4 MR. DEUTSCH: Objection. Form. 5 Scope. 6 A. If it hits light -- if it hits 7 215? 8 Q. Correct. 9 A. So the beam is coming in and 10 something hits over here. Okay. So if you do 11 your proper optical design, I would have 12 absorbing material here, which is standard 13 technique, because you put opaque material and 14 you would put some type of other material here 15 so that it would come in -- it would hit it, 16 but then you can't be totally certain that all 17 of it would be absorbed here. 18 So what would happen is you would 19 have some reflection off in this direction. So 20 standard technique would be to put something 21 here that absorbs or blocks that radiation. 22 So what happens, as I explain in

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73 1 my section of the declaration, the whole 2 analysis of this is that once your system is 3 laid out and you have all the waveguides and 4 every component in there, we do something in 5 the business called stray light analysis, and 6 this is a program – synopsis that does nothing 7 but stray light analysis, and it tells you 8 where every beam of light off axis in that 9 system is going. 10 So what happens then is the 11 designer, and I've done this a couple of times, 12 will sit there and design baffles and apertures 13 to absorb and block that light. 14 So it's very well understood that 15 whole optical design and how you do that. 16 Q. Okay. Understood. So if this 17 system worked, shown in Figure 9, if this 18 system worked such that that light beam we were 19 just talking about, it shifted over so it hits 20 layer 215, and some light gets through, what 21 does that mean for the material in layer 215? 22 MR. DEUTSCH: Objection. Scope.	75 1 has the diode part, and then a valley, and then 2 you go up again to the next diode. 3 So this would look like – how can 4 I explain this? You have a flat top and then 5 you etch away the surface of that structure, 6 and then you bring it up and you have the next 7 structure, and you go along and you etch it 8 again with the valley. 9 So the ray looks like a flat top 10 and a bunch of valleys. So that ray coming 11 into this opaque structure, if it did get 12 through, there's absorbing layers in there and 13 it may hit those valleys where it would be 14 suitably taken care of. 15 So that's a device consideration, 16 and a POSITA would know that who is doing this 17 part of the design. 18 Q. I promise we can take a break in a 19 minute. I want to finish this line ever 20 questioning. You just mentioned if a ray gets 21 through, you just said that a ray gets through 22 this opaque material.
74 1 Calls for speculation. 2 A. I don't understand. So normally, 3 though, the way this works, if you go to – 4 there's a patent by Grzesik, and Grzesik 5 explains what the device manufacture is, and 6 what you do in device manufacturing, so that 7 you wouldn't have that problem. 8 If it gets through in a detector 9 array, you could have crosstalk. And I explain 10 in my declaration what you do for optical 11 crosstalk in the beginning, in the technology 12 section, if you remember that. 13 And then if you go further to 14 Grzesik's patent, and we cite that – Grzesik 15 has a figure that shows the surface of the 16 device, usually at the device. 17 If a ray gets through the 215 18 layer, you've got the passivation layer and 19 things like that. And then it may be that the 20 photodiode or SPAD structure is something we 21 called mesa etched. Basically those structures 22 look like a mesa. You have a structure that	76 1 My question is, is layer 215 still 2 opaque if light can get through that layer? 3 MR. DEUTSCH: Objection. Scope. 4 Form. 5 A. Yeah, I mean, it's – it depends. 6 Light is a funny thing. It's like water 7 basically, I mean, referred to in an optical 8 system. It can go the strangest places. When 9 you think you've designed an optical system 10 that's the best you can do, and all of a sudden 11 you get your stray light analysis and you go, 12 oh, my God, and you've got to go back and do 13 all of these supernatural things. 14 Would it happen? I highly doubt 15 it. Could it happen? I guess it could. But 16 if it's an opaque material, it shouldn't, and 17 if you choose your material right, it 18 shouldn't. 19 MR. LAUPPE: How about we take 20 another ten-minute break and give 21 everybody a chance to stretch their 22 legs.

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77 1 (Recess taken at 11:08 a.m. and 2 reconvening at 11:19 a.m.) 3 BY MR. LAUPPE: 4 Q. I want to change gears now a 5 little and turn to the Retterath, Borowski and 6 Pacala combo. So can you open up your 7 declaration for the '381 IPR. 8 A. Okay. 9 Q. Again, this is Exhibit 1. Can you 10 go to Paragraph 223? 11 A. Okay. 12 Q. And in Paragraph 223, do you see, 13 I think it's the second sentence that starts at 14 the bottom of that first page, Page 108, 15 "Pacala suggests a commonly used LiDAR 16 construction that is overall compact in size 17 and provided low-cost optical layout with the 18 optoelectronic elements behind bulk optics." 19 Do you see that sentence? 20 A. Yes. 21 Q. So let's take a look at Pacala, 22 which is Exhibit 1013.	79 1 Q. Is compactness important for a 2 rotating system? 3 MR. DEUTSCH: Objection. Scope. 4 A. Depends on the system requirements 5 and where it's going to go. I think that's the 6 main thing. 7 Q. So looking at the disclosures of 8 Pacala, what indicates to you that it is a 9 low-cost device? 10 A. A couple of things. One, just the 11 layout of the device in the figure, in Figure 12 2. And also the fact that the lenses transmit 13 and receive are close together. The fact that 14 it's, I think -- just the overall look of it 15 and the precise compactness and the form of it 16 looks very low cost, I would assume. 17 Q. Let's look back at your 18 declaration for the '381. 19 A. Okay. 20 Q. We're still looking at Paragraph 21 223, and this is the last sentence. Do you see 22 where you say, "Based on my knowledge and
78 1 MR. LAUPPE: Pacala is Exhibit 2 1013, and that's the same exhibit number 3 for both of the IPRs. 4 (Document marked as Exhibit 1013 5 for identification) 6 Q. Dr. Shanley, can you show me what 7 in Pacala suggests LiDAR construction that is 8 overall compact in size and provided low-cost 9 optical layout? 10 A. Looking at Figure 2 in Pacala. 11 Q. So what about Figure 2 in Pacala 12 indicates that it's a compact device? 13 A. Yeah, the way the arrangement of 14 the swivel device is, the two optical elements, 15 the transmit and receive areas, and his 16 electrical layout on the side, just the drawing 17 looks very, very compact, and the description 18 that he provides in the text basically leads 19 one to assume that it's a nice compact device. 20 Q. And Pacala is a rotating system, 21 correct? 22 A. Yes.	80 1 experience and review of Retterath, Borowski 2 and Pacala, a POSITA would have recognized that 3 implementing the Retterath-Borowski combination 4 with similar compact configuration as suggested 5 by Pacala, in which the bulk optics are 6 positioned immediately next to one another, 7 would have provided such benefits without 8 hindering operation of the device." 9 Do you see that? 10 A. Yes. 11 Q. Now turning to the '381 patent, 12 let's go to Claim 1. Again, this is between 13 Column 16 and 17. This is Exhibit 3. 14 Do you see on Column 16, lines 4 15 to 5, where -- Column 17, lines 4 to 5, where 16 Claim 1 requires a "bulk imaging optic disposed 17 adjacent to the bulk transmitting optic." 18 Do you see that? 19 A. Yes. 20 Q. So returning you to Paragraph 223 21 of your declaration, you say that the bulk 22 optics in Pacala are positioned immediately

