UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SHENZHEN TUOZHU TECHNOLOGY CO., LTD,

Petitioner,

v.

STRATASYS, INC.,

Patent Owner.

Case IPR2025-00531 (US Patent No 9,168,698)
Ref. 56224-0008IP1

Case IPR2025-00532 (US Patent No 10,556,381)
Ref. 56224-0009IP1

VIDEOCONFERENCE DEPOSITION OF

DR. TIM A. OSSWALD

MAY 6, 2026

Page 1 - 119 6:59 a.m. - 10:20 a.m.

REPORTED BY:
Tamara L. Houston
CA CSR No. 7244, RPR, CCRR No. 140
Job Number J14709605

REMOTE VIDEOCONFERENCE DEPOSITION OF Dr. Tim A. Osswald, taken on behalf of the Petitioner, commencing from 6:59 a.m. to 10:20 a.m., Wednesday, May 6, 2026, before Tamara L. Houston, CSR No. 7244, CCRR, RPR.

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WEDNESDAY, MAY 6, 2026, 6:59 a.m.

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All counsel present stipulate
that the witness shall be sworn remotely
by the court reporter

* * *

COURT REPORTER: My name is Tamara Houston, California Certified Shorthand Reporter, License Number 7244.

Whereupon, DR. TIM A. OSSWALD, having been
called as a witness was duly sworn
to tell the truth, the whole truth,
and nothing but the truth testified
as follows:

EXAMINATION BY MR. BROWN:

Q. Good morning, Dr. Osswald.
Can you please state your name for the record?

A. Tim Andreas Osswald.

Q. And please state your city of residence.

A. Madison, Wisconsin.

Q. And where are you located today? Are you in Madison?

A. Yes.

Q. And you understand that we are here today regarding two IPR proceedings; IPR Number 2025-00531, and 2025-00532 regarding U.S. Patent Numbers 9,168,698, and 10,556,381; is that right?

A. Yes.

Q. Okay. And you understand you're taking this deposition under oath, right?

A. Yes.

Q. And this is the same oath as if you were in a court.

Do you understand that?

A. Correct.

Q. And you understand you have to tell the truth and nothing but the truth, and you'll do that today; is that right?

A. Yes.

Q. Okay. If you ever don't understand a question, will you let me know? Okay?

A. Yes.

Q. And so if you answer a question, I will assume that you understood the question; is that fair?

A. Correct.

Q. We'll try to take breaks about every hour, but if you need a break at any point, please just let me know, and we can do our best and wrap up and get you to a break.

Is that okay?

A. Okay.
Q. And the court reporter is typing everything today for a transcript.
Do you understand that?
A. Yes.
Q. So we can make her job easier if we don't speak over each other and if you stick with verbal answers like "yes" or "no" instead of nodding your head.
Is that okay?
A. Yes.
Q. You're doing a great job already, so thank you.
Is there any reason that you cannot give truthful, complete, and accurate testimony today?
A. No.
Q. And if that changes at any point, it's important that you inform me immediately. Okay?
A. Okay.
Q. Is there anyone else in the room with you today?
A. No.
Q. Do you have any documents with you?
A. No.
Q. Do you have any notes?
A. No.

Q. And do you have anything on your computer open other than this Zoom window?

A. Yes. Here, let me close them. There, quit, and I'll quit my e-mail. I think that's it.

Q. Okay. So you don't have any messaging services or systems open on your computer anymore?

A. No.

Q. Okay. Please let me know if that changes. Okay?

A. Okay.

Q. Do you have copies of your report on your computer or printed with you?

A. I would have them on my computer but not printed here with me.

Q. Okay. And I think you just said that you don't have them open right now; is that correct?

A. No.

Q. Okay. So there are several terms I'll be using today, and I want to make sure we're on the same page for; is that okay?

A. Yes.

Q. When I use the terms "patent owner" or "Stratasys," I'm referring to Stratasys, Incorporated, the patent owner in this proceeding.

Do you understand that?

A. Yes.
Q. And when I use the term '698 patent, I'm referring to U.S. Patent Number 9,168,698.
Do you understand that?
A. Yes.
Q. And similarly, when I use the term '381 patent, I'm referring to U.S. Patent Number 10,556,381.
Do you understand that?
A. Yes.
Q. And if I use the term "these IPRs" or "these proceedings," something like that, I'm referring to the proceeding numbers IPR 2025-00531 and 532 filed against the '698 and '381 patents.
Do you understand that?
A. Yes.
Q. Okay. And do you understand that the patents, the '698 patent, '381 patent are Exhibits 1001 in their respective proceedings?
A. Yes.
Q. Okay. And you've reviewed those patents before; is that right?
A. Yes.
Q. Great. And when I use the acronym POSITA or POSITA, I'm referring to a person of ordinary skill in the art at the time of the alleged invention.

Do you understand that?
A. Yes.
Q. Okay. Great. So in these proceedings you've submitted two declarations.
Is that right?
A. Correct.
Q. One declaration was for -- or addressed to the '381 patent, right?
A. Yes.
Q. And I believe that declaration is Exhibit 2027 in the respective proceeding.
Does that sound right?
A. That sounds right.
Q. Okay. And it was dated January 30th, 2026.
Is that right?
A. Yeah, I believe you. I mean, I don't have it in front of me. That sounds about right.
Q. Okay. And that you also submitted a declaration for the '698 patent.
Is that right?
A. Yes.
Q. And that was also Exhibit 2027 in that proceeding, correct?
A. That sounds about right. Yes.
Q. And it was also dated the same date,

January 30th, 2026.

Does that sound right?

A. It sounds right, yes.

Q. Okay. Let's go ahead and -- I'm going to put these two declarations into the Zoom chat. They are both labeled Exhibit 2027. The patent number has been -- the last two digits of the patent number have been appended to the end.

Can you go ahead and download those and open them when you get a chance. Let me know when you have them open.

A. They're open.

Q. Okay. Let's take a look at the '381 patent first.

Can you go ahead and open that document and pull it up?

A. Yes.

Q. Okay. And this looks like the declaration that you submitted with respect to the '381 patent.

Is that right?

A. Correct.

Q. Okay. And if you scroll to page 126 of the PDF. Let me know when you're there.

A. Yes.

Q. This is your signature on that declaration,

correct?
A. Yes.
Q. And it was dated on January 30th, 2026, right?
A. Yeah.
Q. Okay. Great. Let's put the other one, the '698 --
Does this look like the declaration that you submitted with respect to the '698 patent?
A. Yes.
Q. And, again, if you scroll to the signature page, it should be again 126 on the PDF.
Let me know when you're there.
A. Yes.
Q. And this is your signature on page 122 of the declaration, correct?
A. Yes.
Q. And it's dated January 30th, 2026?
A. Yes.
Q. So you understand that these two patents, the '698 and '381 patents, are related patents, right?
A. Correct.
Q. And both these patents claim priority to the same original disclosure.
Is that right?
A. Yes.

Q. And so that means that both these have the same priority date, right?
A. Yes.
Q. And that priority date that you used for this declaration is October 29, 2012, correct?
A. Yes, as I recall.
Q. Okay. And the two patents share substantially the same specification.
Is that right?
A. Correct.
Q. And this is why your declarations have a large amount of overlapping opinions.
Is that fair?
A. Yes.
Q. What are the primary differences between the inventions in the '381 and '698 patents?
A. One of them is a method patent, the '698. And the '381 is a product. I don't remember the term. It's a piece of equipment method. And the '381 requires computation, calculating a force.
Q. Okay. And so I think you were saying -- looking for maybe the word "system patent"; is that right?
A. Yes.
Q. Can you think of any other primary

differences, or is that -- does that cover it?

A. No, there are other differences, but, I mean, I think that's a bird's eye view of them. I'd have to go back and look at the detail.

Q. That's the main difference that you remember.

Is that fair?

A. That I remember right now, yes.

Q. Did you review any materials to prepare for this deposition today?

A. Yes.

Q. What did you review?

A. These two documents, the references.

Q. The two patents; is that what you mean?

A. Yeah, and the references used in the IPR, in each one of them and the different grounds. And I reviewed the validity report. And I reviewed some other documents to refresh my memory with all of that.

Q. When you say "validity report," are you referring to the declarations that we looked at just a second ago?

A. No.

Q. Okay. What do you mean by "validity report"?

A. The rebuttal to the invalidity report from the experts.

Q. Are you referring to opinions that you offered

in the district court --
A. Yes.
Q. -- case?
Okay. Did you review your declarations that you submitted in these IPRs that we just looked at a minute ago?
A. Yes.
Q. And you said you reviewed, I believe, the invalidity grounds.
Did that include looking at each of the prior art references that were cited in the grounds in these IPR petitions?
A. Yes.
Q. Okay. Besides what you've already listed, can you think of anything else that you reviewed?
A. I can't think of anything right now.
Q. Other than reviewing these documents, what else did you do to prepare for this deposition?
A. I met with the attorneys.
Q. Who did you meet with?
A. With Mr. Oaks and Mr. Kapadia online.
Q. And when did you meet with those -- with your attorneys?
A. Yesterday.
Q. Did you meet with them any other time other

than yesterday?

A. I've met them on different occasions, but I don't think regarding this preparation.

Q. Okay. So for preparing for today's deposition, you just met with them yesterday.

Is that right?

A. Correct.

Q. And approximately how much time yesterday did you meet with the Stratasys attorneys?

A. About six hours.

Q. Did you meet with anyone else to discuss this deposition?

A. No.

Q. Did you talk to anyone else about this deposition other than Stratasys counsel?

A. My wife.

Q. Did you talk about any of the details with your wife?

A. No.

Q. I'm sure she was very jealous of you getting to have a deposition today.

A. Yeah, she was actually. No, she wasn't.

Q. Have you ever spoken with any of the named inventors of the '698 or '381 patents?

A. Oh, gosh, it has been a while. No, I don't think so. I don't think I've spoken to any of the inventors.

Q. And so you haven't -- you didn't speak with any of the inventors in preparation for your deposition, I assume?

A. No.

Q. Dr. Osswald, did you conduct any independent searches or searches on the Internet related to your opinions in this case?

A. I mean, in the past, sure. I mean, I've done literature searches and things like that in the past. I've searched through my own writings, and that's all in my -- in my report -- reports.

Q. When would you have conducted those searches, approximately?

A. I don't remember. Obviously before January 30th.

Q. Have you done any searches related to this case after January 30th?

A. Relating to the IPR?

Q. Correct.

A. No.

Q. How about relating to these patents more generally?

A. Well, I have. I mean, I was deposed sometime after my report, so I probably looked at -- searched for the information, some of the papers that I had references to patents, that I referenced. I downloaded them again from Google Patents and things like that. I mean, just typical things, but not related to the IPR.

The IPR obviously was turned in on the 30th of -- of January. And I had all of the references for that.

Q. Okay. Approximately how many times have you been deposed before?

A. I should know that, but I would say anywhere between 50 and 100 times.

Q. Were all of those depositions -- were you acting as an expert?

A. Yes.

Q. And about how many of those depositions occurred in IPR proceedings?

A. I don't remember. I don't remember.

Q. Do you think it would be around half?

A. I don't know. I don't know. Maybe 20 times. I don't know. I'm not sure.

Q. Okay. Somewhere -- but it sounds like, you know, more than -- more than ten; is that fair?

A. Yes, that's fair.

Q. And how many of those depositions were about

patents?
A. I would say 80 percent of them.
Q. And so 20 of those depositions would have been for cases that did not involve patents; is that right?
A. Yeah. Product liability cases and trade secrets. Maybe more than 20 percent. I don't know. I'm not sure. I just sort of grabbed that number.
Q. And in your -- in the cases where you were being deposed for an IPR, approximately how many of those cases were you working for the patent owner?
A. I think most of them.
Q. Have you -- have you ever served as an expert for the Petitioner in an IPR?
A. I may have. I'd have to go back and look.
Q. And for --
A. Yeah, I have. I have. I'm sorry.
Q. Do you remember how many times? It sounds like you just maybe remembered one?
A. Yeah, I don't remember how many times.
Q. For each of the times when you were deposed, were you offering an accompanying expert report or declaration in those cases?
A. I think most of them, yes.
Q. Do you know if your opinions have ever been excluded by a tribunal?

