

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

THE BOEING COMPANY
Petitioner,

v.

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Patent Owner.

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 7,487,684**

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1001	U.S. Patent 7,487,684 (“’684 Patent”)
1002	Prosecution History of U.S. Patent 7,487,684 (“’684 File History”)
1003	Declaration of Junlan Wang, Ph.D. (“Wang Declaration”)
1004	Curriculum Vitae of Junlan Wang, Ph.D.
1005	Wang J., 2002 Ph.D. Dissertation at University of Illinois at Urbana-Champaign, “Thin-Film Adhesion Measurement by Laser-Induced Stress Wave” (“Wang-Dissertation” or “Wang”)
1006	Declaration of Ingrid Hsieh-Yee (“Hsieh-Yee Declaration”)
1007	Anderholm, N., “Laser-Generated Stress Waves,” Appl. Phys. Lett., 16(3), pp. 113-115, 1970
1008	Fox, J.A., and Barr, D.N., “Laser-Induced Shock Effects in Plexiglas and 6061-T6 Aluminum,” Appl. Phys. Lett., 22(11), pp. 594-596, 1973
1009	Yang, L.C., “Stress Waves Generated in Thin Metallic Films by a Q-Switched Ruby Laser,” J. Appl. Phys., 45(6), pp. 2601-2608, 1974
1010	Stephens, A.W., and Vossen, J.L., “Abstract: Measurement of Interfacial Bond Strength by Laser Spallation,” J. Vac. Sci. Technol., 13(1), pp. 38-39, 1976
1011	Gupta, V., Argon, A., Parks, D., and Cornie, J., “Measurement of Interface Strength by a Laser Spallation Technique,” J. Mech. Phys. Solids, 40(1), pp. 141-180, 1992 (“Gupta-1992”)
1012	Yuan, J. and Gupta, V., “Measurement of Interface Strength by the Modified Laser Spallation Technique. I. Experiment and Simulation of the Spallation Process,” J. Appl. Phys., 74(4), pp. 2388-2396, 1993
1013	Yuan, J., Gupta, V., Pronin, A., “Measurement of Interface Strength by the Modified Laser Spallation Technique. III. Experimental Optimization of the Stress Pulse,” J. Appl. Phys., 74(4), pp. 2405-2410, 1993 (“Gupta-1993”)
1014	Wang, J., Sottos, N. R. , and Weaver, R. L., “Laser Induced Thin Film Spallation,” TAM Technical Reports, University of Illinois Urbana-Champaign, 2000
1015	Wang, J., Weaver, R.L., “Abstract: Laser-induced weak shock in fused silica for destructive testing of thin films” J. Acoust. Soc. Am. 109, 2308, 2001

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1016	Wang, J., Weaver, R. L., and Sottos, N. R., “A Parametric Study of Laser Induced Thin Film Spallation,” <i>Exp. Mech.</i> , 42(1), pp. 74-83, 2002 (“Wang-2002”)
1017	Wang, J., Sottos, N. R., and Weaver, R.L., “Thin Film Adhesion Measurement by Laser Induced Stress Waves,” <i>J. Mech. Phys. Solids</i> . 2003
1018	Wang, J., Weaver, R. L., and Sottos, N. R., “Laser-Induced Decompression Shock Development in Fused Silica,” <i>J. Appl. Phys.</i> , 93(12), pp. 9529–9536, 2003
1019	Gupta, V., Kireev, V., Tian, J., Yoshida, H., Akahoshi, H., “Glass-Modified Stress Waves for Adhesion Measurement of Ultra-Thin Films for Device Applications,” <i>J. Mech. Phys. Solids</i> , 51(8), pp.1395-1412, 2003
1020	Fairand, B.P., Clauer, A.H., “Use of Laser Generated Shocks to Improve the Properties of Metals and Alloys,” <i>Indus. App. Of High Power Laser Tech.</i> , Vol. 86, pp. 112-121, 1977
1021	Barker, L.M., Hollenbach, R.E., “Shock Wave Studies of PMMA, Fused Silica, and Sapphire,” <i>J. Appl. Phys</i> , 41, pp. 4208-4226, 1970
1022	December 13, 2023 Defendant’s Motion to Dismiss Plaintiff’s Second Amended Complaint Under Federal Rules of Civil Procedure 12(b)(2), 12(b)(3), and 12(b)(2), Dkt. 78, <i>Laser Spallation Technologies, LLC v. The Boeing Company</i> , Case No. 2:23-cv-02294 (C.D. Cal.)
1023	February 1, 2024 Order Denying Defendants’ Motion to Dismiss, Dkt. 86, <i>Laser Spallation Technologies, LLC v. The Boeing Company</i> , Case No. 2:23-cv-02294 (C.D. Cal.)
1024	February 7, 2024 Order Setting Deadlines Re Jurisdictional Discovery, Dkt. 90, <i>Laser Spallation Technologies, LLC v. The Boeing Company</i> , Case No. 2:23-cv-02294 (C.D. Cal.)
1025	February 27, 2024 Order Conditionally Granting Motion to Compel Gupta Deposition [ECF 91] and Denying Application to Expedite Hearing on Motion to Compel [ECF 92], Dkt. 93, <i>Laser Spallation Technologies, LLC v. The Boeing Company</i> , Case No. 2:23-cv-02294 (C.D. Cal.)
1026	February 1, 2024 Order Re: Civil Jury/Court Trial, Dkt. 89, <i>Laser Spallation Technologies, LLC v. The Boeing Company</i> , Case No. 2:23-cv-02294 (C.D. Cal.)

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1027	Provisional Application No. 60/550,803
1028	Pronin, A., 1995 Ph.D. Dissertation at Dartmouth College, “Applications of Laser Generated Stress Pulses for Materials Characterization,” 1995
1029	Gupta, V., and Argon, A.S., “Measurement of Strength of Thin Film Interfaces by Laser Spallation Experiment,” <i>Inelastic Deformation of Composite Materials: IUTAM Symposium, Troy, New York, May 29–June 1, 1990</i> , pp. 51-74, New York, NY: Springer New York, 1991
1030	Conference Program Book, ASME International Mechanical Engineering Congress and Exposition, November 17-22, 2002, New Orleans, Louisiana
1031	Uerara, K., Sakurai, M., “Bonding Strength of Adhesives and Surface Roughness of Joined Parts,” <i>J. Materials Processing Tech.</i> , 127, pp. 178-181, 2002
1032	Yu, A., Gupta, V., “Measurement of <i>In Situ</i> Fiber/Matrix Interface Strength in Graphite/Epoxy Composites,” <i>Composites Science and Technology</i> 58, pp. 1827-1837, 1998
1033	November 2, 2023 Declaration of Vijay Gupta in Support of Plaintiff’s Second Amended Complaint, Dkt. 75, <i>Laser Spallation Technologies, LLC v. The Boeing Company</i> , Case No. 2:23-cv-02294 (C.D. Cal.)
1034	U.S. Patent No. 5,438,402
1035	March 15, 2024 Declaration of LaTonya Morris, ProQuest
1036	February 7, 2024 Declaration of Carl Mageski, ProQuest

I. INTRODUCTION

The Boeing Company (“Petitioner”) petitions for IPR of Claims 1-24 (“Challenged Claims”) of U.S. Patent No. 7,487,684 (“’684 Patent”) (Ex-1001), which lists The Regents of the University of California (“Patent Owner” or “PO”) as assignee. The Challenged Claims merely claim a single well-known concept from the prior art: **use of glass-modified stress waves**. As set forth below, the Challenged Claims should be found unpatentable and cancelled.

II. MANDATORY NOTICES

Real Parties-in-Interest: Petitioner identifies the following as the real party-in-interest: The Boeing Company.

Related Matters: The ’684 Patent is asserted in *Laser Spallation Technologies, LLC v. The Boeing Company*, Case No. 2:23-cv-02294, in the Central District of California.

Counsel and Service Information:

Petitioners identify lead and backup counsel below. A Power of Attorney is filed concurrently herewith under 37 C.F.R. § 42.10(b).

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Pursuant to 37 C.F.R. § 42.8(b)(4), Petitioner requests that all non-electronic correspondence be directed to lead counsel and back-up counsel as shown above. Petitioner consents to electronic service by email at Boeing-IPR-MS@mckoolsmith.com.

A copy of this entire Petition, including all Exhibits and a Power of Attorney, is being served by FEDERAL EXPRESS, costs prepaid, to the address of the attorney or agent of record at the USPTO for The Regents of the University of California: John P. O'Banion, O'Banion & Ritchey LLP, 400 Capitol Mall, Suite 1550, Sacramento, CA 95814.

III. REQUIREMENTS FOR IPR

A. Payment of Fees

The undersigned authorizes the Office to charge the fee for this Petition to Deposit Account 505723.

B. Grounds for Standing

Petitioner certifies that the '684 Patent is available for IPR, and Petitioner is not barred or estopped from requesting IPR on the below grounds.

C. Statutory Grounds for the Challenges

Petitioner requests cancellation of Claims 1-24 on the following grounds:

Ground	Claims	Basis for Unpatentability
1	1-22	§ 102 – Wang-Dissertation (Ex-1005)
2	4, 6, 9, 15, 17, 20, 23-24	§ 103 – Wang-Dissertation
3	1-24	§ 103 – Wang-Dissertation in view of Gupta-1992 (Ex-1011)
4	1-8, 10-19, 21-22	§ 102 – Gupta-1992
5	9, 20	§ 103 – Gupta-1992 in view of Gupta-1993 (Ex-1013)
6	4, 6, 10, 15, 17, 23-24	§ 103 – Gupta-1992
7	1-24	§ 103 – Wang-2002 (Ex-1016) in view of Gupta-1992

For purposes of this proceeding only, Petitioner assumes (but does not concede) the earliest effective filing date of the '684 Patent is March 5, 2004—the filing date of the earliest priority application. Ex-1001, Cover; Ex-1027.

Wang Dissertation published on March 4, 2003, Gupta-1992 published on January 9, 1992, Gupta-1993 published on August 25, 1993, and Wang-2002 published on April 8, 2002. Ex-1006, Table 3. Each are prior art under at least pre-AIA 35 U.S.C. §102(b) and were not considered by the Office during prosecution. Ex-1001 (“References Cited”).

IV. CLAIM CONSTRUCTION

In IPRs, a claim is construed “using the same claim construction standard that would be used to construe the claim in a civil action” 37 C.F.R. § 42.100(b). The Board only construes claims when necessary to resolve the underlying controversy. *Toyota Motor Corp. v. Cellport Systems, Inc.*, IPR2015-00633, Paper 11 at 16 (Aug. 14, 2015); *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999). Here, no terms need to be construed to resolve the issues raised herein because the prior art discloses all limitations under the plain meaning as well as under any plausible construction.¹ Ex-1003, ¶40.