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81 1 next to one another, correct? 2 A. Yes. 3 Q. So that claim language in Claim 1 4 of the '381 patent, "a bulk imaging optic 5 disposed adjacent to the bulk transmitting 6 optic," does that require that the bulk optics 7 are positioned immediately next to one another? 8 MR. DEUTSCH: Objection. Form and 9 scope. 10 A. I would interpret the claim saying 11 adjacent to one another to be that. 12 Q. So just to clarify, "adjacent to 13 one another" means immediately next to one 14 another? 15 MR. DEUTSCH: Objection. Scope. 16 A. Looking at the -- from the figure 17 of Pacala and looking at the other devices, 18 Borowski and Retterath in conjunction, it would 19 be the only way I could interpret that. 20 Q. Let's change gears. Let's talk 21 about the Imai and Higashi combo. 22 MR. LAUPPE: I'm going to	83 1 sorry. 2 Q. So this is at the top of Page 126 3 or 133 of your declaration, right above 4 Paragraph 256. 5 Do you see that there's a 6 demonstrative figure you provided? 7 A. Yes. 8 Q. Okay. That's what I'm looking at 9 -- strike that. 10 This demonstrative shows your 11 opinion that in the combination of Imai and 12 Higashi, a POSITA would use four SPADs in each 13 of the PDA elements of Imai; is that correct? 14 A. Yes. 15 Q. And so, on the right side of this 16 diagram, it might be a little hard to see on 17 the printout, but do you see there are these 18 little dotted red line boxes around the four 19 SPADs and some associated circuitry? Do you 20 see that? 21 A. Yes. 22 Q. Would everything you see in that
82 1 introduce the Imai reference, which is 2 Exhibit 1009 for both of the IPRs. 3 (Document marked as Exhibit 1009 4 for identification) 5 MR. LAUPPE: Then I'll also 6 introduce, just so we have it on hand, 7 the translation of the Higashi 8 reference. This is Exhibit 1111. 9 (Document marked as Exhibit 1111 10 for identification) 11 Q. Let's go to Paragraph 255 of your 12 Exhibit 1. 13 A. Okay. 14 Q. You might need to flip pages. If 15 you go to the bottom of Paragraph 255, do you 16 see you've provided a demonstrative figure? 17 A. Okay. 18 Q. And -- 19 MR. DEUTSCH: Hold on. Could you 20 say that again? Where are you 21 referring? 22 MR. LAUPPE: Of course. I'm	84 1 dotted red line box, for example, a top one on 2 the right side of that demonstrative figure, 3 would everything in that dotted red box be 4 incorporated into each of the PDA elements of 5 Figure 11 of Imai? 6 MR. DEUTSCH: Objection. Form. 7 Scope. 8 A. Yes. 9 Q. Is what you see in the red dotted 10 boxes on the right side of this demonstrative 11 figure, is that all the material that would 12 need to be included in each of the PDA elements 13 of Imai in order to achieve the combination or 14 would there be other material that would need 15 to be incorporated? 16 MR. DEUTSCH: Objection. Form. 17 A. Other material? Can you describe 18 what you mean by "other material"? 19 Q. Absolutely. So basically I just 20 want to get your opinion as to whether what we 21 see in the dotted red boxes here in this 22 demonstrative figure, is that all that would

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85 1 need to be incorporated into each of the PDA 2 elements of Figure 11 of Imai? 3 A. Well, it's my understanding, and 4 looking at it, a pixel consists of those four 5 SPAD elements, and each of those elements 6 represent a pixel. 7 Of course you would need, you 8 know, the quenching circuits and other things 9 surrounding that electronics to process the 10 signal and scanning material, and stuff like 11 that. 12 But it's my opinion that the SPAD, 13 the four SPAD elements, represent each of the 14 pixels in the figure. 15 Q. And, sir, you just mentioned 16 scanning material. Can you elaborate what you 17 mean by scanning material? 18 A. I meant all the peripheral 19 equipment to make play for this type of 20 instrument. 21 Q. Would there be any challenges 22 associated with the combination you demonstrate	87 1 emitters would be VCSELs and the detectors 2 would be SPADs, correct? 3 A. Yes, as I stated in my 4 declaration. 5 Q. Okay. Are you aware of any 6 challenges related to the use of VCSELs as 7 emitters and SPADs as detectors in a LiDAR 8 system? 9 MR. DEUTSCH: Objection, form. 10 Objection, scope. 11 A. I don't think there are at this 12 point, and, you know, I think they're perfectly 13 suitable for LiDAR systems. 14 Q. Let's turn to Paragraph 233 of 15 your '381 declaration. That's not right. Let 16 me find the actual one. 17 Can you turn to Paragraph 268 in 18 the '381 declaration, which is on Page 133. 19 A. Okay. 20 Q. Do you see this demonstrative 21 figure you've provided at the bottom of this 22 page based on Imai's Figure 2C?
86 1 in this figure? 2 MR. DEUTSCH: Objection. Form. 3 A. I don't perceive any. 4 Q. Let's turn to Paragraph 290 of 5 your '381 declaration. 6 A. Okay. 7 Q. So Paragraph 290 indicates that, 8 in your opinion, in Imai satisfies the VCSEL 9 limitations in Claim 12; is that correct? 10 MR. DEUTSCH: Objection. Form. 11 Mischaracterizes. 12 A. As stated in Paragraph 290, and I 13 said Imai expressly provides VCSELs, and as its 14 LDs, and the LD array is a plurality of – it 15 goes on to say – it also goes on to say about 16 the plurality of VCSELs. 17 Q. And then based on, for example, 18 what we were just talking about, it's your 19 opinion that the Imai/Higashi combo would use 20 SPADs as the photodetectors? 21 A. Yes. 22 Q. So in the Imai/Higashi combo, the	88 1 A. Yes. 2 Q. Do you see at the top of this 3 figure where it says, "Light Projecting Optical 4 System, Light Receiving Optical System 5 (Partially Omitted)"? 6 A. Yes. 7 Q. What is your understanding of what 8 is omitted from Figure 2C of Imai? 9 MR. DEUTSCH: Objection. Scope. 10 A. If we look back on, for instance, 11 if we go to the Paragraph 264, and above it in 12 Figure 2A, it shows a better schematic of these 13 things. 14 If you go to the first part where 15 22 is, you can see that he truncates a lot, a 16 fair amount of that drawing, and he just comes 17 up with this little schematic that we have on 18 the bottom of Paragraph 268. 19 Q. Okay. Let's turn to Imai itself. 20 That might be more helpful, because I think 21 both of these figures are kind of on the same 22 page. Could you turn to Figure 2.

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89 1 A. Sure. 2 Q. I think you're looking at Higashi. 3 Exhibit 1009. Do you see that? 4 A. I'm sorry. 5 Q. It's my fault for giving you so 6 much paper. 7 A. This would be easier to do on a 8 computer. Okay. I have it. 9 Q. Great. So are you at Figure 2? 10 A. Yes. 11 Q. So Figure 2 shows the two diagrams 12 we've just been talking about, right? 13 A. Right. 14 Q. There's 2C and 2A were what we 15 were just discussing, correct? 16 A. Yes. 17 Q. So 2C is the part of this figure 18 that indicates that it's partially omitted, 19 correct? 20 A. Yes. 21 Q. So you pointed to 2A as including 22 elements that are omitted from 2C is that	91 1 correct? 2 A. Mm-hmm, yes. 3 Q. Okay. But -- sorry. Can you walk 4 me through your understanding of how Figure 2C 5 works in your understanding? 6 A. Well, if you go up to the 2A and 7 2B, basically they're using that device to 8 reflect the light from the transmitter into a 9 scanning mirror, and that mirror is also used 10 to reflect the return light to the detector 11 from the scanning mirror. 12 So you send a pulse out and it 13 comes back. I've seen systems like that which 14 are folded onto themselves and can actually do 15 that. It's not a big design issue. 16 Q. So is the scanning mirror element 17 26 in Figure 2A and 2B? 18 MR. DEUTSCH: Objection. Form. 19 A. Let's look back into the -- 20 Q. Of course. 21 A. -- patents. It shows that it is 22 a scanning device.
90 1 correct? 2 A. That's right. 3 Q. So what elements of 2A are omitted 4 from 2C? 5 A. Well, I think you see that 24 is 6 consistent with all of them, and everything to 7 the left of 24. So 26 is omitted, and it just 8 shows, you know, the element 24. 9 Q. So it's your understanding that 10 2C, a POSITA would understand that 2C includes 11 element 26; is that correct? 12 MR. DEUTSCH: Objection. Form. 13 Mischaracterizes. 14 A. I look at 24 and take it more as a 15 schematic just showing the fact that they have 16 in sort of a semi-empirical way the optics for 17 the transmitter and receiver. To me it's just 18 a sketch basically. There's nothing that is 19 anything outstanding in it, but it just 20 amplifies the emitter and the detector section. 21 That's all. 22 Q. So element 24 is a mirror,	92 1 Q. So I'll just direct you, it looks 2 like Paragraphs 38 and 39 in Imai. 3 A. If you go to Paragraph 37, Page 2, 4 it says, "The light receiving optical system 30 5 includes the rotary mirror 26," so 26 is the 6 rotary mirror, "and reflects the light 7 projected from the light projecting optical 8 system to be reflected (scattered) by the 9 object located in the valid scanning area, the 10 reflecting mirror 24 which reflects the light 11 from the rotary mirror 26, and an image forming 12 optical system arranged on the optical path of 13 the light from the reflecting mirror to form an 14 image of the light on the PDA (photo diode 15 array) as an optical detector to be described 16 later ... in Figure 2." 17 It's a pretty rough translation, 18 but you get the whole idea there. So you have 19 that rotary mirror, which is the scanning 20 mirror, and basically you're using a compact. 21 Just parenthetically let me 22 comment on these optical systems. We use