A. No. I mean, there was one time when I opined what potable water was, and the judge said I'm not a water expert, but that's about it. It was a case related to plastic containers for sippy cups.

Q. And you were opining on the status of potable water; is that right?

A. Well, it was one of the terms in one of the elements in the claim. So potable water or potable liquid or something like that.

Q. And was -- were your opinions just as to that term struck or excluded, or was it all of your opinions?

A. No, just that term. I think the other side raised the -- they always do try to sort of discredit you, and they said, "Well, he's opining on potable water, and that's not his area."

And so the judge said, "Okay, I give you that."

But it didn't -- it was not so substantial in the whole claim.

Q. And you were, generally speaking in that case, opining on the plastics and plastic water bottles; is that right?

A. It was a case of sippy cups, so the plastic and the design of the product.

Q. Okay. Was that a patent case?

A. Yes.

Q. And was it in a district court or in front of the patent office?

A. No, it was in the district court. Although at one point I did go to the patent office with the attorneys.

Q. And so other than that case with the sippy cups, have any of your other opinions been excluded by either a district court or the patent office?

A. No.

Q. When did you first start working on the declarations for these two IPR proceedings?

A. I don't remember. Something last year. Summer of 2025.

Q. And you submitted those, at least declarations, in January, so is it fair to assume that you worked on these for somewhere between three and six months?

A. Something like that. Yeah. I don't remember exactly. Yeah.

Q. Do you know -- did you start on one of the declarations first?

A. Yeah, I think I was first working on the '698.

Q. How long would you say you spent drafting the declaration for the '698 patent?

A. Oh, gosh. I don't remember. I have -- yeah, I don't remember. Maybe 50 to a hundred hours. I don't know. I'd have to look and -- because I was working on different patents and all of that, and this one is probably what it was.

Q. So your -- your best guess is somewhere between 50 hours and a hundred hours over those span of a couple months; is that right?

A. Something like that, yes. Maybe more. I don't know. I don't remember.

Q. And what about for the '381 patent; do you remember approximately how much time you spent drafting that declaration?

A. I mean, I re -- I recycled a lot of what I wrote for the '698 declaration, and so it was obviously less, but I don't remember.

Q. Did you spend -- did you draft the entirety of the declaration for the '698 patent before you kind of switched over to work on the '381 declaration?

A. I don't remember how I was -- I think that happened parallel.

Q. And did you draft both of these declarations yourself?

A. Well, they both contain -- I got a structure of it, general structure from the attorneys. I filled in the blanks. I had discussions with them. I sent drafts and they inserted them. I corrected them. So it was -- I mean, like it always goes with attorneys and experts. But, yes, I -- it fully contains my opinion.

Q. I believe you said that you filled in some drafts. Does that mean -- or some gaps, I apologize.

Does that mean that Stratasys's attorneys sent you sort of a first draft with things to fill in?

A. No, I mean, I think -- I think I sent them my background and things like that, and they inserted it into a skeleton. I mean -- and then I started filling in, and we had discussions with them. I sent them more writings, and they would add things and subtract. I mean, I physically didn't type the whole thing, but it certainly contains all my opinions.

Q. Would you say that you've drafted or prepared the first draft of this declaration?

A. Well, the substantial opinions, yeah. If it wasn't typed in by me, it was a discussion between me and the attorneys.

Q. Approximately how many discussions about these declarations would you estimate that you had over the course of drafting?

A. Oh, gosh, I don't remember. I don't remember. A lot of them.

Q. If you had to put an estimate on it, do you think it was more than ten?
A. I don't remember.
Q. So it could be more than ten?
A. Possibly.
Q. Could be less than ten; you just don't remember?
A. I don't remember. Sufficient to get my points across and discuss things with the attorneys. And there were other patents, so I'm having a hard time separating them in my brain right now when we drafted things.
Q. Did you -- well, strike that.
Did you read every word of your declaration before you submitted it in this case?
A. Yes. Several times probably.
Q. And I'll say -- I guess I should clarify, and that's for both declarations; is that right?
A. Yes.
Q. And you said you didn't type every word.
Do you have any estimate on the percentage of words that you, yourself, wrote or typed?
A. No.
Q. Are there any specific sections in your declaration that you drafted without the assistance of Stratasys counsel?

A. Yes, many of them.
Q. Which sections would those be?
A. Things under technical issues of the patents or on the references that were given, but I don't remember which ones exactly. I'd have to go back and look at the report.
Q. Would the summaries of the prior art references have been something that you typed without assistance?
A. Yes. I think it was edited back and forth between the attorneys and me.
Q. So you might have had some assistance with those sections?
A. Yes.
Q. What about your responses to the substantive grounds presented in the petition? Would those have been something that you prepared without assistance?
A. Can you ask again that question?
Q. Yeah. The responses to the specific grounds, prior art grounds in the petitions, would that have been something that you drafted without assistance?
A. Yeah, I mean, we certainly had discussions, but I don't remember who exactly typed things in, but they certainly contain a hundred percent my opinions on those grounds.

Q. Were there any sections in your report that you did not personally draft?

A. I mean, there were some things. I think -- I don't remember in this report if there's any legal -- legalese in there, so I'd have to go back and look. And whenever there is some legal -- I'm told by attorneys that -- infringement as well, whatever -- those are typically drafted by the attorneys.

Q. Okay. Let's -- and I guess it may be easier here. We can pull up your declaration for maybe the '381 patent.

Is the legal standard section, that is Section 4 of your report, is that what you're referring to as the legalese?

A. Yes.

Q. Okay. And so that would have been something that Stratasys counsel helped prepare for you; is that right?

A. Yes.

Q. Okay. And though you -- I'm sorry, strike that.

That legal standard section is still something that you would have reviewed and agree with; is that right?

A. Oh, yes. Everything that is in those -- that is in those reports I agree with in stance. But obviously I'm not an attorney, so I -- I like having my brain refreshed on those legal issues.

Q. And those legal standards are the standards that you applied throughout your report; is that right?

A. Yes.

Q. Did Stratasys's lawyers provide any facts or assumptions that you relied on in reaching your opinions in this case?

A. I don't understand your question.

Q. Were there any underlying facts or assumptions that you relied on for your declaration that were provided by Stratasys counsel?

A. I think all of the facts and assumptions and opinions are mine. I don't think they told me what I should assume. I mean, I think -- other than what obviousness means and anticipation, et cetera, grounds of validity or invalidity; but, no, I don't think any substantial things that have to do with the technical background of the patents was given to me by the attorneys.

Q. Okay. So other than the legal standards we've already talked about, they did not provide anything that you relied on?

A. No. I mean, look, there were other reports that I read and that I had an opinion on. And so -- so -- of the experts on the other side, et cetera, or the petitions, I read those too, and so I had an opinion of those.

So this was all sort of a fluid discussion between the attorneys and me. But the technical aspects of my opinions and the technical aspects of both patents are certainly of my opinions. The legal standards, I mean, I'm not an attorney, and so there was a back-and-forth between the attorneys and me, so...

Q. When were you first contacted to work on this matter?

A. I don't remember. Something at the beginning of 2025, end of 2024.

Q. Was that when Stratasys first contacted you about working on -- on any matters for these two patents?

A. Yeah. I don't remember how -- how exactly it evolved with these two patents, but obviously I was already deposed on the other patents that I offered an opinion in the IPR proceedings. And so I don't remember exactly the timeline. I mean, and I don't care about the timeline. I simply am shown the IPRs, and I give my opinion on them. I don't remember the timing on those.

Q. When you were first approached by Stratasys, were you asked if you would give opinions in this specific IPR? Or these two IPRs.

A. I don't remember. I mean, I do remember seeing the patents from the beginning. And I do remember seeing the Warren reference and going through that long patent trying to figure out what it meant. But I don't remember the timing, when that happened and all of that. So --

Q. Do you remember if that was before you were retained by Stratasys or while you were discussing engagement?

A. No, no. That all happened afterwards. I wouldn't spend hours on some patent if I'm not going to be engaged.

Q. When you -- when Stratasys first contacted you, did they send you either the '698 or '381 patents to consider?

A. I don't remember. I remember I got a bunch of patents.

Q. When you say you got a bunch of patents, was that sort of in the initial contact with Stratasys counsel?

A. Yes.

Q. And had you seen -- do you recall if you've seen the '698 or '381 patents prior to that initial reach-out from Stratasys?

A. Yeah, I believe I have. I mean, I look at a lot of manufacturing patents, particularly for the course that I teach on additive manufacturing, and those I have. Those I had. At least the '698 patent, I had seen that.

Q. When do you think you first saw the '698 patent?

A. I don't remember. A few years back when I was working on -- on melting and FFF printer.

Q. How often do you teach the course that you just mentioned in additive manufacturing?

A. I teach at UW Madison and University of Wisconsin here. I taught it at least once a year to seniors and graduate students. I retired two years ago, the summer of 2024. So I became professor emeritus, but I'm still teaching the class at the University of Erlangen in Germany. In fact, I will be teaching it the second week of June.

And I've taught it at the university in Colombia, additive manufacturing course, and in the additive manufacturing course, I have a whole unit on intellectual property.

Q. Did you ever specifically -- or did the '698 patent ever come up in your -- in your lectures?

A. No. That's not one of the patents that I show in my lectures.
Q. How did you find the '698 patent originally?
A. I don't remember. A search.
Q. And that's something that you said -- it sounds like you typically do is search for patents in the space?
A. Yes.
Q. Do you remember what you were searching for specifically when you found it?
A. I was searching for --
(Reporter requested clarification.)
THE WITNESS: Force transducers.
BY MR. BROWN:
Q. And why were you searching for force transducers at that time?
A. We were -- we developed a model that -- to predict melting in an FFF printer, and the harder you push on the filament into the nozzle, the higher the force generated by -- to measure the -- to melt the material. And so it was -- we -- our model related the force to the speed of printing, to the speed of the filament, or visa versa, the speed of the filament to predict the force.
And so the model worked really well. I had

somebody install force transducers in the -- in the nozzle region to be able to determine the force that is used to push down into -- in an encoder to measure the speed to test the model. And that's published material. We published that in additive manufacturing.

Q. Would that have been part of research that you were conducting at the time?

A. Correct.

Q. And were you searching -- what was the purpose of your -- your search for patents on force transducers? What were you looking for?

A. To see how someone would measure force with a nozzle. I mean, except the '698 and the '381 patents were not exactly what we were looking for. But I did see them. I thought it was interesting.

Q. Did you find something that was closer to what you were looking for?

A. No.

Q. And you said you published on this research; is that right?

A. Yes.

Q. Do you remember approximately when that would have been?

A. I think one of the papers was -- I don't know -- early 2020, 2021. Something like that. I don't remember exactly when it was, and then I published a couple of papers afterwards -- afterwards.

Q. Do you remember the title of any of those papers?

A. Pardon?

Q. Do you remember the title of any of those papers?

A. Yeah, I think the melting one is called the "Melting Model in the FFF Printer," in the fused filament fabrication printer.

Q. And all of those publications would have used or involved a system with a force transducer? Is that right?

A. I think the first one wasn't, but then the ones afterwards were to test the model with the real printer.

Q. Okay. And before you were contacted by Stratasys in this case, had you ever heard of or read any of the prior art that were cited in the petition?

A. No.

Q. So was it -- so it was the first time that you had you seen these prior references when you started your work on your declarations; is that right?

A. Yeah. I don't -- I mean, the thing is I don't remember. I think I -- if I recall, I think I had seen the Ashton patent before. I mean, I see a lot of reference. I think the Ashton patent looked familiar. I don't remember exactly.

Q. And you said you do regularly or at least you did when you were teaching class do searches for kind of patents in the additive manufacturing space; is that right?

A. Yeah, I still do. I mean, I look at patents that are -- that come up. I read articles that come out on additive manufacturing. I'm a reviewer of the journal so I've edited a whole set of papers in my own journal and polymer composites that deal with additive manufacturing. So, I mean, I keep up in the field quite a bit, so I still look at patents. I mean, I'm still interested in it.