¹ In the parallel district court litigation, the first named inventor/PO’s purported exclusive licensee has put forth a broad construction for “glass element.” Ex-1033,

V. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art at the time of the alleged invention (“POSITA”), which for purposes of this proceeding is on or around March 5, 2004, would have had an M.S. in Mechanical Engineering or a related field, and at least five years of experience using laser systems to characterize and test mechanical behavior in materials. Ex-1003, ¶38.² More education may supplement practical experience or vice versa. *Id.*

VI. BACKGROUND AND SUMMARY OF THE ’684 PATENT

A. Technology Overview

Thin films play a role in many technological applications, including multilayer microelectronic devices. The ability to quantify film adhesion can help design and evaluate these multilayer components. Ex-1003, ¶¶41-42.

¶10. Petitioner does not concede that the Challenged Claims are not invalid under one or more sections of § 112 and reserves the right to assert challenges under § 112 in other proceedings. The prior art teaches a “glass element” under any plausible understanding of the term. *Nautilus, Inc. v. Biosig Instruments, Inc.*, 572 U.S. 898, 910 (2014).

² Petitioner submits the Declaration of Dr. Junlan Wang, an expert in the field. Ex-1003, ¶¶1-39; Ex-1004.

Laser spallation is a technique developed in the 1970s to understand the adhesion of films with substrates. *Id.* A schematic of tensile laser spallation technique is shown below (Ex-1017, 6):

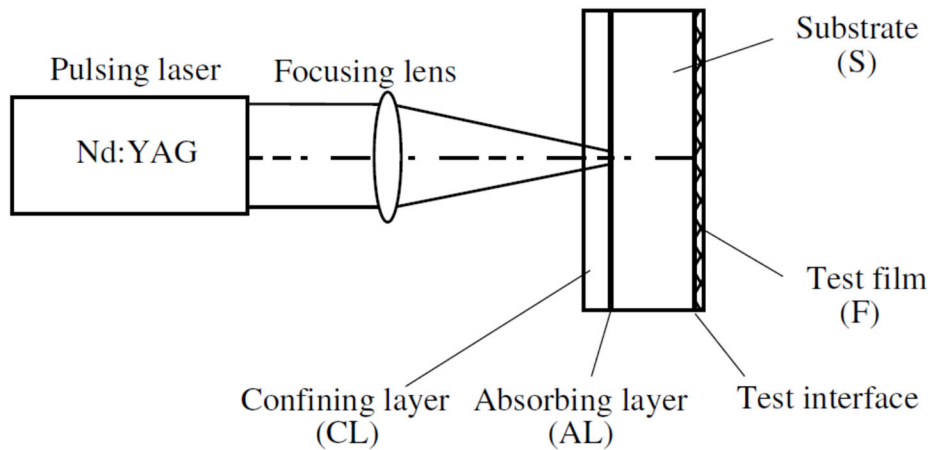


Figure 1: Schematic of the tensile laser-spallation technique.

A high-energy pulsed laser, typically neodymium-doped yttrium aluminum garnet (Nd:YAG), vaporizes an energy absorbing material held under a confining layer. Ex-1003, ¶¶43-44. The expansion of vaporized material constrained by the confining layer creates a compressive stress wave directed at a substrate, where it propagates and reflects as a tensile stress wave at the free surface of a testing film. This tensile stress wave spalls (*i.e.*, separates) the testing film while propagating back towards the substrate if the magnitude of the tensile stress wave at the film/substrate interface is greater than the interface bonding strength. *Id.* The strength of the bond between the testing film and the substrate can then be quantified. *Id.*, ¶45.

The ability of a pulsed laser beam to generate stress waves was first recognized in the early 1960s. *Id.*, ¶46. Studies were conducted that generated high-amplitude stress waves in metals by striking a high-energy pulsed laser beam on the surface. In the 1970s, techniques were developed for confinement of laser-vaporized materials and generating higher stresses by placing an overlay adjacent to the metal surface. *Id.*, ¶¶47-49. The configuration confined the vaporized materials in the vicinity of the metal surface to significantly increase the peak stresses developed. Several confining overlays were developed, including quartz and transparent glass overlays, to increase the magnitude of stress waves. *Id.*

The use of these techniques evolved into laser spallation. *Id.*, ¶¶50-53. By the early 1990s, laser spallation experiments included a high-energy Nd:YAG laser pulse made to impinge on a metal absorbing layer placed between the back surface of the substrate and a fused quartz confining layer in an arrangement as shown below (Ex-1011, 143):

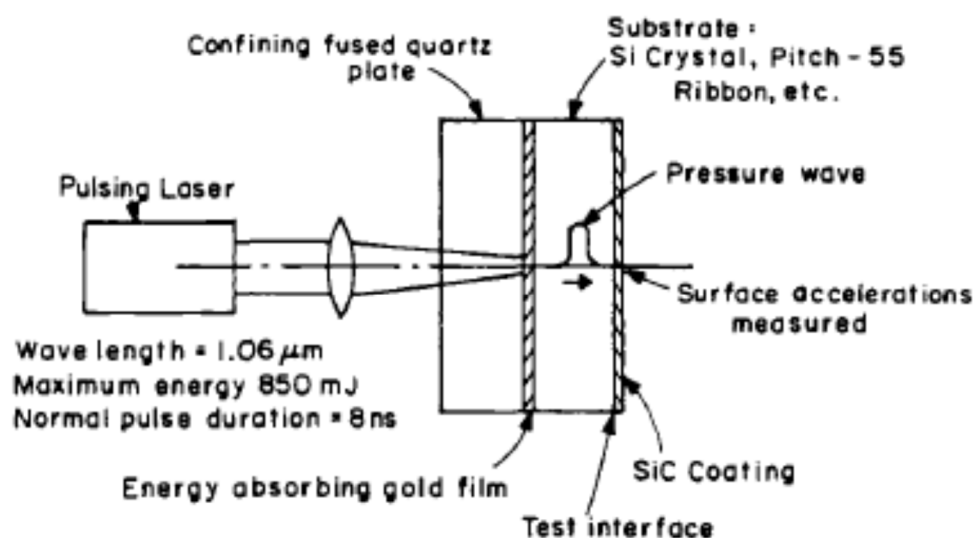


FIG. 1. Schematic view of the laser spallation experiment.

Absorption of the laser energy in the metal layer, confined by the fused quartz plate, led to sudden expansion of the metal film, leading to generation of a compressive shock wave directed toward the film coating/substrate interface. Ex-1003, ¶54. Spallation experiments were carried out for several thin-film coating/substrate interfaces (*e.g.*, SiC/C, SiC/Si, and epoxy/C interfaces). Ex-1011; Ex-1028.³

Modifications of this experimental setup were also made in the 1990s, including the replacement of the fused quartz plate by a thin layer of solid waterglass (Na_2SiO_3) as a confining layer. Ex-1003, ¶55. The waterglass was found to generate

³ These techniques were known to be applicable to any type of composite, whether metal-, polymer- or ceramic-matrix-based, including graphite/epoxy composites. Ex-1032.

the strongest stress pulse. It was known that the peak decay time of the stress pulse is critical in maximizing the interfacial tensile stress. The stress pulse in waterglass had a shorter rise time and a much sharper decay, which increased the interface tensile stress. *Id.*

In the early 2000s, additional advancements in laser spallation techniques were developed by Wang *et al.*, including adhesion measures of submicron to a few micron thick films (0.1-10 μ m) with strong interfaces. Ex-1003, ¶¶56-59; Ex-1014-Ex-1018. It was determined that thinner film testing could be accomplished by using non-linear elastic substrates, *e.g.*, fused silica. *E.g.*, Ex-1016, Abstract. In fused silica—a glass consisting of almost pure silica (SiO₂)—the laser-generated compressive stress wave evolves over a distance into a linear ramp followed by a weak shock having a fast fall time. Ex-1003, ¶57. Wang determined this decompression or “**rarefaction shock**,” a known property of fused silica, is critical for significant loading of a surface/thin-film interface.⁴ *Id.*; Ex-1021.

B. The '684 Patent

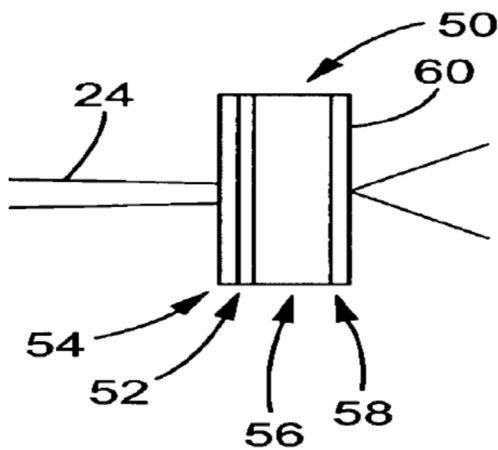
The '684 Patent generally relates to these known properties of glass and the modification of stress waves. *See* Ex-1001; Ex-1003, ¶¶60-67. The patent relates to a “method and system for generating spallation of ultra thin films and measuring the interface tensile strength between a substrate and the thin film.” Ex-1001, 1:50-52.

⁴ Emphasis added unless otherwise indicated.

The patent acknowledges laser spallation is commonly applied in the art and describes the typical arrangement of a high-energy laser pulse made to impinge upon a planar arrangement of a confining plate, a metallic layer, a substrate plate, and a coating combination. *Id.*, 2:16-34.

The '684 Patent teaches it was known “for a given coating thickness the post-peak decay time is the most critical in maximizing the inter-facial tensile stress.” *Id.*, 8:43-45. Therefore, “if the post-peak decay time is **reduced to zero**, i.e. the wave profile has a ‘**rarefaction shock**,’ then the interface tensile stress for a film of arbitrarily small thickness theoretically will equal the amplitude of the incoming compression pulse.” *Id.*, 8:45-49. The '684 Patent states that “this theoretical possibility has been realized experimentally with sample assemblies using glass layers.” *Id.*, 8:49-51.

The '684 Patent discloses the addition of a “glass substrate element (106)” on the back side of the substrate (108), as shown in red on Figure 4 (annotated) compared to the prior art sample assembly in Figure 2A:



Prior Art (Figure 2A)

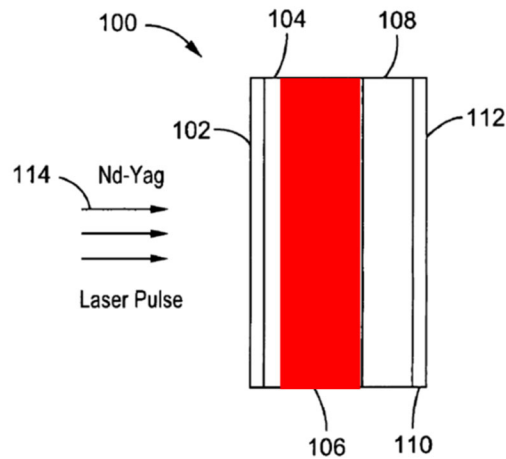


Figure 4 (Annotated)

Id., 8:52-67, Fig. 4; Ex-1003, ¶64. Similar to prior art techniques, a laser pulse is directed at the sample assembly in Figure 4, with the pulse passing through a waterglass constraining layer 102 to heat up energy absorbing layer 104. Ex-1001, 8:59-63. The expansion of aluminum layer 104 generates a compressive shock wave that “propagates through the glass substrate 106 and silicon substrate 108.” *Id.*, 8:63-67. As shown in Figure 5A, “the rise-time of the stress wave 120 gets longer but the post-peak stress profile starts 122 to decay rather quickly.” *Id.*, 9:32-38, Fig. 5A. “Ultimately, a profile is attained with the post-peak stress dropping virtually instantaneously (the drop time is within the resolution limit of our instrumentation), much like ‘**rarefaction shock.**’” *Id.*, 9:38-41. While the magnitude of the modification of the stress wave profile varies from glass to glass, “all showed the formation of rarefaction shock.” *Id.*, 9:47-49.