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93 1 something called Optigami, and it's basically 2 faulting mirrors, it's like one with Origami, 3 so you just take everything and fold it and 4 share paths and things like that. This is an 5 example of an Optigami system. 6 Q. So rotating mirror 26 is not shown 7 in Figure 2C, correct? 8 A. No. So it's just, I take it, you 9 know, an engineer saying, I have these two 10 paths. I'm going to show that those two 11 optical paths are shared by a common mirror. 12 In addition, we do this little 13 thing where we put 22 in there and say, okay, I 14 have some optical elements that I'm doing B 15 forming and stuff. Is that the real form of 16 that element? Probably -- definitely not. 17 The same thing with the image 18 forming optical system, there are a couple 19 optical elements there. Is that the system? 20 No. It's just a schematic, remember. So I 21 would have to populate these with the proper 22 system. But it's schematically showing what's	95 1 know they're imaging and emitting, but we don't 2 know any of the details. It's just saying this 3 is what they are. 4 So a POSITA would have to go in 5 there and have to design those specifically for 6 the geometries of the arrays that are being 7 used. 8 Q. And let's just look back at Imai 9 real quick. Can you go to Paragraph 39 of the 10 Imai reference, which is Exhibit 1009. 11 A. Okay. 12 Q. Do you see where Paragraph 39 13 says, "As is understood from (C) in Figure 2, 14 the light projecting optical system 20 and the 15 light receiving optical system 30 are arranged 16 so as to be overlapped in the Z-axis 17 direction"? 18 Do you see that? 19 A. Yes. 20 Q. So looking back at 2C, how are the 21 light projecting optical system 20 and the 22 light receiving optical system 30 overlapped in
94 1 going on and how my scan is being used. 2 Q. Let's go back to your declaration 3 for the '381. Go back to Paragraph 268. 4 Do you see where you've, in this 5 demonstrative diagram, it says "Imaging Lens"? 6 A. Yes. 7 Q. Then there's an arrow that points 8 down to two lenses, correct? 9 A. Yes. 10 Q. So which of these lenses is the 11 imaging lens? 12 A. As I explained earlier, this would 13 be a -- this is just a schematic showing that 14 the imaging lens is different from the transmit 15 lens, and the actual form, they don't have a 16 description there. They don't tell me how many 17 lenses or anything, you know. 18 So it's just a diagram saying, 19 hey, this is the way it is, and there's going 20 to be a packet of imaging optics and there's 21 going to be a packet of emitting optics. What 22 they are in form and function -- function we	96 1 the Z-axis direction? 2 A. Let's see, this is -- if we read 3 the rest of this, they say they overlap in the 4 Z direction, and I take this to be a one-to-one 5 correspondence between the emitter and the 6 detector. 7 We get into all the translational 8 difficulties on these patents, and basically 9 I'm taking this as -- so basically -- I'm not 10 sure "overlapped" is the right word that he 11 should be using, but one would take it 12 designing this that the "direction of the 13 rotary mirror and reflecting mirror are shared 14 by the light projecting optical system and the 15 light receiving optical system. According to 16 this, it is possible to make relative 17 positional displacement between an irradiation 18 range of a LDA and a light receivable range of 19 the PDA on the object small, and thereby 20 realizing stable object detection." 21 Reading this says to me, yeah, I'm 22 going to overlap beam one with beam two, so

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97 1 beam one goes out, hits the object, and then it 2 overlaps with beam two coming in. I'm not 3 sure, I don't know if the translator is a 4 technical person or you have the words in 5 Japanese that are so -- it's not a one-to-one 6 correspondence to what we would think of in 7 English. 8 So I would take that as coincident 9 basically may be a better word than overlapping 10 between the two beams. 11 Q. Okay. 12 MR. LAUPPE: I'm about to change 13 gears to another combo. I know we're 14 coming up on the lunch hour. I could 15 also keep going. Whatever works best. 16 It probably makes sense to take a break. 17 MR. DEUTSCH: Let's take a break. 18 (Luncheon recess taken at 11:59 19 a.m. and reconvening at 12:43 p.m.) 20 BY MR. LAUPPE: 21 Q. Hello, again, Dr. Shanley. Coming 22 back from the break, just to confirm, did you	99 1 imaging system"? 2 Do you see that? 3 A. Yes. 4 Q. Can you go to Paragraph 222 of 5 your declaration. Do you see where you say, 6 "Each 4-SPAD pixel has a field of view that is 7 non-overlapping beyond a threshold distance in 8 a field external to the optical imaging system 9 with fields of view of all other pixels in the 10 plurality of pixels"? 11 A. Yes. 12 Q. And you're discussing the Imai, 13 Higashi and Grzesik combination here, correct? 14 A. Yes. 15 Q. So what is the threshold distance 16 you're referring to here for the Imai, Higashi, 17 Grzesik combo? 18 MR. DEUTSCH: Objection. Form. 19 A. I think that's just the projection 20 distance that I'm referring to so that you have 21 individual beams. So it's not a quantifiable 22 number.
98 1 speak to anybody about the substance of your 2 testimony during the lunch break? 3 A. No. 4 MR. LAUPPE: I'm going to 5 introduce the Grzesik reference which is 6 Exhibit 1012 for both of the IPRs. 7 (Document marked as Exhibit 1012 8 for identification) 9 Q. I'd like to turn to your '750 10 declaration about the Imai, Higashi, Grzesik 11 combo, and that's Exhibit 2, Paragraph 219. 12 A. Okay. 13 Q. Do you see above Paragraph 219 you 14 provided the claim language for Claim 44 -- 15 limitation 44(c) of the '750 patent? 16 A. Yes. 17 Q. Do you see where that claim 18 language says "each pixel in the plurality of 19 pixels comprises a plurality of single photon 20 avalanche diodes (SPADs) and has a field of 21 view that is non-overlapping beyond a threshold 22 distance in a field external to the optical	100 1 Q. And then let's go to Paragraph 2 225. Do you see where you say, "In a second 3 manner, the Imai-Higashi-Grzesik combination 4 provides Element 44(c) based on Imai's 5 embodiment shown in Figure 11 and Higashi's 6 suggestion of using multiple SPADs at each 7 detector pixel"? 8 Do you see that? 9 A. Yes. 10 Q. Moving on to Paragraph 226, do you 11 see where you say, "Each pixel (pixels 1 to 16) 12 has a field of view that is non-overlapping 13 beyond a threshold distance in a field external 14 to the optical imaging system with fields of 15 view of all other pixels in the plurality of 16 pixels"? 17 A. Yes. 18 Q. So what is the threshold distance 19 you're referring to here? 20 A. Again, that would be the same 21 comment as I previously had. 22 Q. Which is to say that's not a