Q. Do you find it helpful to review patents to help you keep up with the field; is that fair?

A. Yes.

Q. And you mentioned a journal that you're an editor on.

What journal is that?

A. Polymer Composites.

Q. Did you review the petition for these two IPR proceedings or -- let me rephrase that question.

Have you reviewed the -- both of the petitions

for these two IPR proceedings?
A. Yes.
Q. And approximately how many times would you say you looked at the petition for, let's say, the '381 patent?
A. I don't know how many times; but, I mean, I always go back and review to refresh my memory. So I don't know exactly how many times. But I certainly read through the petitions.
Q. Do you think it's more than five times?
A. I don't know.
Q. Could be less than five times?
A. No. I think looking into them, probably more than five times, but I don't know how many times.
Q. But you definitely read through the entirety of the petition at least one time; is that fair?
A. Yes.
Q. And same for the '698 patent; is that right?
A. Correct.
Q. You don't remember how many times you've looked at or reviewed the petition for the '698 patent, do you?
A. I don't remember exactly how many times.
Q. Likely more than five times, you think?
A. I don't know.

Q. Is it fair to say that you disagree with the conclusions in the petition?
A. Yes.
Q. Are there any portions of the petition that you agree with?
A. I don't remember. I mean, I'd have to look at my -- my own report. But I disagree with the grounds. And it's all in my -- both of my reports.
Q. What about the -- the overall summary of the patents? Do you generally agree with that?
A. I think the description of the patents is probably -- I would agree with it. I mean, I don't know. I would have to go back and look and see how they describe them again.
Q. What about the general overview or summary of the prior art, was there anything that you agreed with there?
A. I don't remember exactly what Dr. Wolfe wrote in those, but I certainly disagree on his interpretation of the -- of the references. I don't remember exactly what he wrote, so I'd have to go back and look at that.
Q. And you mentioned Dr. Wolfe. Did you review Dr. Wolfe's declarations along with each of the petitions?
A. Yes.

Q. And just to clarify, did you -- you separately reviewed kind of the substance of the petitions in addition to Dr. Wolfe's declarations; is that right?
A. Yes. I remember reading Dr. Wolfe's declarations as well.
Q. Okay. Are you aware the patent owner --
(Reporter requested clarification.)
BY MR. BROWN:
Q. Are you aware that patent owner filed a preliminary response to the petition in July 2025?
A. I can't remember what the terms are, so I'm -- yeah. I mean, I remember reading the -- the petition. I remember reading reports from Dr. Wolfe. I don't remember the names, what -- whatever that means. So I'm not an attorney.
Q. Fair enough. We like to add convoluted names where probably unnecessary.
Let me rephrase it this way: Did you review any filings in these IPRs that were prior to your declaration that maybe helped informing your opinions in the declaration?
A. I mean, I remember -- I think I remember reading a patent owner responses. Again, there are five patents I'm working with, and so I remember that there was a petition where there was an expert reported

petition. I don't remember which order they were or are, and then I -- I remember also reading patent owner responses.

But I don't remember timings and all of that. Yeah, I think that was not really relevant to my own opinion. I mean, it was relevant to my own opinion, but the timing I don't -- I don't -- I'm not sure.

Q. Were you working on drafting your declarations in this case in July of 2025?

A. I mean, working on drafting -- I mean, I was forming opinions in my head. That's -- I would say that would be working on drafting an opinion in the report.

Q. Well, let's break that down then.

Were you actually drafting the reports in July 2025?

A. I don't remember if I wrote -- I don't think I wrote anything at that point. Maybe I had. Maybe I was. Yes, maybe.

Q. When you were working on -- I'll say more generally working on these -- these proceedings and forming your opinions; is that fair?

A. Yeah. I was forming my opinions the moment I read -- I started reading the reports that were at hand.

Q. Okay. And so you don't recall for sure if you read a patent owner's preliminary response to the

petition prior to drafting your declarations, do you?
A. Patent owner's preliminary response? I think I did read that, yes.
Q. Okay. And would you have read that -- actually, strike that.
Are you aware that patent owner then filed a response to the petition; is that right?
A. I don't remember. I mean, there's a lot of documents. I'm sure they are listed -- there must be a list of documents that I reviewed in my reports.
Q. So this is the -- the patent owner response would have been submitted along with your declaration.
Does that sound familiar?
A. I don't remember.
Q. Okay. Do you remember reviewing the patent owner --
(Reporter requested clarification.)
MR. BROWN: You know, we've been going -- maybe -- we've been going about 50 minutes. Let's maybe go off the record and take a quick break, and I'll try and fix my mic.
(Recess.)
BY MR. BROWN:
Q. Okay. Dr. Osswald, did you speak to anyone during the break?

A. No.
Q. All right. So before we were -- before we took that break, we were talking about the patent owner response.
Have you reviewed the patent owner response in this case or in these two petitions?
A. I don't remember. I've looked at so many documents. Whatever I reviewed is probably on the list of documents that is in my report or that are in my reports.
Q. You mentioned that you are involved with several IPRs for Stratasys.
Is it -- do you typically review the patent owner response that's being sort of accompanying your declaration?
A. Yeah. I mean, I think I do. I mean, whatever I review in those responses should be in the documents. If it's not in my documents, then I haven't reviewed it.
Q. Are you involved in -- in drafting the patent owner response at all?
A. Well, I mean, the attorneys do ask me for my opinion on different grounds and things, and so I would imagine, yes, my opinion is there somehow, but I don't type anything in the patent owner response. I mean, I have discussions with attorneys. I'm sure they take my

opinion and -- and weave that into their legal response.

Q. Do you know if you reviewed a draft of the patent owner response while you were preparing your declarations in this case -- in these proceedings?

A. No. No.

Q. Sorry. Is that a "no," you don't recall; or "no," you did not review?

A. I don't think I review drafts of their work like that, no.

Q. So is it fair to say that all of the arguments in the patent owner response were drafted by someone other than yourself?

A. Yes.

Q. Okay. And we looked at your two declarations that are both titled Exhibit 2027 earlier. Right?

A. Yes.

Q. Those two declarations set forth your opinions concerning both the '381 patents and -- '381 and '698 patents and the prior art; is that right?

A. Yes.

Q. Were there any opinions that you have with either of those patents or the prior art that was omitted from your declaration?

A. No.

Q. Have you -- well, strike that.

In forming your opinions did you rely on any assumptions that are not identified in your declaration?

A. I mean, in an expert report there's always sort of a general knowledge of the expert, and so I don't know if that -- if I have a specific reference for every single technical statement. So I don't know. I mean, the references are there; my opinions are there in both of those reports.

Q. So you can't think of any explicit assumptions that you would have made and omitted from your report though, right?

A. That's correct.

Q. And I think you mentioned earlier that part of your preparation for today's deposition was reviewing both of your declarations, right?

A. Yes.

Q. Did you find any errors or anything that you think should be corrected in your declarations?

A. No.

Q. Okay. So you stand by the declarations that you submitted; is that right?

A. Yes.

Q. And there's nothing that you would change in those declarations?

A. No, not right now.

Q. Are there any opinions in those two declarations that you are maybe less certain about than other opinions?

MR. OAKS: Object to the form of the question.

BY MR. BROWN:

Q. And just to repeat. Did you say no to that?

A. Yeah, correct.

Q. You have -- so that means you're a hundred percent confident in the opinions that you offer in your declaration; is that right?

A. As of right now, yes.

Q. I think we mentioned this earlier, but are you aware there's a district court case that involves these patents and Stratasys right now as well?

A. Yes.

Q. Are you involved in that district court case?

A. Yes.

Q. What's your role?

A. I'm an expert in some of the patents. I think in infringement and validity. I wrote two more reports in which I was deposed. Not this spring.

Q. And so you've offered expert opinions through those reports that you'd submitted in the district court case; is that right?

A. Yes.

Q. And did you offer opinions on the '381 or '698 patents?

A. Yes.

Q. Is the "yes" to both of those two patents?

A. Yes.

Q. Did you offer your opinions on those two patents before or after your declarations in these IPR proceedings?

A. I think that -- some of those ran parallel to each other. I don't remember when the due date was. I think there were a lot of reports due in those days. So I was working on them parallel.

Q. So approximately similar timing for the reports in the district court and your declarations in these IPRs; is that right?

A. Yes, around -- give or take a couple months.

Q. Did any of your opinions change based on the analysis or testimony that you provided in the district court?

A. No.

Q. So nothing that you learned in the district court case changes your opinions that you presented in your declarations; is that right?

A. Correct.

Q. And are your opinions consistent between the

IPR declarations and the reports and opinions you've offered in the district court?

A. Yes.

Q. Are there any inconsistencies that you're aware of?

A. No.

Q. Have you ever heard of Dr. Wolfe before this IPR?

A. No.

Q. So you've never worked with him or read anything by Dr. Wolfe; is that fair?

A. That's fair.

Q. What degrees have you earned over the course of your career, Dr. Osswald?

A. They're all in my CV, but I received a Bachelor's of Science in mechanical engineering in 1981. I received a Master's of Science in 1982 and also mechanical engineering. I received a Ph.D. in the field of polymer processing and manufacturing, things with polymers and plastics in 19 -- early 1987.

And I did a postdoctoral research internship postdoc at the Institute for Polymer Processing in Aachen, Germany. And I worked on -- in the field of polymer processing, polymer engineering for the past 40 years.

Q. And your Ph.D. you mentioned was in polymer manufacturing and processing, I believe; is that right?

A. Yes.

Q. Is that -- did that Ph.D. fall under kind of the umbrella of mechanical engineering or was it under a different department?

A. No, it was in mechanical engineering, but obviously there were courses there in mechanics and mechanical engineering, et cetera. I mean, polymers is kind of like a field. Some universities have polymer processing. Chemical engineering in Wisconsin happens -- Illinois happens to be out of mechanical engineering, but it's a field that falls within the material science, mechanical engineering, chemical engineering.

Q. Was your training kind of spread out across all of those fields as well, or did it focus more on the mechanical engineering side of polymers?

A. I think from a Ph.D. it was spread over the different fields in the work that I did in subsequent years. It was interdisciplinary between all those fields.

Q. What is it about the polymer manufacturing and processing that specifically ties it to the field of mechanical engineering versus some of those other options that you said?

A. Well, I mean, polymer processing involves mixing and flows, flow -- fluid flow, solidification, melting, which is heat transfer. And, I mean, there's an overlap between different departments. Transfer phenomena, which is more material science and chemical engineering.

Q. How would you, at a high level, describe kind of the field of polymer processing and manufacturing?

A. Well, I mean, in general, I would say my field is polymer engineering, which is in the material science of polymers as used in engineering, which involves the material itself, the polymer. It involves the process that is used to make something. It involves the product that you make. It involves the performance, and it involves the recycling, the sustainable aspects of polymers, which is a topic that is of importance today.

So it's -- one of those fields in polymer engineering is polymer processing. My Ph.D. was in polymer processing. My general field is engineering, polymer engineering.

Q. After your Ph.D., did you focus on any specific facets that you just mentioned?

A. Yes, on all of those. When I did a two-and-a-half-year postdoc in Germany, I worked with all of those in sort of preparing for courses that I was going to teach, and I started teaching, relatively soon in Wisconsin when I arrived, a course in polymer processing which I was most familiar with at the time.

But I also started teaching a course, Engineering Design With Polymers, where I wrote the textbook, Materials Science of Polymers For Engineers, which is used as a textbook for that course, but it's used in other universities and other places. So it's part of it -- that's a bigger umbrella of polymer engineering.

Q. And do you hold yourself out to be a specialist at all in any of these particular facets within polymer engineering?

A. I think I'm an expert in all of those. I've written textbooks in all of those fields. I am the editor of the Plastics Handbook, which also literally covers the -- the field of polymer engineering.

So I'm -- I'm involved now, and I just finished publishing the fifth edition of the Plastics Handbook. I'm working now on the 33rd edition or 34th edition of the German version of that book. I wasn't involved in all 30 some, but in the last, I think, ten editions, I was involved in.