C. '684 Patent Prosecution History

The Examiner initially rejected all claims under §102(b) based on U.S. Patent No. 5,438,402 to Gupta (“*Gupta*”). Ex-1002, 91-93; Ex-1034; *see also* Ex-1003, ¶¶68-72. The Examiner found that *Gupta* disclosed the apparatus and method as claimed, including a glass element (*i.e.*, waterglass) propagating a stress wave to the coating and substrate. Ex-1002, 91-93. In response, the Applicant argued:

The glass stress wave modification element is particularly important to this invention, as it has been found that with sufficiently high pulse pressures, glass materials tend to modify an input stress wave to where it has a virtually instantaneous post-peak drop time, resulting in “**rarefaction shock**.”

Id., 77. The Applicant further argued that “an important principle of operation in this invention [] is that the stress wave propagates through a glass substrate, rather than merely using a glass substrate as a confinement for generating a wave launched directly into a substrate.” *Id.*, 79 (emphasis in original). The Applicant described the glass element as “used to modify the stress wave as it propagates through the glass layer 106. After the wave has been modified by the glass substrate (**into a rarefaction shock**) it is transmitted through the substrate 108 to coating 110.” *Id.*, 80.

The Examiner rejected this argument, as the solid waterglass confining layer disclosed in *Gupta* propagates a stress wave to the coating and substrate. *Id.*, 62. The Applicant amended the independent claims to add the word “modify,” *id.*, 37-43,

and argued that the glass materials have “the effect of compressing the tail end of a propagated shock, **thereby modifying the input stress wave**, resulting in a ‘rarefied shock’ pulse tail.” *Id.*, 44-45 (emphasis in original). The Examiner allowed the application. *Id.*, 18.

VII. PRIOR ART

A. Wang-Dissertation (Ex-1005)

Dr. Junlan Wang (Petitioner’s expert) submitted a dissertation entitled “Thin-film Adhesion Measurement by Laser-Induced Stress Waves” in 2002 while a Ph.D. student (“Wang-Dissertation” or “Wang”). Ex-1005.⁵ Dr. Ingrid Hsieh-Yee, an expert on library cataloging and classification, considered numerous facts relating to Wang-Dissertation (*e.g.*, ProQuest declaration) and explains on the basis of such evidence that Wang-Dissertation was publicly accessible by at least March 4, 2003. Ex-1006, ¶¶27-34. Wang-Dissertation is prior art at least under §102(b).

A Record of Wang-Dissertation was first published to the ProQuest Dissertations and Theses database on March 4, 2003. *Id.*, ¶¶31-33; Ex-1035. The full text of Wang-Dissertation was also available for purchase from ProQuest as of March 4, 2003. Ex-1006, ¶¶31-33; Ex-1035. A POSITA in 2003 was familiar with

⁵ Ex-1005 is a true and correct copy of Wang-Dissertation. *See* Ex-1035 (ProQuest declaration attaching Wang-Dissertation).

the ProQuest database and would have been able to find the dissertation readily in various ways, including keyword search. Ex-1003, ¶73; Ex-1006, ¶33.

Wang-Dissertation relates to tensile laser spallation techniques for measuring thin-film adhesion and is in the same field of endeavor and reasonably pertinent to the problem addressed by the '684 Patent. Ex-1005, Abstract (“Laser spallation techniques have been developed to investigate the intrinsic strength of planar interfaces using laser-generated stress waves”); Ex-1003, ¶¶74-78. Wang investigated laser-generated stress waves to characterize interfacial strength of thin films and, as a part of this analysis, the mechanism for shock development in fused silica substrates was studied. Ex-1005, 24-81, 119-124. At the time, the development of “**rarefaction shocks**” in fused silica was known (“as opposed to the more common compression shocks found in other materials”). *Id.*, 26; Ex-1021.

Wang performed tensile laser spallation techniques using fused silica. *See* Ex-1005, 40-81. Wang’s tensile laser spallation apparatus is shown in Figure 2.1 (*id.*, 7-8, 42):

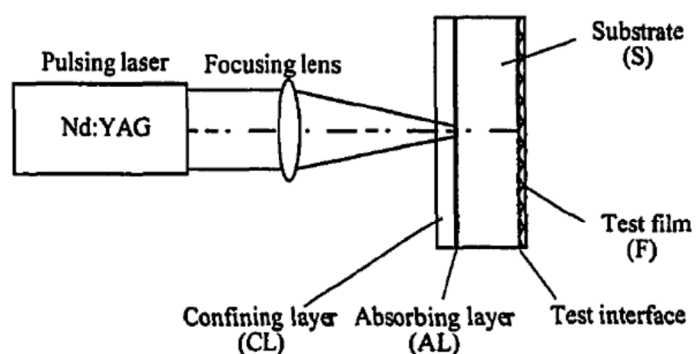


Figure 2.1: Schematic of the tensile laser-spallation technique.

Wang investigated fused silica and silicon as substrate materials, with aluminum layers used as both the test film and absorbing layer. Ex-1005, 45. A large number of tests were performed to investigate the effects of laser power and substrate, film, and confining layer thickness. *Id.*, 46-81. Wang identified a laser-induced weak shock formation in fused silica. *Id.*, 62-66. Specifically, “[a]n initial fall time of a few nanoseconds has therefore been **reduced to nearly zero** and occurs long before the pulse arrives at the test film.” *Id.*, 65. A “**decompression shock**” occurred that “is especially beneficial for tensile thin film tests, where the optimal compressive pulse ought to have a rapid fall time.” *Id.*, 65-66, 81, 120 (“The existence of a shock created a large stress at the film interface, promoting failure.”).

Wang determined that “fused silica is found to be an ideal substrate material for launching high-amplitude shock waves (its negative nonlinear elasticity being critical for the development of a decompression shock).” *Id.*, 124. “By inserting an

extra layer of the desired substrate material between the fused silica and the thin film, the current technique can be used to test a variety of substrates and thin films.”

Id.

B. Gupta-1992 (Ex-1011)

Dr. Hsieh-Yee explains on the basis of evidence (*e.g.*, bibliographic records) that Gupta-1992 was accessible to the public no later than January 9, 1992. Ex-1006, ¶¶83-95. Gupta-1992 is prior art under §102(b).

Gupta-1992 relates to tensile laser spallation techniques for measuring thin-film adhesion and is in the same field of endeavor and reasonably pertinent to the problem addressed by the '684 Patent. Ex-1011, Abstract; Ex-1003, ¶¶79-82. Gupta-1992 discloses that laser spallation is a “technique [that] can be used to determine the strength of planar interfaces between **coatings** (>0.3 μm in thickness) **and substrates in general.**” Ex-1011, 142. Gupta-1992 discloses a technique wherein “a laser pulse of a high enough energy and a pre-determined duration is converted into a pressure pulse of a critical amplitude and width that is sent through the substrate toward the free surface with the coating.” *Id.*, Abstract. The reflected tensile wave from the surface with the coating pries-off (*e.g.*, spalls) the coating. *Id.*, Abstract, Fig. 1.

Gupta-1992 discloses application of the technique to different substrates—Si single crystal wafers, pyrolytic graphite (PG) platelets, and Pitch-55 (P-55) type

carbon ribbons. *Id.*, 163-169. Gupta-1992 discloses two different sample configurations for the experiments, as shown in Figure 2, including a layer of fused quartz in addition to the substrate (*id.*, 145):

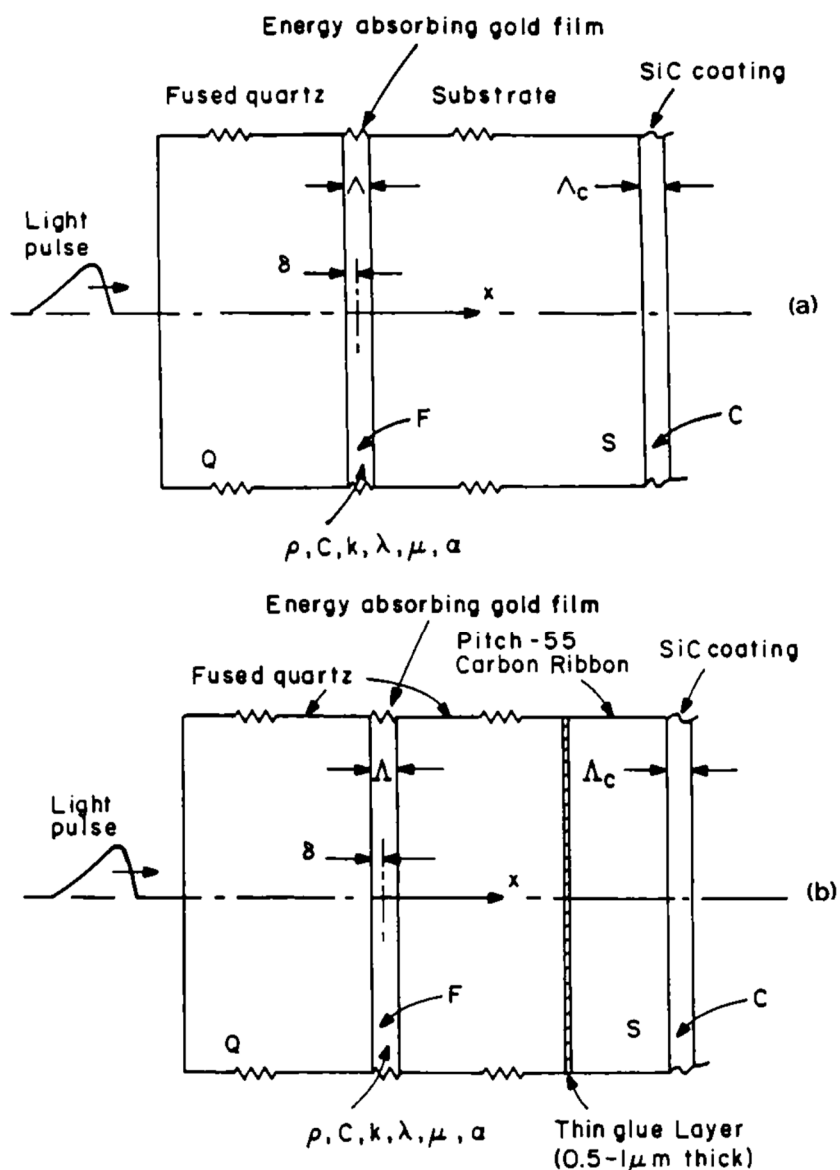


FIG. 2. (a) Configuration of the laser spallation probe with a homogeneous substrate. (b) Configuration for testing the Pitch-55 Ribbon/SiC system.