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1 quantifiable distance; is that correct? 2 A. Yes. 3 Q. And then let's turn to the '381 4 declaration, Exhibit 1. Let's turn to 5 Paragraph 311 of that declaration. 6 A. Okay. 7 Q. So do you see where Paragraph 311 8 says, "Grzesik discloses that the crosstalk 9 absorption layer should include a thin opaque 10 structure. For example, Grzesik describes 11 'Region 64' and is shown in Figure 3, that 12 suppresses internal reflection of secondary 13 radiation and is shown in Figure 3 as a thin 14 structure," and there you cite to Exhibit 1012, 15 Paragraph 33 and supra sections X.H and XI.I. 16 And then finally do you see, you say, 17 "Moreover, a POSITA would have understood that 18 this thin layer relative to the optical 19 system." 20 Do you see that sentence? 21 A. Yes. 22 Q. So you're pointing to Region 64 in	101 103 1 expressly, it's a coating layer, so that would 2 be put on by -- a POSITA would have understood 3 that would be put on by some type of deposition 4 layer, which means it would be a thin coating. 5 So any time "coating" is 6 referenced in a device patent, it's taken to 7 mean some type of deposition coating, and a 8 deposition coating usually are thin films. 9 Q. So returning to your declaration 10 for the '381, Paragraph 311, do you see halfway 11 through the paragraph there's a sentence that 12 starts, "And even if Grzesik did not explicitly 13 disclose a thin opaque structure, a POSITA 14 would have found it obvious to form the 15 crosstalk absorption layer as a thin structure 16 in the combined system, in order to promote a 17 compact overall profile"? 18 Do you see that? 19 A. Yes. 20 Q. Is a compact overall profile 21 important for Grzesik? 22 MR. DEUTSCH: Objection. Scope.
102 1 Grzesik's Figure 3 as the thin opaque 2 structure; is that correct? 3 MR. DEUTSCH: Objection. Form. 4 A. Let me check. Yes. 5 Q. So are you looking at Figure 3 in 6 Grzesik? 7 A. Yes. 8 Q. What in Figure 3 of Grzesik would 9 have indicated to a POSITA that region 64 is a 10 thin layer relative to the optical system? 11 A. If we go to Grzesik patent, I 12 believe it's Page 3 of the patent, Paragraph 13 0034, he states, "The blanket-coating material 14 regions 64 of the crosstalk absorption layer at 15 least partially suppresses, at the optical 16 surface, the internal reflection of secondary 17 radiation that is generated in the substrate 18 due to recombination or relaxation of 19 electrical charge." 20 So that statement underneath, I 21 put my device physics hat on and would believe 22 that the blanket coating, and he says "coating"	104 1 A. Depending on most system 2 requirements in most systems I've worked with, 3 you would like as small compact structure as 4 possible, because you would have to fit it in 5 certain parameters, and it's platform 6 determined, but the smaller the better is 7 usually the case. 8 Q. And how about for Imai, is a 9 compact overall profile important for Imai's 10 system? 11 MR. DEUTSCH: Objection. Scope. 12 A. I would say for any system that's 13 designed, compact is always better, but that 14 may or may not be true. It depends on the 15 system, though. 16 Q. How about Higashi, is a compact 17 overall profile important for Higashi? 18 MR. DEUTSCH: Objection. Scope. 19 A. A POSITA would absolutely think 20 so, probably. It's also system dependent, the 21 size. But usually you go for power, size and 22 weight, you want to minimize everything as you

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105 1 go along. 2 Q. And why is that? 3 MR. DEUTSCH: Objection. Scope. 4 A. Just for space. It depends, 5 because you're usually fitting these objects on 6 some type of platform, and the way these design 7 things work, they don't design the platform 8 around the object. They design the object for 9 the platform. 10 And usually they will come to you, 11 say, for a space-borne LiDAR system, for 12 instance, they will come to you and say, these 13 are my power, weight and volume things fitted 14 in there or, say, an automobile, if you're 15 designing a system for that, you have a certain 16 profile you want to maintain. So it's usually 17 always a good consideration. 18 I've had programs where people 19 would come to us and they say here is the box 20 that exists now, fit it in there, and so you 21 have to go and fit that in, consistent with 22 their requirements.	107 1 thin opaque structure"? 2 A. Yes. 3 Q. What is a thin opaque structure? 4 MR. DEUTSCH: Objection. Scope. 5 A. I think Grzesik Figure 3 is a 6 prime example of that. And I also think we've 7 reproduced Figure 3 in my declaration. So 8 that's an example of a thin opaque structure. 9 Q. Correct me if I'm wrong, your 10 testimony just now is that the thin opaque 11 layer in Grzesik was a coating; is that 12 correct? 13 A. Yes, but coatings have structure. 14 Q. So a coating can be a structure? 15 A. Yes. 16 Q. Let's turn to another combo. This 17 is the Weimer, Borowski, Hipp combo. I'm going 18 to give you more paper. I think it should be 19 the last paper I give you for today. 20 A. Okay. 21 Q. So I'm going to give you or 22 introduce the Weimer reference and the Hipp
106 1 Q. So does a smaller overall -- 2 sorry, let me find the exact language. 3 Does a compact overall profile 4 increase the range of applications for a 5 lighter device? 6 MR. DEUTSCH: Objection. Form and 7 scope. 8 A. It depends on what the overall 9 performance of that device is. It could open 10 up a lot of applications or it could be just a 11 specific application. So it really depends. 12 Q. Can you turn to Exhibit 3, which 13 is the '381 patent. 14 A. Okay. 15 Q. And I'm just taking you back to 16 Claim 7. This is on Column 17. 17 A. Column 17? 18 Q. Correct. 19 A. Okay. 20 Q. And so line 42, do you see where 21 Claim 7 says, "The optical system according to 22 Claim 6 wherein the aperture layer comprises a	108 1 reference so we have it on hand. 2 MR. LAUPPE: So the Hipp reference 3 is Exhibit 1007 to both of the IPRs, 4 both the '750 and '381. 5 (Document marked as Exhibit 1007 6 for identification) 7 MR. LAUPPE: Weimer, which is 8 Exhibit 1008 to both of the IPRs. 9 (Document marked as Exhibit 1008 10 for identification) 11 Q. Can you turn to Figure 3 of 12 Weimer, which is Exhibit 1008. 13 A. Figure 3A? 14 Q. Yes. Is Figure 3A to scale? 15 MR. DEUTSCH: Objection. Form. 16 Scope. 17 A. Can you please repeat? 18 Q. Sure. Is Figure 3A of Weimer to 19 scale? 20 A. I wouldn't -- I have no idea. 21 Q. Let's turn to your '750 22 declaration, Exhibit 2. Thank you for your