Q. Was the Plastics Handbook -- what is the general purpose of that book?

A. It's a resource for plastics engineers.

Q. So those are, you know, engineers working in the field of plastics, not necessarily students; is that right?

A. Students. Also students actually get a free copy of it. At least in Germany they do. All of the students in polymer engineering, they get a free copy of it, and I used to hand out free copies that were actually funded by BASF, so they printed extra versions for students.

Q. And how do practitioners generally use this book?

A. As a resource -- like the title says, the resource for plastics engineers. It talks about the different processes. It has a whole chapter on different polymer materials and the processes. There's a whole section on additive manufacturing which obviously is evolving, is changing.

Q. Is it it designed more as a teaching tool or something like a quick reference guide, would you say?

A. Both.

Q. So it has kind of the information that the engineer may go look up as part of their -- their day-to-day practice of polymer engineering?

A. Yes. If they want to find out about some test method to measure something, the standards are listed in there. If they want to learn a little bit about a material, that material likely has a whole section in one of the chapters. The handbook is about a thousand pages long, so there's a lot of information in there.

Q. And what led you to pursue this particular field when you were getting your Ph.D.?

A. I -- with my master's work, I worked on simulation on finite element simulation of hip bone prostheses, and so I took a lot of courses in modeling and program writing. So I wrote a whole software to do the finite element analysis.

And so my Ph.D. advisor, when I applied, he liked the background, and he hired me to develop a software to predict mold filling in compression molding processes, and that's how I got into it.

Q. Were those -- was your work in -- I think you said it was hip prostheses in your master's; is that what you said?

A. Yes.

Q. Were those made out of polymers or plastics?

A. Some of them are. So there's the bone, there is the adhesive, and then there is the titanium implant.

Q. Okay. Have -- you've taught -- I think we've already mentioned this, but you've taught numerous

classes on -- on the study of polymers over the course of your career; is that right?
A. Yes.
Q. And that -- that was primarily when you were a professor at the University of Wisconsin, Madison?
A. Also -- so I also taught the courses -- I've been teaching a course in modeling and simulation in polymer processing at the University of Erlangen-Nuremberg. The first time I taught it there was in 1993. I've taught it every year, so it's been 33 years that I've taught there.
I eventually became an honorary professor there in 2006. I taught that course -- many years I taught it twice a year. And I also became an honorary professor at the National University in Colombia where I teach courses in Material Science of Polymers For Engineers but also teach courses in additive manufacturing.
So I've -- so I've taught different places, different universities, so not just University of Wisconsin.
Q. Is it fair to say that most of your time spent teaching was at University of Wisconsin?
A. Yes.
Q. And so you said earlier that the University of

Wisconsin kind of puts the polymer field under the umbrella of mechanical engineering department.

Have you taught any classes that were focused on mechanical engineering but not polymers?

A. Yes. So the University of Wisconsin doesn't put all polymers in mechanical engineering but polymer processing.

Q. Okay.

A. There's a distinction there.

And I've taught courses to chemical engineering students. So my engineering design with polymers, it was taught to chemical engineering students, material science students, civil engineering students. Sometimes there were electrical engineering students.

But, yes, I have taught courses that relate to fields like, for example, kinematic and dynamics of machinery, and I taught those at the University of Illinois when I was a graduate student and then when I was an instructor at the South Dakota School of Mines and Technology. So I have taught courses that are really regular mechanical engineering sources.

I taught thermodynamics as well.

Q. Okay. And you mentioned that the Plastics Handbook is not only -- was not only written as a textbook for students.

Are there any textbooks that you've written?

A. Yes.

Q. And how many textbooks have you written?

A. Well, I wrote a textbook called Polymer Processing Fundamentals. That eventually became Understanding Polymer Processing, and that one had just came out last year and it's third edition, and so that one has been translated into Spanish, Farsi, and I think -- well, no, the Material Science of Polymer Science for Engineers, that's been translated into Korean and to Japanese and Chinese.

So I've written several textbooks. Also Modeling and Simulation in Polymer Processing, that was also a textbook that I wrote. So I would say maybe, in general, four textbooks.

Q. What -- what level courses are these textbooks usually used in?

A. Understanding Polymer Processing is a textbook for junior, senior students. And Polymer Introduction -- sorry, Materials Science of Polymers for Engineers that's for maybe seniors, graduate students. Most students that took that class are seniors.

And so -- so it varies. It goes all the way from -- and then of course, Modeling and Simulation of

Polymer Processing, that's just for graduate students.

Q. And so throughout the course of your -- your teaching career, you've taught both undergraduate and graduate students; is that right?

A. Yes.

Q. Let's -- let's talk about the polymer processing fundamental textbook.

When did you first get involved with writing that? I know you said there's been multiple editions, but when did you first start with that?

A. So the first edition could be -- the first version of that book was Polymer Processing Fundamentals, which came out in 1998.

Q. And you were involved with that first edition?

A. Yeah, I was the only author.

Q. Okay. And what about the Materials Science For Engineers, when did you first start working on that?

A. I started working on that in 1994, and it was published in 1996, the first edition.

Q. And what about the Modeling and Simulation textbook?

A. That one I -- I was involved writing it -- well, basically for many, many years, and eventually it evolved in a book that was published in the early 2000s.

Q. And did you use these textbooks when you were teaching?

A. Yes.

Q. And I think we already touched on this briefly, but you mentioned a few classes that you taught that were not polymer or were not specifically -- polymer is kind of more broadly under the umbrella of mechanical engineering.

Did any of those courses come after you earned your Ph.D., or was that all while you were working towards your master's and Ph.D.?

A. That was after my master's and during my Ph.D.

Q. We've -- we've already talked about quite a few projects that you've had kind of in this field.

What -- what would you consider to be the most relevant or closest to the technology of the '381 and '698 patents?

A. My work that I did, research projects that I worked in additive manufacturing.

Q. And when did you start doing those research projects in additive manufacturing?

A. I mean, I've been working on and off in additive manufacturing, at least reading the literature and talking to graduate students at the University of Erlangen-Nuremberg since probably the early 2000s. And the first course that I taught was many, many years later, but I worked on -- on a research project to make powders for selective laser centering, which is an additive manufacturing technique.

And I worked on a research project with some students, undergraduate students, developing a color 3D printer which -- where the students got a prize from the -- first prize from the patent office for student projects. That resulted in a patent dealing with FFF printing.

And then I started researching and trying to understand exactly how the melting occurs inside of an FFF printer.

And that came out with the publication of Melting Model for Fuse Filament Fabrication Processes. So I mean it's been on and off. So I've worked on different area -- also on fiber filled -- FFF systems. I mean, so I have worked on -- also on fiber filled systems, not just FFF, but also injection molding and compression molding.

So my research areas have gone across -- over different areas of processing -- polymer processing, which includes additive manufacturing.

Q. Are there any specific research projects or -- that you were involved with or oversaw in the additive manufacturing space that were particularly close to the

technology at issue in these two patents?
A. Somewhat. I think the -- what I've mentioned earlier, the -- the measuring of the force that the filament exerts on the -- on the nozzle of the printer.
Q. You mentioned that some of your students received a prize from the patent office in relation to FFF printing.
What does FFF stand for?
A. Fuse filament fabrication. The tradename -- a lot of people know it by FDM, which is Fused Deposition Modeling, which is the tradename of Stratasys.
Q. So FDM and FFF are kind of equivalent terms --
A. Yes.
Q. -- from a technical standpoint?
A. Yes, they are extrusion additive manufacturing techniques. They are the same, FDM and FFF.
Q. And so what was the project focusing on that received the prize?
A. It was trying to use the FFF process to print in color.
Q. Is that something that at the time was not being done, or was there some specific improvement to printing in color?
A. It was a way to print in color and also to add additives, different additives in the FFF process. And

the patent was -- there was a patent that was granted for that.

Q. The additives, were they designed to primarily change the color of the filament, or what was the purpose?

A. Well, basically what it was, it was depositing additive to the center of the filament, so the filament was no longer circular, but were two half circles or other geometries where you could introduce the additive in the center of the filament.

And so additives could have been different colors to print in different colors, but it could have also been like a medical -- a medicine or a chemical or a plasticizer to make it softer. And so -- so that's -- that's in general what the patent is.

Q. Do you know if this patent was ever commercialized?

A. I don't know. It was sold to MakerBot.

Q. Okay. So we talked a little bit earlier, and you just mentioned again the research you did on -- with a force transducer, and I believe you were saying that was directed at monitoring the force from extrusion; is that right?

A. Yes, the force that the filament exerts on the nozzle.

Q. So could you explain what you mean by the force that the filament exerts on the nozzle?

A. Sure. When the filament is pushed into the nozzle, depending what speeds you use, if you use relatively normal speeds, then the material melts inside of the nozzle and literally to predict what force is required is determined by the speed of the filament.

So it's just squishing the polymer melt through the capillary at the end. Most of the force is generated that way.

But as you increase the speed, eventually the transition between solid and melt reaches the bottom of the -- of the -- of the nozzle, and then the force -- the whole melting mechanics or kinematics changes, and your force are increasing to the power of four with -- through the model. And so -- and so the model was developed to determine a limiting speed and how that -- how we can predict that.

And so that was the first paper that we -- that we submitted. So in order -- in order to see if it works for an FFF printer, so we -- then what we did is we built a little nozzle and we did a very simple experiment to prove the model without printing, and now we wanted to do it with a printer, with an FFF printer.

And so we wanted to measure that force in the

FFF printer, and we wanted to measure the speed, and that was the general view of that -- of that research project.

Q. Why was the force important?

A. Well, our model used force to predict speed or used speed to predict force, and we wanted to see if our model worked.

Q. And what was the kind of primary purpose of the model?

A. To find a limit of the FFF printing process. What's the fastest we can print.

Q. And that's kind of to optimize the process, I guess?

A. Yeah, to know what the limiting factors are. And that -- based on that then, we did another research project which -- how can we speed up the melting. And so then we developed the spinning nozzle so we developed an FFF printer where the nozzle spins at really high speeds, and where the friction ends between the filament and the nozzle enhanced the mixing and speed up the printing process.

So I mean, it was -- there are several papers -- there's a patent that came out on that as well. I think it's come out already on the spinning nozzle.

Q. And when you were measuring force, what kind of sensor did you use?

A. We used a donut, a kind of sensor that held -- that held the nozzle. We wanted -- we knew we couldn't have strain gauges close to the nozzle because of the heat, the problem of heat and strain measurement.

And so the donut held the nozzle and so the strain gauges or the sensors were inside of that donut far away from the nozzle to be allow the measurement of force of the filament exerting onto the -- onto the nozzle.

Q. When you say donut, is that referring to a specific type of sensor, or is that the -- maybe the -- some sort of piece of protection? I wasn't entirely sure I followed that.

A. It's a transducer that measures axial force. So it's donut shaped. It's held on the outside, and the nozzle is held on the inside part. And so it's to measure the force that you push the center portion. It wasn't developed for FFF printing, but it was something that was out there that you could -- one could use for something like that.

Q. Is that a common type of sensor?

A. Not really. I mean it took us some searching with a company that manufactured -- that manufactured

the printer for us.
Q. But it's a commercial -- it was a commercially available sensor?
A. It was a commercially available sensor, yes.
Q. And how does it -- how does that donut sensor, I guess, measure the force?
A. It's like a -- like a cantilever beam except it's not a cantilever beam. It's a cantilever disc held on the outside and then -- and then it bends down or it moves down as you apply the force to the center hole.
Q. And does it measure displacement like that downward movement?
A. It measures the strain. I mean, the displacement is varied, but it measures the strain, and that strain on the donut surface is translated into force. There is a calibration that is used for that.
Q. What do you mean by a collaboration [sic]?
A. No, calibration.
Q. Calibration, okay. So the calibration is a way to -- to -- to determine what specific force it's using based on the output from the sensor; is that right?
A. Yes.
Q. And is that calibration something that is material specific?