C. Gupta-1993 (Ex-1013)

Dr. Hsieh-Yee explains on the basis of evidence (*e.g.*, bibliographic records) that Gupta-1993 was accessible to the public no later than August 25, 1993. Ex-1006, ¶¶108-119. Gupta-1993 is prior art under §102(b).

Gupta-1993 relates to tensile laser spallation techniques for measuring thin-film adhesion and is in the same field of endeavor and reasonably pertinent to the problem addressed by the '684 Patent. Ex-1013, Abstract; Ex-1003, ¶83. Gupta-1993 is a part of a three-series experimental optimization of the laser spallation technique. Ex-1013, Abstract. Part III of the optimization focused on changing the type and thickness of the laser-absorbing film and the constraining medium. *Id.*, 2405. Fused quartz, free-standing water, and waterglass were tested as constraining materials. *Id.*, 2405-10.

D. Wang-2002 (Ex-1016)

Dr. Hsieh-Yee explains on the basis of evidence (*e.g.*, bibliographic records) Wang-2002 was accessible to the public no later than April 8, 2002. Ex-1006, ¶¶138-148. Wang-2002 is prior art under §102(b).

Wang-2002 relates to tensile laser spallation techniques for measuring thin-film adhesion and is in the same field of endeavor and reasonably pertinent to the problem addressed by the '684 Patent. Ex-1016, Abstract; Ex-1003, ¶¶84-87. Wang-

2002 discloses a study of laser-induced thin-film spallation. Ex-1016, Abstract. A schematic of Wang-2002's laser spallation apparatus is shown in Figure 1 (*id.*, 76):

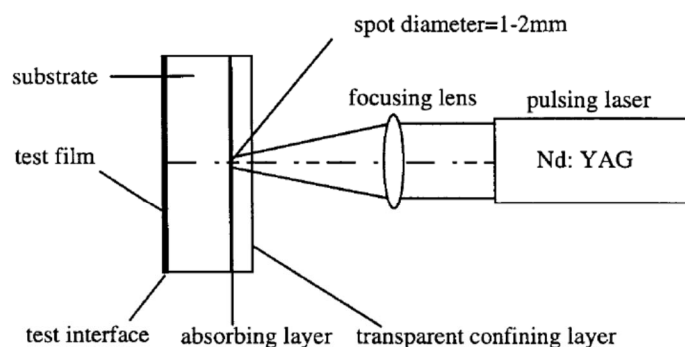


Fig. 1—Schematic of laser spallation technique: absorbing layer thicknesses are typically between $0.4 - 1.0 \mu\text{m}$, test film thicknesses are between $0.6 - 3.0 \mu\text{m}$ and the substrate has a thickness between $400 - 6000 \mu\text{m}$

Two different substrate materials, silicon and fused silica, were considered. Ex-1016, Abstract. The spallation of aluminum thin-film coatings was investigated as a function of substrate and film thickness, laser energy and various parameters governing the source. *Id.* Wang-2002 determined that the maximum stress at the interface increases with increasing laser fluence, and in some conditions, is large enough to damage the silicon. *Id.* Wang-2002 found “of particular significance” the development of a “**decompression shock**” in the fused silica substrates, which resulted in “very high tensile stresses at the interface” and “enhances the failure of thin film interfaces.” *Id.*

VIII. ASSERTED UNPATENTABILITY GROUNDS

A. Ground 1 – Claims 1-22 Are Anticipated By Wang-Dissertation

1. Claim 1

a. [1.pre] “An apparatus for generating a tensile stress between a substrate and a coating”

To the extent the preamble is limiting, Wang-Dissertation discloses the preamble. Ex-1003, ¶¶89-92.

Wang discloses a tensile spallation experiment to measure thin-film adhesion. Ex-1005, 40-81; Section VII.A. Figure 2.1 shows a schematic of Wang’s tensile laser spallation apparatus:

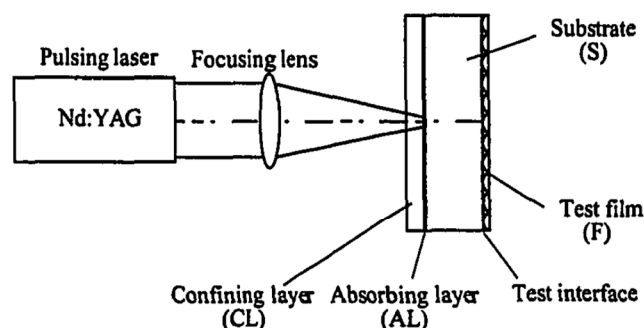


Figure 2.1: Schematic of the tensile laser-spallation technique.

The thin-film sample consists of a confining layer (CL), an energy absorbing layer (AL), a substrate (S), and test film (F) (“coating”). Ex-1005, 7-8. Fused silica and silicon substrates were investigated and aluminum films were either evaporated or sputtered onto both sides of the substrate. *Id.*, 45. A Nd:YAG laser pulse is incident on the aluminum absorbing layer sandwiched between the confining layer

and the substrate to create a stress wave. *Id.*, 8. The wave propagates toward the film/substrate interface and is reflected back from the film into a tensile wave, which then loads the test interface in tension (“generating tensile stress between a substrate and a coating”). *Id.*

b. [1.a] “a substrate having a thickness, said thickness defined by a first side and a second side in a first axis”

Wang-Dissertation discloses limitation [1.a]. Ex-1003, ¶¶93-96.

Figure 2.1 (annotated below) shows the thin-film sample is sequentially spaced along a first axis. *Id.*, ¶94; Ex-1005, Fig. 2.1. A substrate having a thickness is shown, with the thickness defined by a first side and a second side in the first axis (Ex-1003, ¶94):

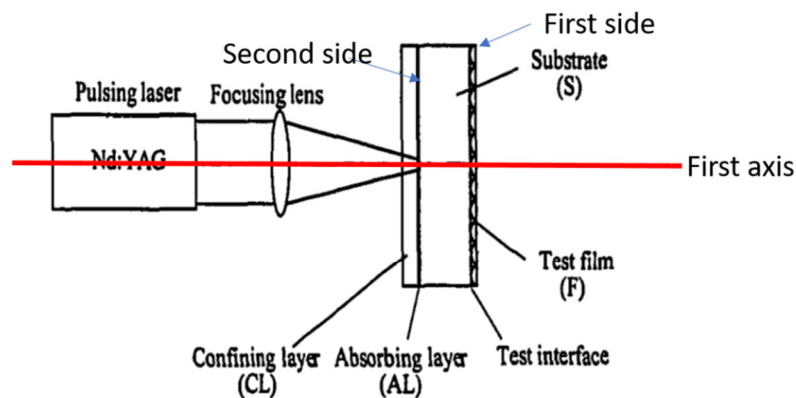


Figure 2.1: Schematic of the tensile laser-spallation technique.

Fused silica and silicon substrates were investigated as the substrate material (“a substrate having a thickness, said thickness defined by a first side and a second side in a first axis”), including different thicknesses. Ex-1005, 45, 56-59.

Wang discloses that fused silica is “an ideal substrate material for launching high-amplitude shock waves (its negative nonlinear elasticity being critical for the development of a decompression shock).” *Id.*, 124. Wang further discloses inserting an extra layer of substrate material such as silicon (“a substrate having a thickness, said thickness defined by a first side and a second side in a first axis”) between the fused silica and the thin film to test a variety of substrates/thin films:

By inserting an extra layer of the desired substrate material between the fused silica and the thin film, the current technique can be used to test a variety of substrates and thin films, especially those of interest to the microelectronics industry, such as polyimide, copper, aluminum and polysilicon on single-crystal silicon substrates.

Id.; Ex-1003, ¶¶95-96. A POSITA would have understood Wang’s desired substrate to have a thickness defined by a first side and second side in a first axis, as shown in the figures for silicon, also an identified desired substrate. *Id.*

- c. [1.b] **“a coating applied to the first side of the substrate such that the coating and substrate are axially spaced along the first axis in intimate facing contact with each other such to form a coating/substrate interface”**

Wang-Dissertation discloses limitation [1.b]. Ex-1003, ¶¶97-100.

Wang discloses using an aluminum film for both the absorbing layer and the test film (a “coating”). Ex-1005, 44-45. Wang discloses that an aluminum test film was either evaporated or sputtered onto the first side of the substrate, *id.*, as shown in Figure 3.2:

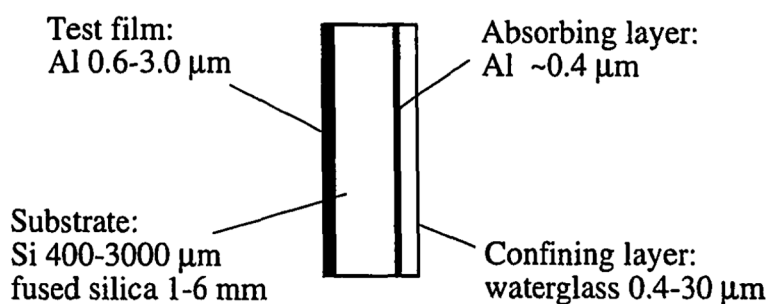


Figure 3.2: Schematic of thin film sample for spallation experiment.

The test film is shown applied to the first side of the substrate such that the coating and substrate are axially spaced along the first axis in intimate facing contact and form a film/substrate interface (“coating/substrate interface”). Ex-1003, ¶98; *see also* Ex-1005, Fig. 2.1 (showing placement of the substrate and coating axially spaced along the first axis). The initial test film was 0.6-3 μm thick. *Id.*, 45.

Wang further discloses inserting an extra layer of substrate material (“substrate”) between the fused silica and the thin film (“a coating applied to the first side of the substrate such that the coating and substrate are axially spaced along the first axis in intimate facing contact with each other such to form a coating/substrate interface”) to test a variety of substrates/thin films. *Id.*, 124; Ex-1003, ¶¶99-100.

d. [1.c] “a glass element disposed on the second side of the substrate and axially spaced along the first axis”

Wang-Dissertation discloses limitation [1.c]. Ex-1003, ¶¶101-103.