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109 1 heroic paper shuffling today, Dr. Shanley. 2 So do you have the '750 3 declaration out? 4 A. Yes. 5 Q. Okay. Great. Can you turn to 6 Paragraph 279 of that declaration. 7 A. Okay. 8 Q. So do you see for the bottom of 9 Paragraph 279 you say, and this is talking 10 about Weimer, "The emission region of each 11 output beam 208 is non-overlapping and 12 coincident with a field of view of a 13 corresponding pixel 326 in the pixel array 14 324." 15 Do you see that? 16 A. Yes. 17 Q. And then you provide Figure 2A, 18 correct? 19 A. Yes. 20 Q. So the dots -- strike that. 21 So do you see the circles in a 22 column, and some of them are labeled 208?	111 1 A. That's the illumination pattern. 2 So if you're in the far field in the scene, 3 that square represents the pattern or 4 pixel-by-pixel representation of that scene. 5 In other words, each beam will 6 represent a pixel in the return light, and will 7 hit a corresponding pixel to construct the 8 whole scene. 9 Q. Let's take a look at Figure 3A. 10 A. Okay. 11 Q. So do you see element 326? 12 A. Yes. 13 Q. And 326 is pointing to one of the 14 detector pixels; is that correct? 15 A. Yes. 16 Q. Okay. And then in some of 17 detector pixels in the array 324, you see these 18 little ovals, correct? 19 A. Yes. 20 Q. What do those little ovals 21 represent? 22 A. Those represent the return light
110 1 Do you see that? 2 A. Yes. 3 Q. Are those emission regions? 4 A. Let me check to make sure. 5 Q. Feel free. So let's find where 6 that is in Weimer. It looks like you provided 7 some cites here, so maybe you could share 8 those. 9 A. Yeah, 208 refers to the beams. 10 Q. Great. And then what are the 11 squares in which each of the 208 emission 12 regions are contained? 13 A. Let's see, the 206 regions 14 represent the plurality -- well, it's the 15 illumination pattern basically 206, and the 208 16 is the plurality of beams, the illumination 17 pattern. 18 I was looking here for -- yeah, 19 and that's it. 20 Q. So I'm just wondering about the 21 squares you see here. So are each -- what do 22 each of these squares represent?	112 1 from the corresponding scene illumination 2 region. So it's a one-to-one correspondence 3 basically. 4 Q. And those illumination regions 5 within the pixels 326, those are smaller than 6 each of the pixels; is that correct? 7 A. Well, that's only illustrative, I 8 think. Ideally what you would do is match the 9 pixel size to the size of the incoming beam, 10 and there are specific documentation in how to 11 actually do that in terms of the optics and 12 beam sizes. 13 Q. But what you can see here in the 14 figure, the illumination regions are a 15 different shape than the pixels; isn't that 16 correct? 17 MR. DEUTSCH: Objection. Form and 18 scope. 19 A. The pixels aren't really -- this 20 is just a schematic. I mean, it's just 21 illustrative to show you what's going on, and 22 it's really not drawn to have a precise

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113 1 physical representation. It's just a schematic 2 drawing saying, hey, this region corresponds to 3 this region of the pixel, this region and the 4 image corresponds to this region of the 5 emitter, and things like that. That's all it 6 says to me. 7 In the language or declaration, 8 it's a one-to-one correspondence or the vectors 9 are similar, or if you want to interpret it 10 another way, the fields of view are the same or 11 anything like that. 12 Q. So in Figure 3A, assuming that the 13 illuminations within each of the pixels 326 is 14 as shown here, smaller, like an emission region 15 that doesn't take out the entire pixel, is it 16 your opinion that those smaller illumination 17 regions, those are coincident with the field of 18 view of each of those pixels? 19 MR. DEUTSCH: Objection. Form and 20 scope. 21 A. Hypothetically, yeah, but it's not 22 reality, and I think it's not mirrored by what	115 1 that you say, "Each pixel in the plurality of 2 pixels has a field-of-view that is 3 non-overlapping beyond a threshold distance in 4 a field external to the optical imaging systems 5 with fields of view of all other pixels in the 6 plurality of pixels"?" 7 A. Yes. 8 Q. And what is that threshold 9 distance that you're referring to there? 10 MR. DEUTSCH: Objection. Form. 11 A. I can't quantify that. 12 Q. So earlier we were talking 13 generally about systems that you've worked on, 14 and I think you've said that you never used 15 SPADs in a LiDAR system that you've worked on; 16 is that correct? 17 A. No. 18 Q. And why is that? 19 A. They weren't available. We were 20 looking and one of our choices was to be SPADs, 21 but basically they were unavailable. I think 22 the things that were available they weren't at
114 1 we say in our declaration. 2 Q. Okay. Let's look at Paragraph 3 270, going back to your '750 declaration. 4 A. Which declaration; '750? 5 Q. Yes. 6 A. 270? 7 Q. That's right. 270. So do you see 8 right above Paragraph 270, you've provided the 9 claim language for element 44(c) of the '750 10 patent? 11 A. Yes. 12 Q. Do you see that language includes, 13 "Each pixel in the plurality of pixels 14 comprises a plurality of single photon 15 avalanche diodes (SPADs) and has a field of 16 view that is non-overlapping beyond a threshold 17 distance in a field external to the optical 18 imaging system"? 19 Do you see that? 20 A. Yes. 21 Q. And then if you move down to 22 Paragraph 271, discussing Weimer, do you see	116 1 the right price point. 2 And I also think at that point we 3 looked at -- Ball Aerospace had a bunch of 4 APDs, and we've also looked at some of the 5 silicon photomultipliers, which are basically 6 single-element SPADs with a passive resistance 7 in them, and we found that that wouldn't have 8 fit our bill at that point, and the expense was 9 just not feasible. 10 Q. And so SPADs require a quenching 11 circuit; is that correct? 12 A. That's right. 13 Q. Are quenching circuits bulky? 14 MR. DEUTSCH: Objection. Form. 15 A. No. 16 MR. DEUTSCH: Scope. 17 Q. And earlier we were also talking 18 about systems you've worked on, and I think you 19 said you had never used VCSELs in a LiDAR 20 system that you worked on; is that correct? 21 A. No. Again, same reason. In the 22 VCSEL technology --

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117 1 MR. DEUTSCH: Objection. Scope. 2 Just pause a little bit. 3 A. VCSEL technology was not enough 4 power at that point. They had to tweak the 5 fabrication methods. 6 I'm getting too wordy here, but 7 just an aside, these are grown in special 8 equipment, and it's a very detailed growth 9 process, and I had several people, personnel, 10 as part of my group who actually specialized in 11 material growth. It's a very complex situation 12 to get power levels out, and then to scale that 13 up to produce it is another huge issue. 14 So these existed as lab queens. 15 And we experimented with the lab queen, but 16 never implemented, because it wasn't -- 17 reliability and several other things weren't 18 available at that time, and they had to be 19 developed to come along. That's all. 20 Q. And so can you elaborate on what 21 you mean by lab queen? I'm not familiar with 22 that terminology.	119 1 power output per device, and so you just didn't 2 have enough to meet the system requirements. 3 So if you needed -- and don't -- 4 these numbers aren't right, but if you needed 5 five watts and at the time the stuff only gave 6 you one watt, then it wasn't feasible to use 7 that, because of the ranges that you were 8 working at. 9 Q. Did you use VCSELs in any type of 10 system you worked on? 11 MR. DEUTSCH: Objection. Scope. 12 A. No. But again, actually when I 13 was at Polaroid, we actually -- and this is not 14 a LiDAR system, but we actually thought of 15 using VCSEL type emitters for projection. So 16 using them to projection images as opposed to 17 using them in a LiDAR system. 18 It's much of the same technology 19 that you have goes into the emitter type 20 system, whether it's any type of illumination 21 system, whether it's a LiDAR or a passive -- 22 what's the word I want -- a designator type
118 1 A. These are special, one of a type 2 units, that just exist. 3 Q. Okay. 4 A. It may involve reproducibility, it 5 may involve reliability, you know, it's like, 6 oh, yeah, that lasts for five minutes, and it 7 doesn't work after that, so I have to put a new 8 one in. It's things like that. 9 Q. And what was the timeframe that 10 you had VCSELs sitting around potentially as a 11 lab queen? 12 A. This is in the end of '90s. 13 Q. Okay. You worked on LiDAR systems 14 after the '90s, right? 15 A. Yeah. 16 Q. Okay. You mentioned that there 17 wasn't enough power at that point for VCSEL 18 technology; is that correct? 19 A. Mm-hmm. 20 Q. Can you elaborate what you mean by 21 that? 22 A. The power output, you need so much	120 1 object where you just use a laser. 2 The Army uses a lot of these 3 things to designate targets, so the person in 4 the trenches shining a light on a tank, and I 5 use "light" euphemistically meaning laser, and 6 the guy flying in an F-18 picks it up and sets 7 his missile to hit that guided by the reflected 8 radiation from the tank, stuff like that. It's 9 a lot of the same emitter technology that you 10 use for things like that. 11 Q. I'm going to ask a couple of 12 questions where I refer to the challenged 13 patents, which I'm just using to mean the '750 14 and the '381. Is that understood? 15 A. Right. 16 Q. So are you familiar with any LiDAR 17 systems prior to the challenged patents that 18 used VCSELs as the emitters? 19 MR. DEUTSCH: Objection. Form. 20 Scope. 21 A. How to answer that? I mean, we've 22 played around with them, and I assume other