A. No. No, it's just to measure the force.
Q. So it's just a general calibration that you do for the sensor?
A. Yes, just to measure the force, correct.
Q. And does -- I think you differentiated or mentioned that the donut sensor is different than a strain gauge. Is that what you said earlier?
A. No. There's strain gauges inside, but those strain gauges are removed from the area where they could be -- where the measurement can be affected by the heat of the nozzle.
Q. Okay. So the donut sensor is maybe a more specialized type of strange gauge -- strain gauge; is that fair?
A. No. I mean, it's just the -- it's just the geometry. It's just the -- a way to -- that we saw that would be beneficial without having the effect of heat.
Q. Okay. So the -- the donut really is -- the purpose of the donut sensor is to kind of isolate the heat in some sense or at least protect it from the heat?
A. Yeah, and it was a practical way of holding the nozzle, so there are two things there.
Q. And so the -- the strain gauges within the donut sensor essentially monitor strain as -- as part of this monitoring or detection of force; is that right?

A. Yeah. The signal that comes out has been calibrated to the force -- force and voltage that comes out is related to the force that you apply on the center of the donut.

Q. And sorry, just to clarify. Did you say force and voltage or force in voltage?

A. No. The voltage is transformed to force.

Q. Okay. Would you consider this donut sensor a type of force sensor?

A. Yes. I mean, it is -- it is a force. It's a load cell. I mean, sometimes they are called -- I mean, you measure stress strain of materials. There are load cells. So a load cell is always a force sensor. You apply a force. That force causes some deformation in some metal part, which is a strain, and that is translated to a force you calibrated.

Some of them are very sensitive, like when you do testing of polymers when you stretch a polymer specimen, you have very, very sensitive load cells that can detect very small loads. Even -- and then -- then -- and measure and translate that into a force. So -- so it's a load cell, literally, yeah, which have existed. They exist.

Q. And are there a variety of different types of load cells?

A. I'm sure there are, yeah.

Q. Okay. Do you -- have you taught any classes that kind of cover force sensors when you're teaching the course?

A. Well, I mean, I taught a course on rheology. That's another textbook that I wrote, which is called Polymer Rheology. And I taught a course in polymer rheology. That would be R-H-E-O-L -- rheology. And -- and in that course we cover sort of the viscoelastic properties of complex fluids like polymers, but there is also a whole area in that course that teaches rheometry, rheometry, which is measuring them.

And a rheometer has load cells and deformation. You need to measure the stress and you need to measure the strain and all of that. And so -- and so, yeah, in that I've taught how one uses those sensors to characterize polymer melts.

Q. What is -- what is the field of -- or maybe subfield or what is polymer rheology?

A. Rheology is the study of flows, the study of the deformation of fluids, how fluids deform and polymers. And the same with physiological fluids. For example, blood, physiological flows. They all have a very complex behavior, which is viscoelastic. And so the field of rheology studies that.

So there's even a Society of Rheology in the United States with maybe, I don't know, 700 members. There's a German Society of Rheology. There's a Journal of Rheology. There is -- thermologically -- where we've published papers in that.

So it's a field that this part -- it's kind of in the crossroads between material science, mechanical engineering, and chemistry and chemical engineering.

Q. What -- what was the class that you were teaching the polymer rheology in using rheometers?

A. Yeah, so it was a course called Introduction to Polymer Rheology.

Q. And did you teach that at Wisconsin or somewhere else?

A. Yes, I've taught that at Wisconsin, but I've also taught a course in rheology in Colombia a couple of times.

Q. What level class is that typically?

A. Well, the Introduction to Polymer Rheology was a course for seniors and also grad students. I did once teach -- so the numbering of that course, I believe, was in the 400 level or 500 level, the one that I taught, which is seniors. Then I also taught one in the 700 level, which is for graduate students.

Q. And how do force sensors generally -- or

rheometers come up in that class?
A. I mean for -- you need to measure a stress and you need to relate that stress to the rate of deformation to the speed. So you measure with solids. You relate the stress to the strain to find out a modulus.
In rheology, you measure the stress and relate it to the rate of the deformation to find the viscosity.
And with complex fluids, you find a viscosity and -- or a loss modulus and a storage modulus, which actually I talk about in my report, in both of my reports, and that's the field of rheology. And to --
Q. And --
A. -- measure the stress -- sorry, to measure the stress you need sensors to do that.
Q. And so, in the class, it was teaching how to use these sensors to do this or something else?
A. It was how to -- how to -- how the sensors or how the stress is measured with what type of sensors and how the strain or the strain rate is measured also using some form of encoders or strain input programs.
Q. Was it generally focused more on -- I would say the material characteristics as in, you know, determining these characteristics of different materials or -- or something else?

A. Yeah. That rheology is related as material characterization.

Q. Okay.

A. How the fluids behave under deformation.

Q. Okay. And so did the sensors come up in the class to kind of understand how some of these material characteristics were determined?

A. Yes. How -- what kind of sensors are used.

Q. Okay. Okay. Did it also focus on, you know, what -- how these sensors are used kind of in the field from a practitioner's standpoint?

A. Yeah. I mean, it literally is -- I mean, in the senior design -- or the senior course, it was how they are used in industry, how the practitioners -- so literally a person that takes the course either could go work for Dow and now know what rheometer to buy or how to modify a rheometer to measure properties of whatever new polymer they are going to develop.

Q. Did the students in these classes actually use force sensors in a lab or anything or was it just more theoretical learning?

A. No. That one was more theoretical and showing them the -- giving presentations on that.

But mechanical engineering students do take a measurements course where they do learn about strain gauges and learn about that, so that's a classic mechanical engineering measurements course where they know about those things. So I don't have to teach them. They already have hands-on experience with that.

Q.   When do mechanical engineering students usually learn or take that class?

A.   Yeah. Probably end of the sophomore year, beginning of the junior year. That's -- even when I took mechanical engineering classes in undergraduate, that's -- the measurements class was done then.

Q.   Okay. And that, you said, covers things like learning stress and strain and strain gauges; is that right?

A.   Yeah, it's -- and there is a lab that goes along with the engineering mechanics course as an undergraduate where people do -- do measurements of stress and strain.

Q.   And so by the time they get to your class, they kind of have that basic understanding already?

A.   Correct.

Q.   And I think you mentioned -- there's another term, modulus for -- I think that was for solids; is that right?

A.   Yes.

Q.   And then what was the equivalent for liquids?

A. Well, for regular liquids it was -- it's viscosity, but for viscoelastic materials like polymers, you have -- when you stretch the material or you shear it, you have two responses. One response is an elastic response. And so with that one you measure what is called the storage modulus or the elastic portion of it.

And then the inner friction, which is the more viscous portion of the viscoelastic material, that's what we call a loss modulus, which is friction which is lost energy.

So the elastic energy is recovered because it's elastic. It's a spring. And the viscous portion, the loss modulus, it's lost because it's a flow, and the flow is not -- the flow can't be recovered. So the combination of the two. So that's what is called a complex modulus.

Q. Okay. Is the viscosity for regular liquids, or modulus for solids, is that also kind of taught in that more basic engineering class? The mechanical engineering measurements, I think you called it?

A. Yes. Yes. The modulus -- people do stress/strain experiments in mechanical engineering, and they also have a fluids lab which -- where they talk about the viscous portions.

Q. Okay. So, again, you're -- they already have

the basic understanding when they come to you, and you kind of further develop that for polymers and rheology?
A. Rheology.
Q. Rheology. Thank you.
Is that right?
A. Yes.
Q. So we talked about the modulus for solids.
Is that referred to as Young's modulus?
A. For some of them, yes. So Young's modulus or elastic modulus is for elastic materials; and, yeah, you can -- there is a modulus or an elastic modulus. Young's modulus is equivalent to that, yes.
Q. Okay. And, again, that's something that would have been taught in that kind of more junior level mechanical engineering class?
A. Probably sophomore.
Q. Okay. Sorry. I used "junior" more loosely as not senior but junior; but, yes, thank you for that.
And did you use the Young's modulus -- is that something that you would use in your rheology class?
A. I use that more in engineering design with polymers when I define the mechanical behavior of polymer.
So if you make a polymer structure, you try to find the modulus. With polymers it's complicated

because it's time dependent. With metals it's a constant material. So with metals you have an elastic material where you have one modulus.

With polymers the materials are deforming and flowing when you apply a stress, so the modulus is time-dependent. And that's what is more -- that is different with polymers than it is with metal materials.

Q. And that's true of polymers more generally or specifically for polymers used in 3D printing?

A. No. Polymers in general.

Q. And so it sounds like you've taught maybe several classes that kind of cover these modulus concepts for -- for maybe different materials, even more specifically for polymers?

A. Yes.

Q. And I guess, if you could explain maybe more generally, why is -- what is -- let's start with Young's modulus.

What is that a character -- or what does that describe?

A. Well, a modulus is a ratio between stress and strain. So if you have a metal, like steel -- if you take the stress, divide it by the strain, it stays constant because it's a straight line. So steel has a modulus of about 207 gigapascals and that you would take and design.

The polymer is a little bit different because when you stretch it, if you stretch it slowly, it's more compliant. You measure at a lower modulus because it's time-dependent.

If you stretch it fast, it behaves as a stiffer material. So the frequency matters. Frequency is time. So one hertz is equivalent to one second. If you stretch it in one second, it is -- is -- has one property; but if you stretch it in a tenth of a second, it's gonna appear stiffer because you don't allow relaxation.

So with polymers, that plays a role. So polymers, you don't really have one modulus. You have a modulus as a function of time.

Q. And so one thing that you use to define it was stress.

What is -- how would you define stress?

A. Stress is the load divided by the area that it acts on. So if you stretch something, if you stretch a specimen that has a rectangular cross-section, you have the force, which when you stretch it, divided by the area of that rectangle, is the stress in that area.

Or if you shear something, the shear force divided by the area that you're shearing, that's also stress. That's a shear stress. So you have elongational stresses, and you have shear stresses.

Q. And how would you define strain then?

A. Strain, if you have -- if you have a specimen -- that rectangular specimen has a certain length. If that length grows a certain distance, the growth of that distance that it changed in length, either decreased or increased, divided by the original length, that's a strain. Could be compressive or could be a tensile strain. Same with stress, could be tensile or compressive.

And shear is a little bit different. You take the amount -- the distance of the two plates and travel in shear divided by the thickness of that shear specimen, and that's the shear strain.

Q. Okay. And so when I asked about Young's modulus, you clarified that for polymers the modulus changes as a function of time.

Is that -- just to make sure I'm using the right terminology, does that mean a polymer wouldn't have a Young's modulus, or it's just a more complicated Young's modulus?

A. It's a complex modulus.

Q. Complex modulus.

A. That has both an elastic component and a viscous component and a time dependence.

Q. So that's sort of the same idea as a Young's modulus, but it's something different because it has more -- more being taken into consideration; is that right?

A. Can you repeat that again? Sorry.

Q. So the complex modulus is kind of the same idea as the Young's modulus; it's just -- you know, has more factors being considered or -- I just want to make sure I'm using that term right.

A. Yes. Literally both of them are stress divided by strain. And if it's a metal, if it's a regular material, the stress and the strain are in sync with each other.

If you have a complex fluid and you apply a strain input, then the stress will be shifted. It will be -- there was a shift between, so you can literally take the stress divided by the strain because the -- the time is shifted, and that's why it's called complex, but they're similar.

Q. So the -- I'm sorry.

Go ahead. Continue.

A. The concept is the same; but, yeah, it's more complicated to analyze it.

Q. So these modulus -- different modulus are

always kind of a ratio of stress to strain?
A. Yes.
Q. And these modulus are specific to a material; is that right?
A. The modulus or moduli are specific to materials, but they are also specific to the frequency of that at which -- or the time scale at which that material is being -- the loads are being applied to that material.
Whereas in elastic material, you can deform something fast or slow, and you're still gonna get the same modulus. But in a viscoelastic material, you're going to get different values.
Q. Okay. So the modulus for some materials are maybe static, but they would vary from material to material; is that right?
A. Yes. For elastic materials, correct.
Q. And that's something that a practitioner could look up and find what that modulus is for the specific material?
A. Yeah, if you have steel or if you have aluminum or those known materials, yeah, they could read it off a handbook or some other system. If you have a new alloy or something you develop, then you need to measure the standard form of measurement.