Wang discloses that fused silica is “an ideal substrate material for launching high-amplitude shock waves (its negative nonlinear elasticity being critical for the

development of a decompression shock).” Ex-1005, 124. Wang discloses inserting an “extra layer of desired substrate material (“the substrate”) between the fused silica (“a glass element disposed on the second side of the substrate”) and the thin film (“a coating applied to the first side of the substrate”) to test a variety of substrates and thin films....” *Id.*; Ex-1003, ¶103. A POSITA would have understood in this disclosed configuration, the fused silica would be disposed on the second side of the substrate and axially spaced along the first axis, as shown in the figures. *Id.*

- e. [1.d] **“wherein the glass element is configured to propagate and modify a stress wave to the coating/substrate interface to generate a tensile stress between the substrate and the coating.”**

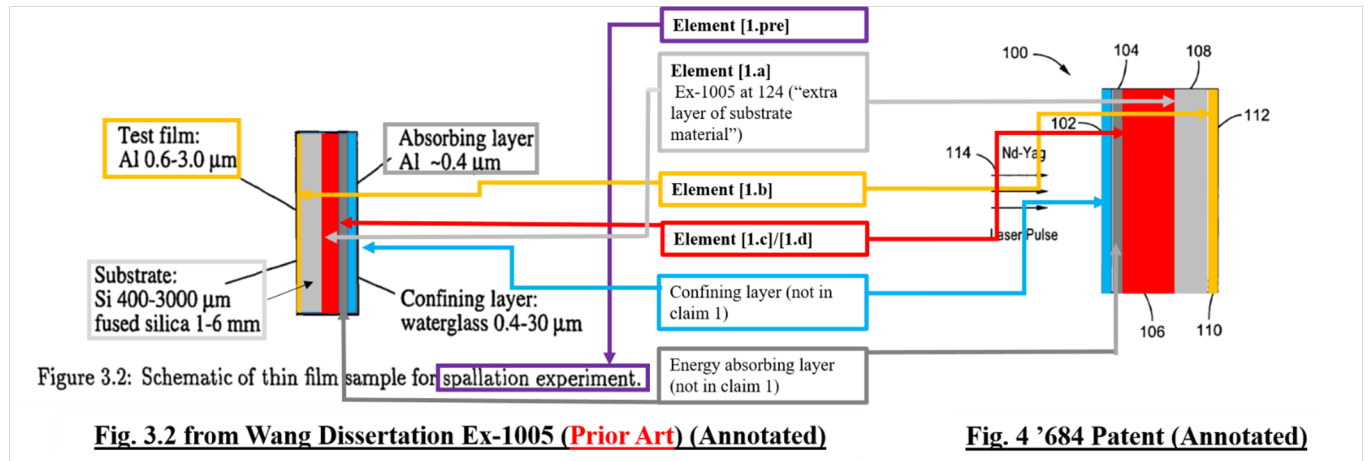
Wang-Dissertation discloses limitation [1.d]. Ex-1003, ¶¶104-112.

The ’684 Patent teaches it was known “for a given coating thickness the post-peak decay time is the most critical in maximizing the interfacial tensile stress.” Ex-1001, 8:43-45. If “post-peak decay time [of the stress wave] is reduced to zero, i.e. the wave profile has a ‘rarefaction shock,’ then the interface tensile stress for a film of arbitrarily small thickness will be equal to the amplitude of the incoming compression pulse.” *Id.*, 8:45-49. During prosecution, a claimed glass-propagated and modified stress wave was identified as the creation of a **“rarefaction shock.”** Ex-1002, 44-45, 80; Ex-1003, ¶¶68-72. The ’684 Patent states that all tested glass substrates “showed the formation of the rarefaction shock.” Ex-1001, 9:47-49.

Wang discloses in fused silica, the initial stress pulse generated at the absorbing layer evolves into a shock after traveling a short distance. Ex-1005, 30, 38, 65, 81. Wang discloses that fused silica is “an ideal substrate material for launching high-amplitude shock waves (its negative nonlinear elasticity being critical for the development of a decompression shock).” *Id.*, 124. A POSITA would have understood that fused silica propagates a shock wave and forms a “decompression shock” or “rarefaction shock.” Ex-1003, ¶¶108-09. Wang expressly discloses that fused silica was chosen for investigation because there was known evidence of formation of “**rarefaction**” shocks. Ex-1005, 26; Ex-1021.

Wang discloses, like the '684 Patent, this decompression shock is “especially beneficial for tensile thin film tests.” Ex-1005, 66, 81; Ex-1001, 8:45-51; Ex-1003, ¶110. Wang’s fused silica (“the glass element”) is configured to propagate and modify a stress wave to the coating/substrate interface to generate a tensile stress between the substrate and the coating. Ex-1005, 120 (“This shock mechanism was advantageous for failing thin-film interfaces on thick substrates.”); Ex-1003, ¶110.

Figure 3.2 (annotated) shows how Wang anticipates Claim 1:



Shown in blue is the confining (*i.e.*, constraining) layer, dark gray is the energy absorbing film, red is the glass element, light gray is the substrate, and the orange layer is the coating. Ex-1005, Fig. 3.2, 124; Ex-1001, 8:52-67; Ex-1003, ¶¶111-12.

2. Claim 2

Wang-Dissertation discloses “wherein the tensile strength is configured to separate the coating from the substrate at the coating/substrate interface.” Ex-1003, ¶113. Wang discloses that the decompression shock created a large tensile stress at the substrate/film interface, promoting failure to separate the coating from the substrate. Ex-1005, 120; *see also* 42 (“The laser energy is increased until a longitudinal wave is generated with an amplitude sufficient to fail the film/substrate interface.”).

3. Claim 3

Wang-Dissertation discloses “wherein the glass is configured to propagate the stress wave as a result of impingement by a Nd:Yag laser beam directed to the first axis.” Ex-1003, ¶114. This is shown in Figure 2.1 (annotated):

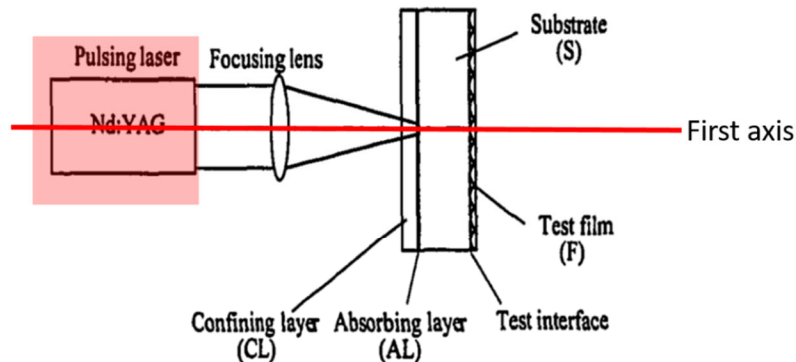


Figure 2.1: Schematic of the tensile laser-spallation technique.

Id.; Ex-1005, 7. Wang discloses a Nd:YAG laser pulse is incident on the metallic absorbing layer sandwiched between the waterglass and the substrate. *Id.*, 8. Wang thus discloses the propagation of the stress wave by the fused silica (the “glass”) as a result of the Nd:YAG laser impingement shown in Figure 2.1. *See id.*, 8, 124.

4. Claim 4

Wang-Dissertation discloses “wherein the stress wave has a length ranging from approximately 5 nanoseconds to approximately 1 microsecond.” Ex-1003, ¶¶115-17. Wang discloses stress waves between 10 to 30 nanoseconds (ns), depending on the duration of the laser pulse used and the substrate material. Ex-1005, 19, 62 (“The fringes develop over 20 to 30 ns in fused silica, whereas in

silicon, the full waveform was confined to a duration of about 10 ns comparable to the duration of the laser pulse”). These points fall within the claimed range.⁶ Ex-1003, ¶¶115-17.

5. Claim 5

Wang-Dissertation discloses “wherein the stress wave comprises a rarefaction shock formation.” Ex-1003, ¶118. Wang discloses there was known evidence of “**rarefaction**” shock formation in fused silica. Ex-1005, 26. Wang discloses fused silica is “an ideal substrate material for launching high-amplitude shock waves (its negative nonlinear elasticity being critical for the development of a decompression shock).” *Id.*, 124; *see also* 65, 81. A POSITA would have understood Wang’s “decompression shock” to be the claimed “rarefaction shock” as these terms are interchangeable. Ex-1003, ¶¶108-09.

⁶ *See Fresenius-Kabi USA LLC v. Cubist Pharma., Inc.*, IPR2015-00227, Paper 13 at 9-10 (May 14, 2015) (range of 1.4 mg/kg to 14 mg/kg anticipates claimed range of 3 to 75 mg/kg); *Ineos USA LLC v. Berry Plastics Corp.*, 783 F.3d 865, 869 (Fed. Cir. 2015) (“When a patent claims a range ... that range is anticipated by a prior art reference if the reference discloses a point within the range.”).

6. Claim 6

Wang-Dissertation discloses “wherein the coating has a thickness of less than approximately 0.5 μ m.” Ex-1003, ¶¶119-21. Wang discloses the aluminum test film (“coating”) for the spallation experiments was 0.6-3 μ m thick. Ex-1005, 45. Wang further discloses testing different film thicknesses of 0.3 μ m on the fused-silica substrate and 0.4 μ m for the silicon substrate. *Id.*, 53-56. These specific coating thicknesses fall within the claim. Ex-1003, ¶¶119-21.

7. Claim 7

Wang-Dissertation discloses “wherein the glass element is bonded to the second side of the substrate.” Ex-1003, ¶¶122-23.

A POSITA would have understood that to insert an extra layer of the desired substrate material between the fused silica (“the second side of the substrate”) and the thin film as taught by Wang (Ex-1005, 124), the fused silica (the “glass element”) would have to be bonded to the second side of the substrate, as there can be no air gap between the fused silica and the substrate. Ex-1003, ¶123.

8. Claim 8

Wang-Dissertation discloses “wherein the glass element comprises one of the following: Pyrex, soda lime, quartz, or borosilicate.” Ex-1003, ¶124. A POSITA would have understood fused silica (the “glass element”) is quartz (*e.g.*, SiO₂) or

quartz derivatives (*e.g.*, sodium silicate) in the context of this technology and exhibits the same properties in a laser spallation technique. *See id.*

9. Claim 9

Wang-Dissertation discloses “wherein the glass element has a thickness ranging from approximately 0.1mm and approximately 5mm.” Ex-1003, ¶125. Wang discloses testing different thicknesses of fused silica, including 1500, 3000, and 6000µm, that fall within this claimed range of thickness. Ex-1005, 56-59; Ex-1003, ¶125.

10.Claim 10

Wang-Dissertation discloses “wherein the substrate comprises silicon.” Ex-1003, ¶126. Wang investigated silicon as a substrate material. Ex-1005, 45. Silicon is also disclosed as a desired substrate material for the substrate/thin film interface with the fused silica. *Id.*, 124, Fig. 3.2; Ex-1003, ¶126.

11.Claim 11

Wang-Dissertation discloses “[a]n apparatus as recited in claim 1, further comprising a constraining element disposed adjacent to the glass element.” Ex-1003, ¶¶127-28. Wang’s thin-film sample is shown in Figure 3.2, with a confining layer of waterglass (“constraining element”) disposed adjacent to the fused silica (“glass element”):

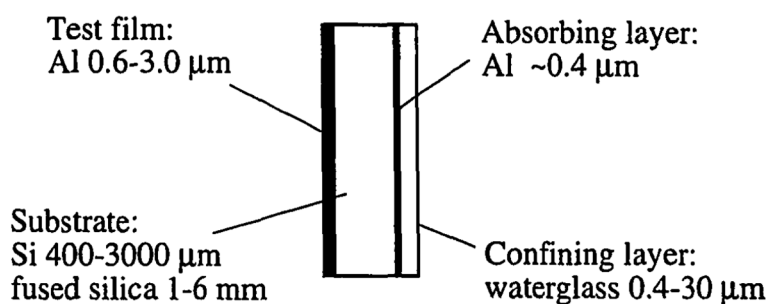


Figure 3.2: Schematic of thin film sample for spallation experiment.