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121 1 people played around with them also. So that's 2 where I'm coming from. 3 Q. And are you familiar with any 4 LiDAR systems prior to the challenged patents 5 that use SPADs as the detectors? 6 MR. DEUTSCH: Objection. Form. 7 Scope. 8 A. Lincoln Labs, 2003 timeframe, did 9 a tremendous amount of research on those 10 systems, and I spent a lot of time with Dave 11 Spears and Vince Chan at Lincoln Labs, and we 12 often talked about these type of systems and 13 the work that was done by, I believe it was, 14 Marino who I referenced. 15 So Vince was working on 16 space-based laser communication. I know a lot 17 of people were working on SPADs system and 18 SPADs and VCSELs together in that timeframe for 19 LiDAR systems and other applications. 20 So that's 2003. I was going 21 there, oh, God, over the last umpteen years, 22 and I remember the first conversations that we	123 1 it was just inevitable that they were going to 2 use those before the timeframe. 3 There's a lot of geophysical 4 LiDARs, there's a lot of other ones that -- we 5 were always looking in the 2000 timeframe to 6 put SPADs into systems. So I assume that there 7 were people using them. 8 Q. But you chose not to put SPADs in 9 the systems; isn't that correct? 10 MR. DEUTSCH: Objection. Form. 11 Scope. 12 A. Our system requirements were such 13 that the particular wavelengths that were 14 available at that time didn't suit themselves 15 to SPADs, and a lot of the things I did with 16 LiDAR systems in that timeframe were in the 17 infrared, and we were also working down in the 18 UV in the far blue area. 19 So that's not where a lot of the 20 silicon-based, you know, the current SPADs 21 we're talking about were available. 22 Q. And why is that?
122 1 had were back in '97, '98 timeframe. 2 Q. Did any of these conversations 3 lead to systems that were designed? 4 MR. DEUTSCH: Objection. Form. 5 Scope. 6 A. I don't remember. 7 Q. Are you aware of any commercial 8 systems prior to the challenged patents that 9 used VCSELs in a LiDAR context? 10 MR. DEUTSCH: Objection. Scope. 11 A. Yeah, I really can't comment. 12 Q. Just to clarify the record, is 13 that, no? 14 A. I don't know. 15 Q. Okay. Are you aware of any 16 commercial systems that used SPADs for LiDAR 17 prior to the challenged patents? 18 MR. DEUTSCH: Objection. Form and 19 scope. 20 A. It's a hard question to answer. 21 You know, going back and looking at stuff, I 22 just assumed that some systems were, you know,	124 1 MR. DEUTSCH: Objection. Form. 2 Scope. 3 A. Because the detector wavelength 4 and sensitivity that we needed, and there were 5 specialized systems. 6 Q. What about those wavelengths that 7 you just mentioned were not a good fit for a 8 system that used SPADs? 9 MR. DEUTSCH: Objection. Scope. 10 A. They couldn't detect the radiation 11 that we were interested in. They weren't 12 sensitive in the ten micron region. 13 Q. SPADs were not; is that correct? 14 MR. DEUTSCH: Objection. Form and 15 scope and mischaracterizes. 16 A. SPADs couldn't detect the 10.7 or 17 10.6 micron radiation. 18 Q. And why is that? 19 A. Bandgap of the semiconductor was 20 too short or too small. 21 Q. What is the bandgap of the 22 semiconductor?

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1 MR. DEUTSCH: Objection. Scope. 2 A. Distance between the conduction 3 and valiant span of the semiconductor, which 4 dictates how the -- or the wavelength of 5 detection. 6 Q. So this was too short for -- 7 strike that. 8 So the bandgap of the 9 semiconductor for SPADs was too short to detect 10 certain wavelengths that you work with? 11 MR. DEUTSCH: Objection. Form and 12 scope. Calls for speculation. 13 Hypothetical. 14 A. Bandgaps, let's see, it's a huge 15 explanation, and I don't think it's really 16 relevant. You have to go into the whole device 17 physics, and you have to fit the physics of the 18 particular device to the wavelength of light 19 that you're detecting. 20 And so, the short answer, it was 21 incompatible with the long wavelength device. 22 Q. So SPADs were incompatible with	1 scope. 2 A. My opinion is that a lot of these 3 patents that I examined satisfied that need 4 from Retterath to Borowski to Imai to Higashi, 5 and we could throw in Hipp. All of those 6 patents satisfy a need. 7 Q. What about the challenged claims 8 of the '381 patent? 9 MR. DEUTSCH: Objection. Form and 10 scope. 11 A. As I said earlier, I believe all 12 of these patents satisfy a need, and that same 13 need. 14 Q. Did others fail in the area of the 15 challenged claims of the '381 patent? 16 MR. DEUTSCH: Objection. 17 A. I can't comment on that. I don't 18 know. 19 Q. Are there commercially successful 20 embodiments of the challenged claims of the 21 '381 patent? 22 MR. DEUTSCH: Objection. Scope.
1 the long wavelengths that you were working 2 with; is that correct? 3 MR. DEUTSCH: Objection. Form. 4 A. Yes. 5 MR. DEUTSCH: Mischaracterizes the 6 testimony. 7 Q. What were the wavelengths that 8 SPADs were incompatible with? 9 MR. DEUTSCH: Objection. Form and 10 scope. 11 A. The patents disclose eye-safe 12 wavelengths, and that's in the 1.3, 1.5 micron 13 region. 14 Q. So wavelengths longer than that 15 were incompatible with SPADs? 16 A. Yes. 17 MR. DEUTSCH: Objection. Scope. 18 A. Yes. 19 Q. Did the challenged claims of the 20 '381 patent satisfy a long-felt but unsolved 21 need? 22 MR. DEUTSCH: Objection. Form and	1 A. Again, I can't copy on that. 2 Q. Does Ouster manufacture products 3 that embody the '381 patent claims? 4 MR. DEUTSCH: Objection. Scope. 5 A. I believe they do. 6 Q. And what's your basis for that 7 belief? 8 A. Because of the patent and from 9 what I've seen. 10 Q. What have you seen from the Ouster 11 products? 12 A. Not really much except for what 13 was given to me in the patent, so, you know, 14 don't search the web or anything for looking 15 for that information. 16 Q. Are any Ouster products 17 commercially successful? 18 MR. DEUTSCH: Objection. Scope. 19 A. I can't comment on that. 20 Q. Have the challenged claims of the 21 '381 patent been copied? 22 MR. DEUTSCH: Objection. Form and