Q. Okay. And then for more complex materials, you now have this element of time, but it's the same kind of basic idea, it just becomes a more complex modulus?

A. Yeah, it becomes -- and it depends what time scales you're looking at.

Q. Is that also -- I'm sorry. Continue.

A. Yeah. Some polymers, for example, if you load a polymer, you want to know what it's gonna be doing in five years. You're going to have to do some creep experiment, which is putting a weight on it. It's a constant stress, and the strain varies over time. So it always -- there's a time aspect to it.

But if you want to know impact, how does a bumper behave in a crash, there you need to do either a very high frequency, in order of a millisecond maybe type of test, impact test. So you do impact testing to determine the properties. So it's more complicated with polymers.

Q. Can you look up the complex moduli or modulus for a specific polymer?

A. Well, they are -- there is data -- creep data, there is time-dependent data for design, but not all of that is in there. So that's -- I mean, so in our handbook or even in the Material Science of Polymers For

Engineers I have, for general polymers, general properties.

But there are data banks, so -- at Dow and SABIC and BASF and all of those, they are -- they measure -- they have to measure the properties, the creep properties or the dynamic properties which is the complex modulus and have those in data sheets, and they are all in data banks. So people could look up some polymers in the databank. Not all of them are there. New materials are -- are obviously not there. That needs to be measured by a rheologist. That's why I teach the rheology course.

Q. So the standard -- maybe more standard polymers kind of have that information more readily accessible; is that right?

A. More standard polymers have it more accessible. Yeah. Exactly.

Q. And how did -- how do these kind of tables get created? I think you mentioned a company like Dow might put one together for new material. How is that generally created?

A. They usually -- if they want time-dependent modulus, then they do creep tests or they take a specimen. They hang a weight from it. But you need to have several stresses. So they -- they have maybe five or six different weights hanging from the specimen, and they measure the strain over time, and that strain over time is recorded as a function of also the different stresses. And you can generate stress anchors where you can extract a modulus that is time-dependent.

Q. Okay. So the modulus is calculated from empirical tests; is that right?

A. Not from tests. From stress/strain tests. I mean, they are all -- they are not really empirical. There is science behind it, so it's not really empirical, so...

Q. Okay. But it's from, I guess, physical testing, right?

A. Yes.

Q. Okay. As opposed to, you know, theoretically using the -- I guess the theoretical properties of the material? So that's not generally how it's done?

A. Yeah. You need to measure the properties. You need to measure the time-dependent properties or you need to do a dynamic testing to get the complex modulus, which is also useful.

Q. What is dynamic testing?

A. It's when you apply a sinusoidal deformation on your specimen either by shear or by compression, and then you input a strain input, and you measure the stress. And taking that stress divided by strain gives you a complex modulus.

Q. Okay. So if you're not doing dynamic testing, it's kind of the same idea where you apply a specific stress, and then you can divide by a strain; is that right?

A. Yes, in all of those. I mean, there are different test methods. In my book, Materials Science of Polymers For Engineers, I show what measurement techniques are used for different time scales.

So are you measuring properties that you're going to -- for the polymer that goes over months and years, or are you measuring a property that is just an hour, or are we measuring properties that is impact or crash, which is -- where the time scale is really small. And all of those require different test methods.

So one test method doesn't -- doesn't cover the whole territory of material characterization, neither in rheology nor in solid mechanics.

MR. OAKS: Phillip, when you get to a break, we've been going about an hour.

MR. BROWN: Yeah, I was just looking. I think now is a fine time to break, so why don't we go off the record.

(Recess.)

BY MR. BROWN:

Q. Okay. Dr. Osswald, what types of polymers are commonly used for 3D printing?

A. There are all kinds of polymers. There are -- they go all the way from polycaprolactone to PLA, polylactic acid, ABS, Acrylonitrile Butadiene Styrene. And other polymers like polyamides or nylons. I mean, there's all kinds of -- this -- in 3D printing using PEEK, P-E-E-K.

Q. Are there any few in particular that are most common?

A. Yeah. I would say most common to date is PLA and ABS.

Q. Can you look up the modulus for PLA?

MR. OAKS: Objection.

THE WITNESS: Yes. Yeah. Yes. You could. I mean, you could look up properties for PLA. And there are different grades. The same with ABS, but they are differing grades, and that's one problem with 3D printing materials where they use whatever grade or molecular weight is available to make filaments. And so there is significant variability between one ABS and another ABS with 3D printing materials.

BY MR. BROWN:

Q. But it is something that you can typically look up, even if it's not perfectly representative of the exact specimen you're using?

A. In general, ABS and PLA are materials that you can find in databanks, et cetera. But if you want a full rheological or mechanical characterization, you probably need to measure them.

Q. Have you ever measured the modulus for PLA or ABS?

A. Yes. I mean, I don't think I personally pushed the buttons on the machine, but I have either asked my undergraduates or graduate students to perform those measurements.

Q. So that's something that you would do or oversee in a lab?

A. Yes. I would oversee that in a lab, yes.

Q. Okay. So it's fairly -- is it something that you would do regularly, or was it for a specific project?

A. For a specific project, I mean, I -- research projects, we were printing with ABS, and we wanted to measure the properties. We did the whole project on failure criteria of FFF parts and selectively the centering parts. And there we would print specimens, and those specimens we would do the measurements to determine the strength and the modulus of the material.

Q. For those particular projects you are interested in a more precise characteristics of the materials?

A. Yes, to know how those materials fail. If you design a product with them, we developed the model that predicted the failure. So it's a failure criteria we developed for composites, but we extended for 3D printed parts.

Q. Would your research or process testing have been part of what was published from that research, or is that an ancillary part of the project?

A. No. We published data of FFF printed parts or extrusion-based manufacturing parts and develop the whole failure criteria for those. In fact, we did it for -- I believe we did it for ABS.

Q. Okay. Earlier before our break you mentioned creep data and creep tests.

Could you explain kind of what those creep tests look like?

A. Yeah. So you make a specimen, a dog-bone specimen, that starts wide and has a central portion that is constant length. You put a transducer in the constant length, an extensometer, to measure how much it stretches. And then you clamp one side of the specimen, and then the other end. You'd hang a weight from it so you have a constant stress.

And with that constant stress you measure the strain over time. So it starts stretching, very slowly starts flowing. So if you take stress over strain, the strain starts increasing, so that means the modulus starts decreasing over time.

Q. What is a normal time scale for this kind of test?

A. The creep test -- one, I mean typical, because it's very expensive because each -- each test occupies about a square meter, about 10 square feet in your lab.

And they don't -- ideally you would have those tests run for three years, four years. But too expensive to do that.

And so what they do is they do a thousand hours, which is about six weeks. And then you have relationships that exist in those tests that one can extrapolate them in two years -- two years. Whereas to predict modulus as a function of time over years, but it doesn't catch the failure, the creep rupture that would occur.

Q. Okay. What kind of materials is the -- where are these creep tests most relevant to?

A. Thermoplastics.

Q. And is there a specific use case for

thermoplastics that the creep data is needed for?
A. Yeah. It's for long-term mechanical behavior.
Q. Is creep data relevant to the polymers and their characteristics for use in 3D printing?
A. If you're going to do a design analysis of 3D printed parts -- so if you're 3D -- printing some bracket, for example, if that bracket is going to be under stress over time, you want to know how it deforms over time. So, yeah, it would be relevant to any design part, be it manufactured by any method, including additive manufacturing.
Q. So it's helpful to understand, I guess, how the printed part will behave over the long-term; is that right?
A. Yes.
Q. But that test data isn't really useful for the characteristics of actually extruding the part, is it?
A. No. The characteristics for extruding the part are more rheological characteristics, viscosity, et cetera.
Q. Okay. So based on your experience in this field that we went through already, you would meet the limitations or definition of a POSITA in this space, right?
A. Yes.

Q. And in your declarations, you analyzed the patents and the prior art from the perspective of a person of ordinary skill in the art, right?
A. Yes.
Q. Okay. It also looks like on your -- from your declarations that you served as an advisory to the Colombian president.
Are you still in that role today?
A. Well, right now the government is a little bit funky, and so I am still supposedly in part of this advisory board, but we haven't been asked by him to do anything. But I am still on the advisory board.
Q. How did you use your background in polymers for this position?
A. Well, I was asked by the president of the national university if I wanted to be part of this commission, and I said I would. And I was in the -- in the group that dealt with materials and manufacturing.
Q. Did you do any work specific with 3D printers?
A. Yes. One of my advice -- our group had several things that actually were implemented by the Colombian government. But for one, there is now a ministry of science and education in Colombia, which is good.
But one of the -- one of the areas that we

suggested is to have a digital ID to end corruption in the country so that people couldn't hide their taxes and their sales and whatever.

And the other one, and one that was particularly close to my heart, was the democratization of 3D printing because 3D printing can be used throughout the country in the rural areas in order to manufacture parts and to educate people.

And for that, we needed the whole country to have access to internet. And so that was our other suggestion. And so we found a first solution to have phone antennas, which are throughout the country, to use as also an internet access source for Colombians in the rural area.

But that way, by having the Internet, having their digital ID, one could democratized 3D printing and have 3D printing at differing communities, either community houses in rural areas and schools, et cetera, or people could make, like, replacement for some parts like items that break, like the handle of a machete, for example, that you could 3D print.

And so that -- and the other one aspect that I really -- was close to my heart is -- is to expand the usage of natural rubber plantations in Colombia.

Q. So you're using 3D printers as a way to spread

more widespread internet access, it sounds like?
A. In a way, yes. They go hand in hand.
Q. That's -- that's very interesting.
So when was the first time that you personally used a 3D printer?
A. Probably in the early -- late 1990s, early 2000s. There was, I think, an old Stratasys machine in the labs at UW Madison. I think that's when I first used an FFF printer and SLS printer. I think I used it for the first time, or played around with it. It was in Erlangen in Germany in, like, 2000 -- maybe 1999, 2000.
Q. How frequently did you kind of end up using 3D printers throughout the course of your career? Was this something you were using a lot?
A. Well, I mean, I certainly didn't push buttons, but I certainly -- with graduates I asked them to try different powders, and how do we characterize those powders. How do we make a filament? In fact, we made a -- we developed a process at our labs here in Madison to actually extrude our own filament because we wanted repeatability between materials.
And so ABS was the material that we were going to do a lot of experiments with, but we found from batch to batch there were too many differences.
And so we decided to buy, like, a whole

gaylord of ABS from SABIC. Actually, they gave it to us for free. And with that then we made filament that always had the same properties, the same diameter, the same behavior to be able to do a more in-depth analysis.

Q. Was -- was your -- your own kind of research interest generally more related to the actual materials that were being used by the 3D printers, generally speaking?

A. No. I think -- I mean, by the materials, which is the polymer, right? but also by the additive manufacturing technique, so the process. And then what products -- the P for products and the performance. That was -- so literally it was all across the polymer engineering field.

Q. Okay. And you said you didn't literally press the buttons.

Is that you're having your grad students and things -- grad students run the actual tests; is that what you're referring to?

A. Yeah. I mean, I have ran the machines and played with machines throughout, but my graduate students always wanted to keep me away from the machines because I knew I -- they knew I would do something that would break it. I would push it to the limits and break the machines.

And so -- and that's with everything. With an extruder and injection molding machine, I've broken many machines by just doing something that I shouldn't.

Q. So leave it into the hands of your trusted researchers?

A. Yes. Yeah.

Q. When would you say the last time you used a 3D printer was, personally?

A. The last time was in this case playing around with machines at the law firm offices.

Q. Was that at Stratasys's law firm offices?

A. Yes.

Q. Do you personally own any 3D printers?

A. No, I don't. I don't.

Q. Have you -- have you ever personally purchased a 3D printer?

A. No, I haven't. I mean, I've purchased several of them in my lab, but no, I have not.

Q. Okay. I think you mentioned that you're now retired as a professor from Wisconsin but your current title is professor emeritus; is that right?