Ex-1005, 44-45; *see also* 124 (disclosing using an additional substrate layer).

12.Claim 12

Wang-Dissertation discloses “[a]n apparatus as recited in claim 1, further comprising an energy absorbing layer disposed between the constraining layer and glass element.” Ex-1003, ¶¶129-130. As shown for Claim 11 *supra*, Figure 3.2 discloses an aluminum energy absorbing layer disposed between the waterglass constraining layer and the fused silica (“glass element”). Ex-1005, 44-45.

13.Claim 13

- a. [13.pre] “A method for separating a coating from a substrate, the substrate having a first side and a second side transversely disposed in a first axis, the coating applied to the first side of the substrate such that the coating and substrate are axially spaced along the first axis in intimate facing contact to form a coating/substrate interface, the method comprising:”

To the extent the preamble is limiting, Wang-Dissertation discloses the preamble. Ex-1003, ¶¶131-32.

As discussed for limitations [1.pre], [1.a], and Claim 2 *supra*, Wang discloses a method for separating a test film (“a coating”) from a substrate with a first and second side transversely disposed in a first axis, with the coating applied to a first side of the substrate such that the coating and substrate are axially spaced along the first axis in intimate facing contact, by sputtering an aluminum film on the free side of the substrate to form a film/substrate interface. Ex-1005, 7-8, 44-45, 124, Fig. 2.1, Fig. 3.2; Section VII.A.

b. [13.a] “positioning a glass element along the first axis on the second side of the substrate”

Wang-Dissertation discloses limitation [13.a]. Ex-1003, ¶¶133-34.

Wang discloses a sample including a confining layer, absorbing layer, fused silica substrate, and thin-film coating. Ex-1005, Fig. 3.2. Wang discloses inserting an extra layer of desired substrate material between the fused silica (“a glass element”) and thin film, positioning the fused silica glass element on the second side of the substrate (opposite side of the thin-film coating, with the desired substrate in between). *See id.*, 124; Ex-1003, ¶134.

c. [13.b] “directing a laser pulse in the first axis at the glass element”

Wang-Dissertation discloses limitation [13.b] for at least the reasons presented for Claim 3 *supra*. Ex-1003, ¶135.

d. [13.c] propagating and modifying a stress wave through the glass element to the coating/substrate interface to generate a tensile force between the substrate and the coating; and

Wang-Dissertation discloses limitation [13.c]. Ex-1003, ¶¶136-37.

As discussed for limitation [1.d] *supra*, Wang discloses using fused silica to propagate and modify a stress wave through the “glass element” into a rarefaction shock to generate a tensile stress (“tensile force”) between the substrate and the thin-film coating. *See* Ex-1005, 124; Ex-1003, ¶¶104-112.

e. [13.d] “separating the coating from the substrate as a result of the stress wave-generated tensile force.”

Wang-Dissertation discloses limitation [13.d] for at least the reasons presented for Claim 2 *supra*. Ex-1003, ¶138.

14.Claim 14

Wang-Dissertation discloses “wherein directing a laser pulse in the first axis comprises directing a Nd-Yag laser beam in the first axis” for at least the reasons presented for Claim 3 *supra*. Ex-1003, ¶139.

15.Claim 15

Wang-Dissertation discloses “wherein propagating a stress wave comprises propagating a stress wave having a length ranging from approximately 5 nanoseconds to approximately 1 microsecond” for at least the reasons presented for Claim 4 *supra*. Ex-1003, ¶140.

16. Claim 16

Wang-Dissertation discloses “wherein the stress wave comprises a rarefaction shock formation” for at least the reasons presented for Claim 5 *supra*. Ex-1003, ¶¶141-42.

17.Claim 17

Wang-Dissertation discloses “wherein the stress wave is configured to separate a coating having a thickness less than approximately 0.5µm” for at least the reasons presented for Claim 6 *supra*. Ex-1003, ¶¶143-45.

18.Claim 18

Wang-Dissertation discloses “wherein positioning a glass element along the first axis comprises bonding the glass element to the second side of the substrate” for at least the reasons presented for Claim 7 *supra*. Ex-1003, ¶146.

19.Claim 19

Wang-Dissertation discloses “wherein the glass element comprises one of the following: Pyrex, soda lime, quartz, or borosilicate” for at least the reasons presented for Claim 8 *supra*. Ex-1003, ¶147.

20.Claim 20

Wang-Dissertation discloses “wherein the glass element has a thickness ranging from approximately 0.1 mm to approximately 5 mm” for at least the reasons presented for Claim 9 *supra*. Ex-1003, ¶148.

21.Claim 21

Wang-Dissertation discloses “[a] method as recited in claim 13, further comprising positioning a constraining element adjacent to a free side of the glass element” for at least the reasons presented for Claim 11 *supra*. Figure 3.1 shows the waterglass adjacent to the free side of the glass element (opposite the substrate/film layer). Ex-1003, ¶149; Ex-1005, Fig. 3.1.

22.Claim 22

Wang-Dissertation discloses “[a] method as recited in claim 21, further comprising: coating an energy absorbing layer on the free side of the glass element between the constraining layer and the glass element; wherein directing a laser pulse in the first axis comprises directing the laser pulse the energy absorbing layer coated on the glass element.” Ex-1003, ¶¶150-52; *see* Claim 12 *supra*; Ex-1005, 45 (aluminum energy absorbing layer is coated on fused silica), Fig. 2.1 (directing a laser pulse to the energy absorbing layer coated on the fused silica (“glass element”)), Fig. 3.2 (showing the energy absorbing layer coated on the free side of the fused silica between a confining layer (“constraining layer”) and the fused silica).

B. Ground 2 – Wang-Dissertation Renders Obvious Claims 4, 6, 9, 15, 17, 20, 23-24

1. Claims 4, 6, 9, 15, 17, 20

As discussed *supra*, Wang-Dissertation discloses specific points within the ranges of these dependent claims. *See* Section VIII.A. To the extent PO argues these

points do not anticipate these claims, these claims are rendered obvious in view of the same disclosures because they at least overlap with the claimed ranges and the '684 Patent does not disclose that any claimed range is critical to the operability of the invention.⁷ Ex-1003, ¶¶153, 160.

In addition, Wang teaches successful investigation of different film and fused silica thicknesses to optimize the desired result of spallation and to achieve different stress wave lengths and the claimed rarefaction shock, all within the claimed ranges. *See* Section VIII.A. It also would have been within the skill and ordinary creativity of a POSITA to test different thicknesses and optimize Wang's configuration with the extra substrate layer (Ex-1005, 124) to spall thin films, including optimizing the thickness of the glass element and thin film and stress wave lengths, within the claimed ranges.⁸ Ex-1003, ¶¶154-160; *see also infra* Claims 23-24.

⁷ *See UCB, Inc. v. Actavis Lab'ys UT, Inc.*, 65 F.4th 679, 687-90 (Fed. Cir. 2023).

⁸ "Where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." *In re Applied Materials, Inc.*, 692 F.3d 1289, 1295 (Fed. Cir. 2012). "When there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue

2. Claims 23-24

Wang-Dissertation in view of the knowledge of a POSITA discloses or suggests “wherein the stress generated by the stress wave at the coating/substrate interface exceeds approximately 1.0 GPa” and “wherein the stress generated by the stress wave at the coating/substrate interface exceeds approximately 2.0 GPa.” Ex-1003, ¶¶161-65.

Wang discloses that “the stress pulse propagating away from the interface is a copy of and is proportional to the impinging laser fluence $q(t)$.” Ex-1005, 19. $q(t)$ is defined by Equation (2.44), with its coefficient proportional to the maximum pulse energy. *Id.*, 18. Figure 2.7 shows the interfacial stress is also proportional to the pulse energy. *Id.*, 21-22. Thus, Wang discloses that the stress generated at the coating/substrate interface depends on the power of the laser source. Ex-1003, ¶162.

Though Wang did not expressly disclose an experimentally-observed stress generated by the stress wave in excess of approximately 1.0 or 2.0 GPa, these features would have been obvious to implement. A POSITA would have known how to vary the pulse energy to increase the stress generated at the coating/substrate interface, and would have been motivated to do so to fail different thin-film/substrate

the known options within his or her technical grasp.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

interfaces. Ex-1003, ¶163; Ex-1005, 42 (“The laser energy is increased until a longitudinal wave is generated with an amplitude sufficient to fail the film/substrate interface.”). It was known that peak stresses of gigapascals (GPa) could be developed using lasers. Ex-1007, 115; Ex-1020, Abstract. It was also known that high interface stress values, in the range of 3.7 to 10.5 GPa, could be reached for a Si/coating system. Ex-1011, Table 3.

It was within the skill and ordinary creativity of a POSITA to adjust the laser energy to achieve a stress exceeding approximately 1.0 or 2.0 GPa to induce failure in different coating/substrate interfaces, and a POSITA would have had a reasonable expectation of successfully implementing such stresses because they were well-known to be achieved in the art.⁹ Ex-1003, ¶165.

C. Ground 3 – Wang-Dissertation in View of Gupta-1992 Renders Obvious Claims 1-24

1. Claim 1¹⁰

a. Limitations [1.pre], [1.a]-[1.b], [1.d]

Wang-Dissertation discloses these limitations for at least the reasons set forth *supra* Sections VIII.A.1.a-c, e. Ex-1003, ¶166.

⁹ The '684 Patent does not provide how to achieve the claimed stresses nor does it describe these as critical features or parameters.

¹⁰ The language of the claims in Grounds 3-7 is presented above in Grounds 1-2.

b. Limitation [1.c]

Wang-Dissertation in view of Gupta-1992 discloses or suggests limitation [1.c]. Ex-1003, ¶¶167-74.

Wang discloses that laser spallation techniques were developed to test a wide-variety of different combinations of substrate/interfaces. Ex-1005, 4 (“This technique was used to measure the tensile strength of a wide variety of metal/ceramic interfaces, ceramic/ceramic interfaces thermal-barrier coatings, ice/metal interfaces and fiber/matrix interfaces.”) (discussing Gupta-1992). Wang tested two different substrates. *Id.*, 5 (“Two different substrate materials—single crystal silicon (100) and fused silica—were studied.”). Wang discloses that fused silica (“a glass element disposed on the second side of the substrate and axially spaced along the first axis”) is “an ideal material for studying the mechanics of the spallation test in that it is intrinsically strong” and the shock mechanism is advantageous for testing thin-film interface adhesion. *Id.*, 81. Wang further discloses “[b]y inserting an extra layer of the desired substrate material between the fused silica and the thin film, the current technique can be used to test a variety of substrates and thin films.” *Id.*, 124.