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129 1 scope. 2 A. I can't comment on that. 3 Q. Does Hesai sell products that use 4 VCSELs? 5 MR. DEUTSCH: Objection. Scope. 6 I think, Counsel, if you bring it back. 7 A. Same answer, I can't comment on 8 that. 9 Q. Is the use of VCSELs common in the 10 LiDAR industry? 11 MR. DEUTSCH: Objection. Form and 12 scope. 13 A. I really can't comment on that. 14 Q. And was the use of VCSELs common 15 in the LiDAR industry prior to the '381 patent? 16 MR. DEUTSCH: Objection. Form and 17 scope. 18 A. Again, I can't comment on that. 19 Q. Have the challenged claims of the 20 '381 patent been licensed? 21 MR. DEUTSCH: Objection. Form. 22 Scope.	131 1 A. I can't comment. 2 Q. Did the challenged claims of the 3 '750 patent satisfy a long-felt but unsolved 4 need? 5 MR. DEUTSCH: Objection. Form. 6 Scope. Calls for a legal conclusion. 7 A. Looking at the number of patents 8 we have from Retterath to Imai, Higashi, et 9 cetera, they all satisfy the same need. 10 Q. What's that need? 11 MR. DEUTSCH: Objection. Form. 12 Scope. 13 A. This is for building LiDAR 14 systems. 15 Q. Did the challenged claims of the 16 '750 patent satisfy that need? 17 MR. DEUTSCH: Objection. Form. 18 Scope. 19 A. Same comment. 20 Q. Did others fail in the area of the 21 challenged claims of the '750 patent? 22 MR. DEUTSCH: Objection. Form.
130 1 A. Can you repeat the question? 2 Q. Sure. Have the challenged claims 3 of the '381 patent been licensed? 4 A. Been? 5 Q. Licensed. 6 A. I can't comment on that. I don't 7 -- I don't know. 8 Q. Has Hesai licensed the challenged 9 claims of the '381 patent? 10 MR. DEUTSCH: Objection. Form. 11 Scope. 12 A. I can't comment. 13 Q. Have the challenged claims of the 14 '381 patent been praised? 15 MR. DEUTSCH: Objection. Form. 16 Scope. 17 A. I can't comment. I don't know. 18 Q. And prior to the '381 patent, was 19 there industry skepticism about the material 20 claimed in the '381 patent claims? 21 MR. DEUTSCH: Objection. Form. 22 Scope.	132 1 Scope. Counsel, the question should be 2 related to the declaration testimony. 3 A. I can't comment on that. 4 Q. Are there commercially successful 5 embodiments of the challenged claims of the 6 '750 patent? 7 A. Again, I can't comment on that. 8 Q. Does Ouster manufacture products 9 that embody the '750 patent claims? 10 MR. DEUTSCH: Objection. Form. 11 Scope. 12 A. I can't comment on that. 13 Q. Have the challenged claims of the 14 '750 patent been licensed? 15 MR. DEUTSCH: Objection. Form. 16 Scope. 17 A. I can't comment. 18 Q. Have the challenged claims of the 19 '750 patent been praised? 20 MR. DEUTSCH: Objection. Form. 21 Scope. 22 A. I can't comment.

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133 1 Q. Was there industry skepticism 2 about the material claimed in the '750 patent 3 claims prior to the '750 patent? 4 MR. DEUTSCH: Same objections. 5 A. I can't comment. 6 MR. LAUPPE: Okay. I think that's 7 the end of my examination. Counsel, do 8 you have any follow-up questions? Do 9 you want to take a break? 10 MR. DEUTSCH: Let's take a break. 11 MR. LAUPPE: Okay. 12 (Recess taken at 1:35 p.m. and 13 reconvening at 1:59 p.m.) 14 EXAMINATION BY 15 MR. DEUTSCH: 16 Q. Thank you, Dr. Shanley. I just 17 have a couple follow-up questions for you. 18 Earlier this morning you mentioned 19 a few factors when designing a laser system, 20 and you mentioned wavelength, structure, cost. 21 And those are a subset of considerations an 22 engineer would look at, correct?	135 1 which discuss Retterath, and examples from 2 Retterath including Figure 4. 3 Do you recall that? 4 MR. LAUPPE: Object to form. 5 A. Okay. 6 Q. So that's one example your 7 understanding of how Retterath described a 8 configuration that discloses that limitation of 9 Claim 1, correct? 10 MR. LAUPPE: Object to form. 11 A. Yes, that's correct. 12 Q. And similarly you discussed what 13 "field of view" means, and you referred to, 14 again, discussion from Retterath that talks 15 about the emission beams, an example of which 16 you referred to Paragraph 82? 17 MR. LAUPPE: Object to form. 18 MR. DEUTSCH: Let me start over. 19 Q. So let's go to -- so still on 20 Paragraph 82, you had mentioned that paragraph 21 earlier when discussing the "field of view" 22 term in Claim 1 of the '381 patent.
134 1 MR. LAUPPE: Object to form. 2 A. That's correct. 3 Q. So in building a system, there 4 would be many factors that you would look at in 5 doing that analysis? 6 MR. LAUPPE: Object to form. 7 Scope. 8 A. Manufacturability, availability of 9 components. You would also have to consider 10 all the system considerations with it and 11 supply chains and all the logistics and 12 servicing and stuff like that after it's built. 13 Q. Let's turn to Paragraph 49 of the 14 '381 declaration. 15 A. Okay. 16 Q. I'm sorry, that's the wrong 17 paragraph. One second. Paragraph 82, please. 18 A. Okay. 19 Q. And so, earlier you discussed the 20 term "coincident" in the context of Claim 1 of 21 the '381 patent, and you referred to Paragraph 22 82 and subsequent paragraphs of the declaration	136 1 Do you recall that? 2 MR. LAUPPE: Object to form. 3 A. Oh, yes. 4 Q. And when discussing Retterath, you 5 were providing an example of how Retterath 6 provides the field of view as it's recited in 7 Claim 1, correct? 8 MR. LAUPPE: Object to form. 9 A. Yes. 10 Q. All right. Let's turn to 11 Paragraph 222. 12 A. Okay. 13 Q. So do you see Figure 2 at the top 14 of the page? 15 A. Yes. 16 Q. And then in Paragraph 222, you 17 mentioned that, "Multiple reasons would have 18 prompted a POSITA to implement Pacala's 19 conventional suggestions (including to utilize 20 bulk optics positioned immediately next to one 21 another, and a rotational mechanism for a 22 360-degree unobstructed field of view) with a

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1 Retterath-Borowski combination (previously 2 articulated above)"? 3 A. Yes. 4 Q. Then in Paragraph 229, the last 5 sentence that says, "As shown in Figure 2, the 6 bulk optics 80 are positioned immediately next 7 to one another." 8 Do you see that? 9 A. Yes. 10 Q. Continuing to Paragraph 231, 11 "Applying Pacala's suggestions to Retterath and 12 Borowski, the resulting device would mount 13 Retterath's transmit bulk optic 80 immediately 14 next to its receiver bulk optic 230 such that 15 they are adjacent to one another"? 16 A. Yes. 17 Q. So in the resulting combination, 18 one example described here is that the transmit 19 bulk optic 80 is immediately next to its 20 receiver bulk optic 230; is that correct? 21 MR. LAUPPE: Object to form. 22 A. Yes, that's correct.	137 1 2C as a schematic drawing; is that correct? 2 MR. LAUPPE: Object to form. 3 A. Yes, I did. 4 Q. And would a schematic drawing be 5 useful to a person of skill in the art to 6 inform them of certain things? 7 MR. LAUPPE: Object to form. 8 A. Yes, it would. It would describe 9 the physical layout. It's not a precise 10 document, but it's showing the philosophy and 11 how one would lay out these two systems. 12 Q. Is there anything in Figure 2C 13 that helps you -- strike that. 14 Figure 2C shows an XYZ axis; is 15 that correct? 16 A. Yes. 17 Q. So is that an example of something 18 that would inform a POSITA's understanding of 19 the physical layout of the components that are 20 shown? 21 MR. LAUPPE: Object to form. 22 A. Yes, it would. 139
138 1 Q. 230 doesn't -- strike that, 2 please. 3 In the resulting combination based 4 on Pacala's suggestion, the claim limitation 5 adjacent to is satisfied by a claim structure 6 in which these objects are immediately next to 7 one another, correct? 8 MR. LAUPPE: Object to form. 9 A. That's right. 10 Q. But you haven't taken a position 11 whether they need to be immediately next to 12 each other, only that they are adjacent? 13 MR. LAUPPE: Object to form. 14 A. That's right. 15 Q. Let's turn to Paragraph 268, 16 please. 17 A. Okay. 18 Q. Figure 2C is shown at the bottom 19 of the page. 20 Do you see that? 21 A. Yes. 22 Q. I believe you referred to Figure	140 1 Q. Earlier you were asked does Ouster 2 manufacture products that embody the '381 3 patent claims. 4 Do you recall that? 5 A. Yes. 6 Q. Did you compare any Ouster 7 products to the '381 patent claims? 8 MR. LAUPPE: Object to form. 9 A. No. I haven't looked at them. 10 Q. So do you know if Ouster 11 manufactures products that embody the '381 12 patent claims? 13 MR. LAUPPE: Object to form. 14 A. No, I don't. 15 MR. DEUTSCH: Thank you, Dr. 16 Shanley. No further questions. 17 MR. LAUPPE: I've got a couple 18 follow-up questions. 19 RE-EXAMINATION BY 20 MR. LAUPPE: 21 Q. Dr. Shanley, do you recall that 22 before Mr. Deutsch was just asking you