A. Yes. I still have graduate students working with me, so I still go to the lab. I still work there, et cetera.

Q. Are there 3D printers in your lab currently?

A. Yes.

Q. What -- what brand 3D printers do you have?

A. I think until recently we had a Markforged. It's like a fiber -- a continuous fiber printer. We have -- in the other side of the lab with all the professors, Stratasys's machines. We have a Cosine printer, which is for making larger parts. And we have also some Fused Form printers, which is a startup company in Colombia that makes printers.

Q. Have you -- have you ever worked as an expert in a 3D printer case before?

A. Yes.

Q. And what was the -- what was that case?

A. It's a case -- lawsuit between Continuous Composites and Markforged.

Q. And who were you working for?

A. Continuous Composites.

Q. And was that a patent case?

A. Yes.

Q. And any other 3D printing cases that you worked on?

A. I can't think of any right now. Yeah, no. No.

Q. Have you ever personally built or designed a 3D printer before?

A. Yes.
Q. When?
A. The project with the students where we designed a 3D printer that would print in different colors. Then we designed a 3D printer with an actual screw extruder that was built for us, Fused Form in Colombia. We designed and patented the spinning nozzle, FFF printer, and that was manufactured also by Fused Form. So several times, yes.
Q. Have any of those projects -- have you ever -- strike that.
During any of those projects, have you ever designed a sensor for a 3D printer before?
A. No.
Q. So when you've used sensors, they've been aftermarket or commercially available sensors; is that right?
A. Correct.
Q. Did any of those printers use a -- any sort of a force sensor?
A. Yes.
Q. Which project would that have been for?
A. The FFF printers that what we developed for a lab in our class to be able to measure the force that the filament exerts on the nozzle that I was talking

about earlier. But also the force sensor and encoders that were used in the rotating nozzle printer.

Q. And when was the rotating nozzle printer project?

A. I think that was built for us in maybe 2022. The Ph.D. thesis on that work was defended in September of 2023. About three years ago.

Q. Do you have any -- outside of these printers that were designed in your lab, do you have any experience using printers that use a force sensor?

A. Not that I can think of right now.

Q. So none of the printers, for instance, that are in your lab right now that you recall having a force sensor on them?

A. Well, the ones that I said that we developed for the course, they have it in that. We did play around with the force sensors of the Bambu printers in Austin.

Q. Okay. But none of the -- I guess maybe -- let me clarify.

None of the commercial printers that you have in your lab have a force sensor, to your knowledge?

A. I don't think so. I don't know.

Q. Okay. Have you ever worked with a 3D printing company in more of a business relationship as opposed to

your expert role before?
A. I mean, the students that I worked with negotiated the patent with MakerBot, but I don't know if that's a business type of relationship.
Q. Okay. When you say they "negotiated the patent," did they negotiate a sale of the patent for their invention; is that what you're referring to?
A. Yes.
Q. And that was developed in your lab?
A. Yes.
Q. And did MakerBot just buy the patent rights for that patent?
A. Correct.
Q. Okay. Were you involved in that transaction?
A. I was the technical advisor. They also had a business advisor, but, yes, I was involved with it so -- peripherally.
Q. Did you receive any compensation as part of that sale?
A. Yes.
Q. Do you remember what that compensation was?
A. I remember -- what was it? I think it was one percent -- one percent of the patent. So maybe I got -- we never received a second payment for some -- I remember there were some issues with it, but I think I

received $15,000 for one percent.

Q. Okay. So you received a percentage of the sale of the patent rights to MakerBot; is that right?

A. Yes.

Q. Okay. And Stratasys now owns MakerBot; is that right?

A. That's my understanding, yes.

Q. Okay. And before this case, have you ever worked directly with Stratasys?

A. No. I mean, I -- I met once with research -- I don't remember what year it was. He was in Madison. I think he was recruiting. He came to my office, and we chatted a little bit about maybe possibilities of doing researching or consulting, but it never went anywhere.

Q. Okay. And approximately what -- what, like, timeframe would that have been?

A. I don't know. Maybe eight, nine years ago, ten years ago.

Q. Okay. When you were preparing your declaration, how much time would you say you spent reviewing the '381 patent?

A. I don't remember. Probably less time than I spent reviewing the '698 patent.

Q. Okay. Do you remember approximately how much time you spent on '698?

A. No, I don't remember. I mean, I read the patent. I looked it over again, and I studied it, but I don't remember how many hours.

Q. Okay. Do you think it would have been, you know, on the order of ten or more hours?

A. I don't know. Probably more. But I don't know how many hours.

Q. And so as part of that process, did you read the entire patent?

A. Yes.

Q. And that includes all of the claims?

A. Yes.

Q. Do you think you've read the entire patent more than one time?

A. Well, I mean, I think one time I read the whole patent, and then I looked at pieces here and there and claims and all of that, but, yeah, I've read many parts of the patent. I read several times.

Q. Okay. I think we talked about this earlier, but you mentioned earlier that you have not, to your knowledge, ever spoken with any of the named inventors of these patents; is that right?

A. That's -- that's what my memory tells me. Yeah, I don't think I've talked to the inventors.

Q. Okay. Do you remember the inventors of these

patents? I'm not trying to do a memory test here.
A. I don't remember.
Q. Okay. Let me just drop them into the -- the patents into the chat so you can refresh your memory.
Okay. I just dropped in the chat the '698 patent, if you want to go ahead and download it and open it. Let me know when you have it open.
Were you able to open that?
A. I'm trying to find it, where I saved it. Yeah. I've got it now. I have it here. Yes.
Q. Okay. Do you see that there is three named inventors?
A. Yes.
Q. And so just ask my question again.
Do you remember ever speaking with any of these individuals?
A. No, I don't remember.
Q. Okay. And have you ever heard of their names before, before reviewing these patents?
A. I don't remember -- I mean, I -- yeah, no, maybe. I don't know. I mean, I -- I'm not sure. I'm not sure.
Q. Okay. So these patents talk about -- they list quite a variety of different sensors.
Do you remember that?

A. Yes.

Q. And just, if you would like to reference, I'm referring -- I think one of the places they list on this is on the bottom of Column 8 on to Column 9 of this '698 patent that we just put in the chat. So if you would like to reference those.

Dr. Osswald, what is a strain gauge?

A. Yeah. The strain gauge is a flat device -- sorry, I can't see you now that I -- there we go. It's easier if I see you when I answer my question.

A strain gauge is a flat wire system that wraps around.

And when you glue that -- the strain gauge in some substrate, very thin, and when you attach that substrate to a metal, for example, the metal beam, and you stretch the metal beam or you bend it, then the resistor -- the resistance will change.

And the resistance changes because of the -- of the length change in the strain gauge. And so you can calibrate that strain gauge to the -- to the strain.

So you calibrate the resistance to the strain that the strain gauge experiences, and it measures the strain in one direction. So if you want to measure the strain in two directions, you need one strain gauge and then one 90 degrees off from the other one, and you can

measure the X and the Y strains.
Q. What -- what units of measurement does it measure strain in typically?
A. The units of strain are units, so 100 percent stretch, which is much too large, but just to give you an example, 100 percent strain. So when you double the length of something, it's a strain of one.
Q. Okay. What about capacitive sensors? What are capacitive sensors?
A. I don't remember. Yeah.
Q. What about optical sensors?
A. I mean, if you -- you could measure, for example, strain by looking at freckles on a surface and then you can -- you can measure them. But I mean, there are all kinds of different optical sensors. There is also optical sensors that will detect a gap or a lack of a gap. I think one of the references uses that.
Q. Have you seen or used any optical sensors that measure force?
A. I've seen -- well, we've used optical sensors, the ones with the freckles, to measure deformation, not force.
Q. And so from the deformation or the strain, are you able to calculate force?
A. If you have -- if you have the properties of

the substrate where they are on, then, yes, the same with the strain gauge. If you know what the properties of the substrate are, then you can translate that into force.

Q. So that goes back to with the modulus or moduli that we were talking about earlier?

A. Yes, the modulus of the substrate.

Q. Right. Okay. Potentiometric sensors, what are potentiometric sensors?

A. Potentiometers they are similar. I mean, there are different potentiometers. Some of them will measure the displacement at certain force systems. And, look, I -- I don't really want to start -- if you'd point me in my report where I write about all of those, I'd be happy to answer.

Q. I'm just trying to understand -- you know, get your understanding of these sensors that are used in the patent.

So have you ever -- have you used a potentiometric sensor to measure force before, if you recall?

A. Yeah, I mean, I think they are -- as some of them are present, for example, in the -- in the MTS, stress-strain testers, they have potentiometers. But there are also some sensors that -- if I can go -- what column is it? So let me go look. Column 8, you said, right, the bottom of it?

Q. Yes.

A. Yeah, there we go. Yeah. Potentiometric, yes. P as electric, electromechanical. Yeah, electromagnetic eddy currents. Acoustic and other sensors. Yeah, strain gauges. Yeah. I see where you're getting that, yeah. I remember that.

Q. Okay. So do you recall ever using a potentiometric sensor to measure force in your work?

A. They may have been inside of -- inside of load cells.

Q. Okay. What about an electromagnetic eddy current sensor? What is that kind of sensor?

A. It's similar. It measures -- it measures a gap. It measures -- well, if you have the two areas that associate with it and the gap between those two areas changes -- it changes the frequency.

Q. And I'm sorry, what was that?

A. The signal.

Q. So that -- that sensor uses a frequency measurement to change or to measure a displacement; is that right?

A. So, I mean, all those stress or force sensors, they make use of some form of displacement, just like a strain gauge. You stretch the part. The strain gauge measures, so can you translate the signal to strain.

And the strain, if you know the property or the substrate, can be translated to stress, and the stress can be translated to load.

The same with the eddy current system, if you apply a load, a gap will -- depending where the load comes from, the gap becomes smaller. And that will change the frequency signal.

So the frequency is obviously related to the gap, and the gap change is related to some force. So that's calibrated then, and you can then translate frequency to force.

Q. Okay. And that's -- again, we're talking about doing a lookup or testing for the modulus and then using that to calibrate?

A. No, or the general -- general compliance of the system. So if the system -- when you apply a load, I mean, we're talking about -- right now we're talking about the Bambu Labs, printers. If you push on the nozzle -- there is a certain compliance on there. And if you push on the nozzle, the gap where the sensors -- or the sensors gap will change.

So that general compliance is particular to the system. And so you can translate the change in gap to the amount of force that is applied on the nozzle. And that amount of force is then related because the gap is related to the frequency, so you can have a direct relationship between frequency and load.

Q. Okay. How do you -- how do you determine that relationship?

A. Experimentally.

Q. Okay. So would that be like applying a known force and monitoring the displacement or the re -- the frequency change?

A. Correct.

Q. Okay. And then based on that, you would know how that particular system reacts; is that right?

A. Yes, you would know what force is being applied to on the nozzle.

Q. Okay. And so you could kind of use that to work your way backwards and figure out, in some way, something like a modulus factor or some sort of proportional factor and then use that kind of going forward to calculate force from the change in frequency; is that how that would work?

A. No, not necessarily.

Q. Why not necessarily? What did I get wrong there?

A. You're not really -- you don't care what the -- what the system's stiffness is. I mean, you care what the compliance is.

So you push on the nozzle. You have a force that you know that changes the gap, and so you can relate the force to the change in gap. Or the change in gap changes the frequency. So you apply a force, and you see what the frequency is. You apply another force; you see what the frequency is.

And you have now a direct relationship between frequency and force without having to compute any moduli or anything for the system.

Q.   Okay. I understand. And when you say the term "compliance," what do you mean by that?

A.   So a system that has a high compliance -- compliance is -- is the opposite of stiffness. So it's the ability of the system to deform. So in other words, the ability of the gap to become smaller or larger depending on where -- how you apply the force.

Q.   So in your opinion what does it require to calculate a contact force?

A.   Well, have a signal that changes as you apply force. If we're talking about the nozzle and about these patents, you apply a force on the nozzle, and you have a signal, which you can use to compute a force.

Q.   And so you have to -- one of the steps there is you have to understand what that relationship is between the signal and the force; is that right?

A. Well, you, as the user, don't. But the manufacturer of the system would then internally, in the system, know what force you have. If you know the relationship between the change in gap and force or the -- or the frequency change and the force.