Based on these teachings, a POSITA would have understood that Wang discloses that a variety of substrate/coating interfaces could be studied with the fused silica. Ex-1003, ¶¶168-69. A POSITA would have envisaged a sample where a substrate/coating, such as silicon/aluminum, is positioned with the fused silica glass

element on the second side to allow the adhesion strength of the interface to be studied, and Wang discloses this claim limitation as shown *supra*.¹¹ *Id.*

To the extent PO argues that Wang does not disclose or suggest fused silica (“glass element”) on the second side of a substrate, it would have been obvious to a POSITA at the time of the invention to implement Wang’s fused silica glass element and sample configuration with a desired substrate as discussed in Gupta-1992. Ex-1003, ¶¶170-74. Gupta-1992 is directed to tensile laser spallation techniques for thin films (Ex-1011, Abstract), so a POSITA would have had reason to look to Gupta-1992’s teachings when implementing tensile laser spallation techniques and using fused silica to increase interfacial stress for testing thin films as taught by Wang. Ex-1003, ¶171.

A POSITA would have looked to Gupta-1992 for guidance as Gupta-1992 discloses using laser spallation techniques to test various substrate/film interfaces and discloses experiments for testing various substrates. Ex-1011, Abstract, 142 (“[T]he technique can be used to determine the strength of planer interfaces **between coatings** (>0.3 μm in thickness) **and substrates in general**”). Gupta-1992 shows bonding fused quartz to the second side of a desired substrate for testing. *Id.*, Fig.

¹¹ *Kennametal, Inc. v. Ingersoll Cutting Tool Co.*, 780 F.3d 1376, 1381 (Fed. Cir. 2015).

2(b). Wang discloses the same configuration for using fused silica to increase the interfacial failure in thin films and testing a variety of substrate/interfaces, by adding an extra layer of substrate. Ex-1005, 81, 124; Ex-1003, ¶172.

A POSITA would have been motivated to combine Wang's advantageous use of fused silica and disclosure of adding an extra layer of substrate to test a variety of substrate/coating interfaces (Ex-1005, 124) with Gupta-1992's disclosure of testing different substrates, to position fused silica on the second side of a desired substrate/coating interface, and with a reasonable expectation of success, as Figure 2(b) shows how to create a sample with fused silica on the second side of a desired substrate. Ex-1011, Fig. 2(b); Ex-1003, ¶¶173-74. This would have been a mere combination of known components and technologies, according to known methods, to produce predictable results. *Id.*; *KSR*, 550 U.S. at 416.

2. Claims 2-6, 8-12

Wang-Dissertation discloses these limitations for at least the reasons set forth *supra* Sections VIII.A.2-6, 8-12, VIII.B.1. Ex-1003, ¶175.

3. Claims 7, 18

Wang-Dissertation in view of Gupta-1992 discloses or suggests the limitations of Claims 7 and 18. Ex-1003, ¶¶176-81.

As discussed for Claim 7 *supra*, a POSITA would have understood that to add an extra layer of substrate as disclosed by Wang, it would need to be bonded to the

second side of the fused silica. *See id.*; Ex-1005, 124. For example, using glue or epoxy would have been a known, predictable option. *See* Ex-1003, ¶177; Ex-1005, 45; Ex-1031.

To the extent PO argues that Wang does not disclose or suggest the fused silica is bonded to the desired substrate, this would have been obvious to implement in Wang's configuration in view of Gupta-1992. Ex-1003, ¶¶178-81. As discussed *supra* for limitation [1.c], a POSITA would have had reason to look to Gupta-1992's teachings when implementing tensile laser spallation techniques and to use fused silica to increase interfacial stress for thin films as taught by Wang. *Id.* Gupta-1992 discloses fused quartz glued ("bonded") to the second side of a P-55 substrate. Ex-1011, Fig. 2(b).

It would have been obvious to apply the teachings of Gupta-1992 to Wang's configuration to glue the fused silica to a desired substrate and create the sample as shown in Gupta-1992's Figure 2(b). Ex-1003, ¶180. A POSITA would have been motivated to combine the teachings of Gupta-1992 and Wang as Gupta-1992 shows the same configuration disclosed in Wang (Ex-1005, 124; Ex-1011, Fig. 2(b)). Gupta-1992 shows a successful way in which a desired substrate can be bonded to fused silica, as a POSITA would have known is required to create Wang's configuration with an extra substrate layer. *Id.* (showing thin-glue layer between the fused quartz and substrate); Ex-1003, ¶¶180-81. This would have been a mere

combination of known components and technologies, according to known methods, to produce predictable results. *Id.*

4. Claim 13

a. Limitations [13.pre], [13.b]-[13.d]

Wang-Dissertation discloses these limitations for at least the reasons set forth *supra* Sections VIII.A.13.a, c-e; Ex-1003, ¶182.

b. Limitation [13.a]

Wang-Dissertation in combination with Gupta-1992 discloses or suggests limitation [13.a]. Ex-1003, ¶¶183-84.

As discussed for limitation [1.c] *supra*, to the extent PO argues Wang does not explicitly disclose that the fused silica is positioned along the axis on the second side of the substrate, such arrangement is implicitly disclosed because a POSITA would at once envisage the claimed arrangement or combination. To the extent PO argues otherwise, this would nevertheless have been obvious in view of Gupta-1992. *See* Limitation [1.c] *supra*.

5. Claims 14-17, 19-24

Wang-Dissertation discloses these limitations for at least the reasons set forth *supra* Sections VIII.A.14-17, 19-22, VIII.B.1-2; Ex-1003, ¶185.

D. Ground 4 – Claims 1-8, 10-19, 21-22 Are Anticipated By Gupta-1992

1. Claim 1

a. Limitation [1.pre]

To the extent the preamble is limiting, Gupta-1992 discloses the preamble.
Ex-1003, ¶¶186-89.

Gupta-1992 discloses a tensile spallation experiment to measure thin-film adhesion. Ex-1011, Abstract; Section VII.B. Figure 1 shows a schematic of Gupta-1992's tensile laser spallation experiment apparatus (Ex-1011, 142-43):

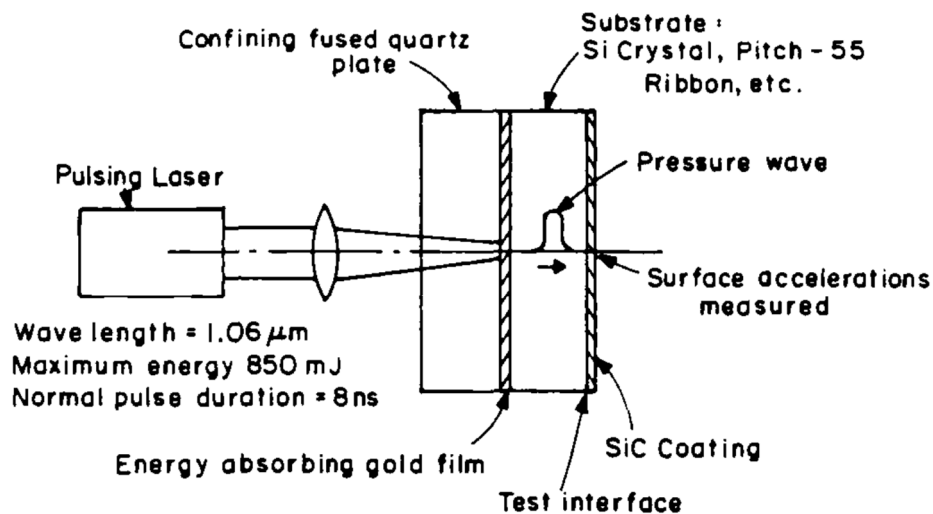


FIG. 1. Schematic view of the laser spallation experiment.

The sample consists of a confining fused quartz plate, an energy absorbing layer, a substrate, and an SiC coating. *Id.*, 144-45. Si crystal, pyrolytic graphite (PG) platelets, and Pitch-55-type (P-55) substrates were investigated. *Id.*, 163. A Nd:YAG laser pulse is incident on the metallic absorbing layer sandwiched between the confining layer and the substrate to create a stress wave. *Id.*, 142, 144. The wave

propagates toward the film/substrate interface and is reflected back from the film surface into a tensile wave, which then loads the test interface in tension (“generating tensile stress between a substrate and a coating”). *Id.*, 142.

b. Limitation [1.a]

Gupta-1992 discloses limitation [1.a]. Ex-1003, ¶¶190-91.

Gupta-1992 discloses that the laser spallation technique was applied to three substrates consisting of Si crystal wafers, PG platelets, and P-55-type carbon ribbons of 35μm thickness. Ex-1011, 163-64. Figure 2 shows two samples for the experiments. *Id.*, Fig. 2, 145. Figure 2(a) shows the configuration for the Si/SiC and PG/SiC substrate/coating systems, and Figure 2(b) shows the P-55/SiC system, with each substrate shown with a thickness defined by a first side and a second side in a first axis x:

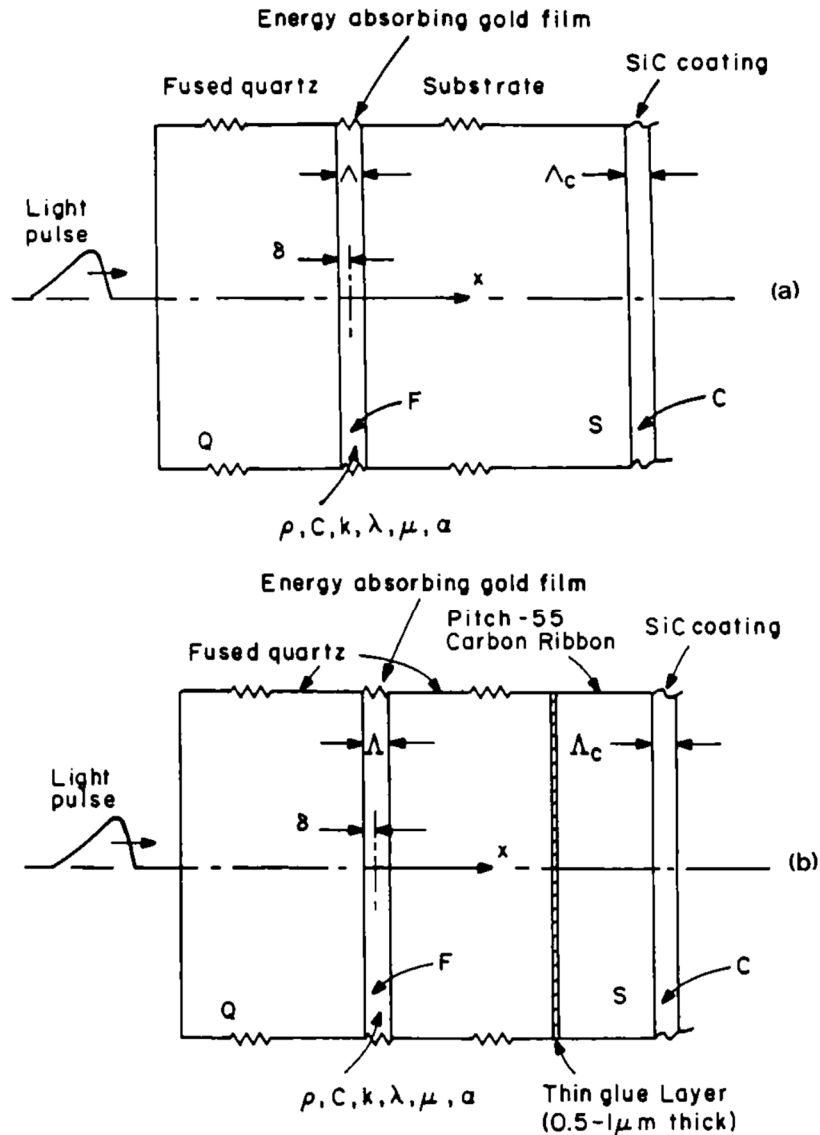


FIG. 2. (a) Configuration of the laser spallation probe with a homogeneous substrate. (b) Configuration for testing the Pitch-55 Ribbon/SiC system.