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141 1 questions there was a break? 2 A. Yes. 3 Q. Did you discuss the substance of 4 your testimony with anybody during that break? 5 A. No. I mean, other than counsel, 6 we discussed some things. 7 Q. So what did you discuss with 8 counsel during the break? 9 MR. DEUTSCH: I would caution the 10 witness to not discuss privileged 11 communication. Maybe we should take a 12 break or we can continue. Go ahead. I 13 just wanted to caution you. 14 MR. LAUPPE: We can take a break 15 if you need it. 16 MR. DEUTSCH: Continue. 17 Q. So just to repeat the question, 18 what did you discuss with counsel during the 19 break? 20 A. I don't know how... 21 Q. Maybe it makes sense for us to 22 take a quick break, then, if you would like to	143 1 That wasn't what the testimony was that 2 he had said. 3 MR. LAUPPE: Are you testifying, 4 Counsel? 5 MR. DEUTSCH: Objection as 6 mischaracterizing the testimony. 7 A. The process of the questions. 8 Q. What questions? 9 A. He didn't say the exact questions 10 or anything, but the questions that... 11 Q. What was the subject matter of the 12 questions that counsel said he was going to 13 ask? 14 A. It was just general and general 15 things in the process. 16 Q. Were there any specifics in terms 17 of subject matter that counsel indicated that 18 he was going to ask you about? 19 A. No. We didn't talk about 20 specifics. 21 Q. What did you discuss? 22 MR. DEUTSCH: Asked and answered.
142 1 discuss with counsel. 2 MR. LAUPPE: Let's take a 3 five-minute break. 4 (Recess taken at 2:20 p.m. and 5 reconvening at 2:22 p.m.) 6 BY MR. LAUPPE: 7 Q. Dr. Shanley, you mentioned that 8 you discussed the substance of your testimony 9 with counsel during the break; is that correct? 10 A. We talked about the process, but 11 not any of the answers or anything like that. 12 Q. What do you mean you talked about 13 the process? 14 A. Of what we were going to do. 15 Q. What specifically did you discuss 16 in terms of the process? 17 A. The kinds of questions he was 18 going to ask me, but not the answers. 19 Q. What are the kinds of questions 20 that counsel provided you? 21 MR. DEUTSCH: Objection. Form. 22 Scope. Mischaracterizes the testimony.	144 1 A. I think there was nothing really 2 specific. Just general things about the 3 process. 4 Q. About what process? 5 A. Of, you know, his counter 6 examination. 7 Q. Did counsel indicate what 8 paragraphs of your declaration that he was 9 going to ask you about? 10 A. Oh, no. 11 Q. Did counsel indicate any specific 12 grounds of your declarations that he was going 13 to ask you about? 14 A. No. 15 Q. Did counsel indicate any specific 16 testimony that you had provided earlier that he 17 was going to ask about? 18 MR. DEUTSCH: Objection. Asked 19 and answered. 20 A. Could you repeat that? 21 Q. Sure. Did counsel indicate any 22 specific testimony that you had provided

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1 earlier in the day that he was going to follow	1 phase, and just be precise in your answers.
2 up about in his examination?	2 Q. How did you understand that
3 A. Not really, no.	3 instruction from counsel?
4 MR. DEUTSCH: Objection. Asked	4 A. It meant really to answer, you
5 and answered.	5 know, not verbose, and to cite my declaration
6 Q. What do you mean "not really"?	6 if necessary.
7 You said "not really." Can you elaborate on	7 MR. LAUPPE: Okay. No further
8 what you mean by "not really"?	8 questions. Thank you so much for your
9 A. No. Definitively, no.	9 time, Dr. Shanley.
10 Q. What was discussed about the	10 COURT REPORTER: Mr. Deutsch, a
11 process of counsel's --	11 rough draft and final by Tuesday?
12 A. Just general process that he was	12 MR. DEUTSCH: Perfect. Thank you.
13 going to ask me some follow-up questions on	13 (Whereupon the deposition
14 material that we covered in the deposition.	14 concluded at 2:29 p.m.)
15 Q. Did he specify what material?	15
16 A. No.	16
17 MR. DEUTSCH: Objection. Asked	17
18 and answered.	18
19 Q. Did he give any general	19
20 indications of what material he was going to	20
21 cover?	21
22 A. No. It was more to be specific	22
146	148
1 about my answers.	1 E R R A T A
2 Q. Counsel told you to be specific	2 I, JAMES F. SHANLEY, Ph.D., do hereby
3 about your answers?	3 certify that I have read the foregoing
4 A. Well, his general appraisal of,	4 transcript of my testimony, and further
5 you know, being more specific in how I	5 certify that it is a true and accurate
6 answered.	6 record of my testimony (with the exception
7 Q. So counsel instructed you to be	7 of the corrections listed below):
8 more specific in how you answered the	8 Page Line Correction
9 questions?	9
10 MR. DEUTSCH: Objection.	10
11 A. I don't think that's the word I	11
12 want to use, but trying to recall the	12
13 conversation. It was more -- it was just	13
14 general, general comments, and on the process	14
15 of what we're going to do when we came back,	15
16 and to answer the questions and be precise.	16
17 Q. Did counsel indicate that you	17 Signed under the pains and penalties of
18 should be more precise in your answers than you	18 perjury this day of ,
19 had been previously?	19 2024.
20 MR. DEUTSCH: Objection.	20
21 A. No. He just didn't say that. He	21
22 just said what we were going to do in this next	22 JAMES F. SHANLEY, Ph.D.

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149 1 CERTIFICATE 2 3 I, Michael O'Connor, Registered 4 Merit Reporter/Certified Realtime Reporter, 5 do hereby certify: 6 That James F. Shanley, Ph.D., the witness 7 whose deposition is hereinbefore set forth, was duly 8 sworn by me before the commencement of such deposition 9 and that such deposition was taken before me and is a 10 true record of the testimony given by such witness. 11 I further certify that the adverse party, 12 Hesai Technology Co., Ltd, was represented by counsel 13 at the deposition. 14 I further certify that the deposition of 15 James F. Shanley, Ph.D. occurred at the offices of 16 Fish & Richardson, P.C., One Marina Park Drive, Boston, 17 Massachusetts, on Friday, June 28, 2024,commencing at 18 9:01 a.m. to 2:29 p.m. 19 I further certify that I am not 20 related to any of the parties to this action by blood 21 or marriage, I am not employed by or an attorney to 22 any of the parties to this action, and that I am in no	151 1
150 1 way interested, financially or otherwise, in the 2 outcome of this matter. 3 IN WITNESS WHEREOF, I have hereunto 4 set my hand and Notarial Seal this 28th day 5 of June 2024. 6 7 <i>Michael O'Connor</i> 8 9 MICHAEL O'CONNOR, RMR, CRR, CRC 10 Notary Public 11 My Commission expires: 12 November 9, 2029 13 14 15 16 17 18 19 20 21 22	

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