Q. Okay. And so in order to calculate a contact force as these patents describe, you would need to know that, if you -- generally speaking, the system would need to know that relationship; is that fair?

A. Yeah, the system would have to have a conversion between hertz per newton or newton per hertz.

Q. Okay. I think we quickly touched on this before. But before you were asked to work on these IPRs, were you aware of the Warren reference?

A. No. I may have come across it, but I did not remember it. It's such a long reference, that -- yeah.

Q. What about the Calderon reference?

A. I don't remember. Yeah.

Q. And so you reviewed both of those references in detail when you're preparing your declarations, right?

A. Yes.

Q. Okay. Just generally speaking at a very high level, what is the Warren reference about?

A. Well, I can read you what I wrote in my report.

Q. Do you have a -- do you have a recollection of just, generally speaking, what it was without reading from your report?

A. Yeah. I mean it's additive and subtractive manufacturing in the field of biomaterials.

Q. Okay. Have you worked in the field of biomaterials before?

A. I have, yes.

Q. Is that overlapping with kind of the field of polymers generally?

A. It is because they are complex fluids, complex materials.

Q. Okay. So maybe they are not polymers, but they are, you know, similar in many ways; is that -- is that kind of the gist of that?

A. Yeah. I mean, tissue and bone and -- are complex fluids, are complex materials. So I advised a couple of Ph.D. theses in those areas. Those were kind of hobby projects, but I did get into physiological flows and behavior of physiological materials.

Q. Have you ever used a system like what's described in Warren?

A. No.
Q. No.
Any aspects of Warren, as you mentioned this, that you've used or something similar to what you've used?
A. No.
Q. Let's look at -- let's flip over to your expert declaration.
I'm going to have open the '381, just so we can be consistent on numbering.
Do you want to go ahead and open that and let me know when you have it open?
A. Yep, I have it open.
Q. Okay. And if we look -- let's flip to your paragraph number 163. It's on page 74 of the PDF, if that helps.
A. 163, yes.
Q. So you would agree that Warren teaches a system that senses a change in amplitude of vibration, right?
A. Yes.
Q. And it's your opinion that that system does not sense a contact force, right?
A. That's correct.
Q. Okay. And you would agree that Warren

explains that a change in amplitude is proportional to the force of contact, right?
A. I disagree with that.
Q. You disagree that Warren teaches an amplitude that's proportional to contact force?
A. Yeah. There is no -- there is no way that the amplitude change can be translated into a contact force.
Q. Okay. If you look at -- I think maybe I'm asking a slightly different question.
If you look at paragraph 165, do you see the second or third sentence there that starts with "Although"?
A. Yes.
Q. So part of that you quote that Warren states, "change in amplitude is proportional to the force of contact between the dispenser and the substrate," right?
A. That's -- that's what he says --
Q. Okay.
A. -- in paragraph 313.
Q. Right. So Warren does say that it's -- that this proportionality exists, right?
A. Well, Warren says that, but he doesn't -- as a writer, he doesn't provide any guidance, and he can't, because it's not possible to translate the shift in frequency that leads to a change in amplitude to a

force.

At best you would know that the material or that the quill has contacted some complex fluid that -- I think in this case it was hydrogels, that would create some damping that would switch the frequency.

So it's not even that the amplitude of the vibration changes. It's the whole frequency spectrum shifts like it does because of the -- of the damping that occurs in the system.

So it's not possible from a materials and from a complex fluid perspective to actually measure a force or to translate that into force.

Q. Okay. And from what I just heard -- and I think your report says the main thing that's missing is it doesn't -- I think you used the term "proportionality constants"; is that right? That's kind of what's missing?

A. It's more than that. I mean, I write about I think the whole system -- first of all, there's no way that you can characterize the material because typically materials are characterized with low frequency as you apply vibration, so it's a dynamic mechanical analyzer or a rheometer that has a certain frequency.

And it can go from really low frequencies like .001 hertz, which is like a thousand seconds per cycle, to at most maybe 100 -- maybe -- or so, or maybe a thousand if you go up, but -- but the Warren system isn't a kilohertz, and there's no way that you can characterize a material with that.

And the thing is you need to know the properties of the substrate to even do any type of translation. So there is no guidance. I mean, I write extensively about it and why it wouldn't work.

Q. And so is it your opinion that Warren requires frequencies in the kilohertz, I think is what you used?

A. No, he uses his system, and I don't know where I write about that. Let me see. Yeah. So Warren's system -- I don't remember where I -- I think it's on the next page somewhere. Yeah, so Warren's system goes between 90 and a hundred kilohertz, which is 90,000 to 100,000 hertz where typical systems go between .01, maybe a little bit lower, to a hundred.

And so there's no way we can find a system that characterizes the material that he's measuring at those high frequencies.

But also things change from material to material. You have temperature dependences. You have frequency dependences. And his graphs or his curves -- and I don't remember which figure they are located at, and his -- his figures, it's not really a change.

Sure. He talks about a change in amplitude, but what he sees is a slight shift to the -- to the right, I think, of the curve of the spectrum. And that shift is due to a damping. And so it's a damping that comes as a result of contacting a fluid, but it's not related to a force. It's related to a damping process.

And so at best he can say, yes, we've touched the material, but you can't -- if you move deeper or -- into this fluid that he's doing or this gel, it's not going to change that -- that -- that shift.

So the delta A will stay very similar because it's a material. It's a damping that is generated. So he cannot translate that into force.

But I think I explain that in my report.

Q. Okay. Let's look at paragraph 169.

You use the term "contact-detection device" there.

Do you see that --

A. Yes.

Q. -- the bottom of the page?

What is a contact-detection device?

A. Well, it detects that it has contacted some -- which paragraph, 169, right?

Q. Yes.

A. Yes. "Warren's sensor cannot provide a quantitative measurement of contact force and functions, instead as a contact-detection device."

As I said, at best, it knows, oh, okay, I touched one of those fluids. That's all. But -- so it's, yes, it has contact; and, no, it doesn't have contact. And that's really what Warren does.

I mean, sure, he does mention forces in all of that, but he doesn't explain it. And he doesn't explain it because he can't. There is no way of doing it.

Q. Okay. Is -- is a contact-detection device, is that a term that you use in the industry?

A. Yeah. I mean, I think you can -- I mean, sure, that's used in industry. I mean, a contact-detection device. If you contact something either by opening and closing a switch -- in this case here, it's by seeing a little shift in the -- in the frequency spectrum.

Q. So you can measure in different ways, but it's more or less just a yes/no kind of device; is that what you're saying?

A. Yes.

Q. Okay. So that's -- the contact-detection device is just measuring, yes, there's contact or, no, there's no contact; it doesn't measure force?

A. Yes, that's what Warren does.

Q. And you said a switch. So, I mean, to take a general example, it's kind of a light switch; on or off kind of thing?

A. Yes.

Q. In paragraph -- a little bit later on in those paragraph you include two charts, in that same paragraph, 169. These are from books that you wrote, right?

A. Yes.

Q. Published?

A. Yes.

Q. And so for these charts, is this data that you collected as part of your research, or is this a figure that you would have obtained the data from somewhere else?

A. Yeah. The first one is one that was measured years ago, and I believe that was measured at BASF, and I've had that -- or by Bayer, one of the two, and I've had that in my books.

And it simply shows the effect of frequency on the -- on the storage modulus up above. In this case think it's PVC. And the lower one is something that we measured in the lab when we were writing the book on rheology.

Q. Okay. Just out of curiosity, is that

something that you would have published as part of your research and then would have included a book, or is that something you've collected just for this book?

A. Something that came from teaching the class on rheology and the students' measurements. So it's data that we collected while teaching and then eventually included it in the textbook of rheology.

Q. Okay. I see we're just under an hour. I'm getting close to wrapping up. I think a quick break would be helpful, unless you'd rather take lunch, but I think I'll be relatively quick after this. So why don't we take a -- go off the record.

(Recess.)

BY MR. BROWN:

Q. Dr. Osswald, you cite to an Ashby reference or book that is Exhibit 2024 in your report.

Do you remember that exhibit?

A. I have to go back and look.

Q. Paragraph 188.

A. Okay. Yes.

Q. And is -- you cited to Figure 4.1 in your report.

Is this a textbook reference that you are citing?

A. Yeah. It's a book.

Q. And do you know, is this a textbook that you've used before?
A. Not this, but, I mean, I've had drafts similar in other textbooks. This is a very common draft to compare moduli of different materials.
Q. Okay. And did you find this particular reference that you cited, the Ashby book?
A. I don't remember where I got this. I think that graph was in maybe Dr. Wolfe's report. I don't remember where that graph comes from. I'm drawing a blank, actually.
Q. We don't need to, but would it be helpful to look at the document, or do you think you're just not going to remember where that's from?
A. I can look at the document, yeah. And I'm -- I'm drawing a blank where that came from.
Q. Sure. I'll drop it in the chat, and you can take a look at it and see if that helps.
A. Yeah, I see it. I've seen that book -- that first diagram, I remember. This is a very common -- common diagrams, and it's just one of many textbooks.
I don't remember where that came from, but it's a very common -- common type of graph. It just illustrates different moduli between different materials.

I don't remember where that came from actually.

Q. Okay. Would that have been -- is that a common figure for, again, more of a basic level of mechanical engineering class talking about Young's modulus?

A. Yes, mostly material science class. So it's the material science class that people take when they are taking mechanical engineering and other courses.

Q. Okay. And so you don't -- you don't remember if this is a book that you searched for for this case or not?

A. Yeah, I don't remember. I don't remember the province of it. I'm drawing a blank right now, but it's -- it's a very typical graph that would have been available to anybody of ordinary skill in the art.

Q. Okay. While we were on breaks today, did you talk to anyone during any of your breaks?

A. No, I didn't.

Q. Okay.

MR. BROWN: That's all I have. I don't know if Brian has anything else?

MR. OAKS: I'd like to take a short break before any further questioning, so let's go off the record.

(Recess.)

MR. OAKS: Thank you for your time today, Dr. Osswald. I don't have any questions for you, so I think we can be done.

COURT REPORTER: Counsel, may I get transcript requests, please?

MR. GRISWOLD: We need the final by Friday, Tamara, if you can do that.

MR. OAKS: No, thanks.

(Whereupon the proceedings concluded at 10:20 a.m.)

ERRATA SHEET

NAME OF CASE: SHENZHEN TUOZHU TECHNOLOGY CO., LTD v. STRATASYS, INC.
DATE OF DEPOSITION: MAY 6, 2026
NAME OF WITNESS: Dr. Tim A. Osswald

Reason Codes:

1: To clarify the record.
2: To conform to the facts.
3: To correct transcription error.

Page _____ Line _____ Reason _____

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Page _____ Line _____ Reason _____

From _______________________ to _____________________

Deponent's Signature ________________________________

Date________________________

DECLARATION UNDER PENALTY OF PERJURY

I, Dr. Tim A. Osswald, do hereby certify under penalty of perjury that I have read the foregoing transcript of my deposition taken on May 6, 2026; that I have made such corrections as appear noted on the Deposition Errata Page(s), attached hereto, signed by me; that my testimony as contained herein, as corrected, is true and correct.

This Declaration is executed this ______ day of ___________, 20___, at ____________________________, California.

____

Dr. Tim A. Osswald

STATE OF CALIFORNIA) ss.

I, Tamara Houston, RPR, CCRR, CSR No. 7244, a Certified Shorthand Reporter in the State of California, duly empowered to administer oaths, do hereby certify:

That, prior to being examined, the witness named in the foregoing deposition was by me duly sworn to testify to the truth, the whole truth, and nothing but the truth;

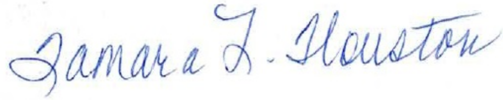
That said deposition was taken down by me in shorthand at the time and place therein named, and thereafter reduced to typewriting by computer-aided transcription under my direction;

That the dismantling, unsealing, or unbinding of the original transcript will render the reporter's certification null and void.

I further certify that I am not interested in the event of the action.

In witness whereof, I have hereunto subscribed my name.

Dated: 8th of May, 2026.



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