Id., Fig. 2; *see also* 144 (“Figure 2(a) shows schematically the configuration of the laser spallation probe consisting from left to right of: fused quartz confining plate (Q), the thin energy absorbing film (F) of thickness Λ , the substrate (S), and the coating (C) of interest of thickness Λ_c .”).

c. Limitation [1.b]

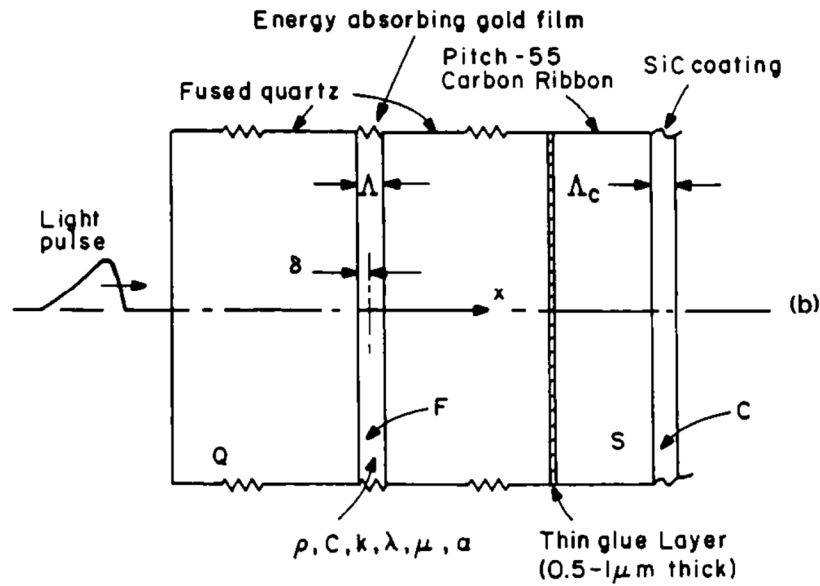
Gupta-1992 discloses limitation [1.b]. Ex-1003, ¶¶192-93.

As discussed for limitations [1.pre] and [1.a] *supra*, Gupta-1992 discloses an SiC coating applied to the first side of the different substrates. *See* Ex-1011, Fig. 1, 143 (“a test coating of interest applied to the front surface of the substrate”), 164 (“In all these cases, the coatings to be removed were amorphous SiC coatings prepared by the plasma assisted chemical vapor deposition technique.”). The coating is in intimate facing contact with the substrate to form a coating/surface interface. *Id.*, 165 (“The Si/SiC, PG/SiC interface systems were tested in an experimental configuration of the type shown in Fig. 2a, whereas for the P-55/SiC system, the configuration shown in Fig. 2b was employed”).

d. Limitation [1.c]

Gupta-1992 discloses limitation [1.c]. Ex-1003, ¶¶194-95.

As shown in Figure 2(b), an additional layer of fused quartz (“a glass element”) is glued to the second side of the P-55 substrate (“disposed on the second side of the substrate and axially spaced along the first axis”) (Ex-1011, Fig. 2(b); Ex-1003, ¶195):



e. Limitation [1.d]

Gupta-1992 discloses limitation [1.d]. Ex-1003, ¶¶196-200.

The configuration of Figure 2(b) and the glass element (the fused quartz glued to the P-55 substrate) in Gupta-1992 is the **exact same** as the configuration shown in Figure 4 of the '684 Patent:

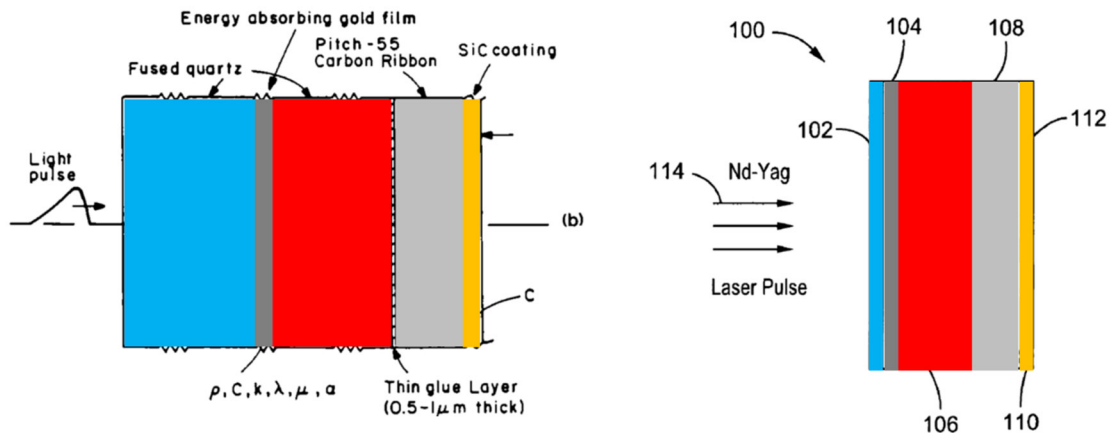


Figure 2(b) PRIOR ART (annotated)

Figure 4 CLAIMED INVENTION (annotated)

Shown in blue is the confining (*i.e.*, constraining) layer, dark gray is the energy absorbing film, red is the glass element, light gray is the substrate, and the orange layer is the coating. Ex-1011, Fig. 2(b), 144; Ex-1001, 8:52-67; Ex-1003, ¶197.

As shown above and explained by Dr. Wang, all structural limitations recited in Claim 1 are found in Gupta-1992. Ex-1003, ¶198. The same glass element (*i.e.*, quartz) and configuration are disclosed in Gupta-1992 as claimed in the '684 Patent, and Claim 1 does not require any additional specific conditions or configuration.¹² Moreover, it was a well-known property that glass elements such as fused silica (*i.e.*, quartz) propagate and modify a stress wave to cause a rarefaction shock in experimental laser techniques. *See* Ex-1021, Abstract (“The fused silica is very well characterized as a nonlinear elastic material having the interesting property of propagating stable rarefaction shock waves.”), Fig. 1 (experimental setup). The natural result of using a glass element, *i.e.* fused quartz, as shown in Figure 2(b) is the propagation and modification of the stress wave and formation of a rarefaction

¹² It is well-settled that the recitation of a new intended use for an old product does not make a claim to that old product patentable. *In re Spada*, 911 F.2d 705, 708 (Fed. Cir. 1990).

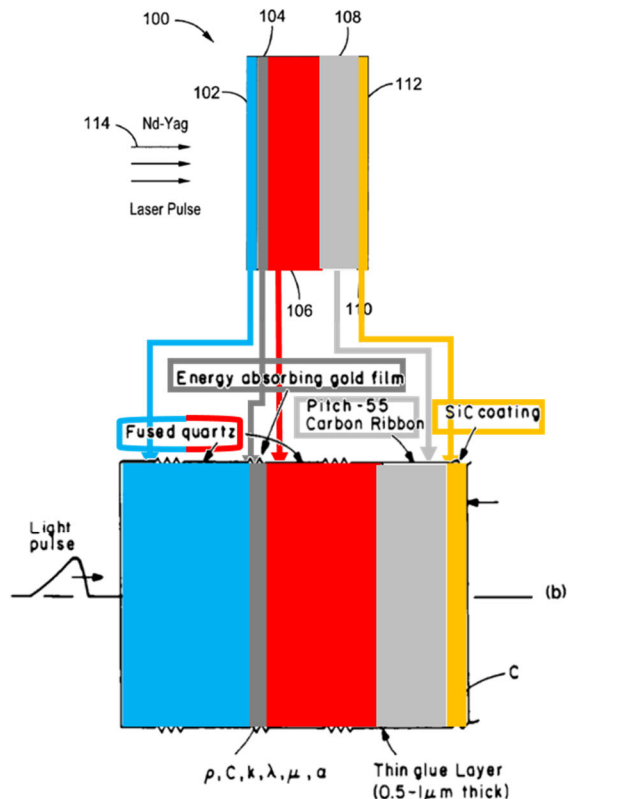
shock to generate a tensile stress between the substrate and the coating, and this element is inherently disclosed in Gupta-1992.¹³ Ex-1003, ¶199.

This application of fused quartz, *i.e.*, fused silica, to generate a rarefaction shock and tensile stress between a substrate and a coating was also known for use in laser spallation techniques prior to the '684 Patent. Ex-1003, ¶200; Exs-1014-1018. This existing, inherent property of a glass element to propagate and modify a stress wave, and for the specific application to generate tensile stress between a coating and substrate, was known and this element is inherently disclosed in Gupta-1992. This is further shown in the annotated figure below (Ex-1003, ¶200):

¹³ A limitation is inherent if it is the “natural result flowing from” the prior art’s explicit disclosure. *Arbutus Biopharma Corp. v. ModernaTX, Inc.*, 65 F.4th 656, 662 (Fed. Cir. 2023). To anticipate, the prior art need only meet the inherently disclosed limitation to the same extent as the patented invention. *King Pharms., Inc. v. Eon Labs, Inc.*, 616 F.3d 1267, 1276 (Fed. Cir. 2010). Gupta-1992 teaches the same laser spallation techniques as the '684 Patent. Ex-1011, Abstract, 144.

Fig. 4 from Patent (annotated)

Fig. 2(b) from Gupta 1992 Ex-1011
(Prior Art) (Annotated)



2. Claim 2

Gupta-1992 discloses the limitation of Claim 2. Ex-1003, ¶201. Gupta-1992 discloses that “a laser pulse of a high enough energy and a pre-determined duration is converted into a pressure pulse of a critical amplitude and width that is sent through the substrate toward the free surface with the coating” and “[t]he reflected tensile wave from the free surface of the coating pries-off the coating.” Ex-1011, Abstract, 165 (“The coating could be successfully spalled off in all cases with appropriate levels of laser pulse energies.”).

3. Claim 3

Gupta-1992 discloses the limitation of Claim 3. Ex-1003, ¶202. Gupta-1992 discloses that “[t]he laser pulse impinging on the energy absorbing film (gold) is generated by a Nd-YAG laser emitting at a wavelength of 1.06 μm .” Ex-1011, 144; Fig. 1 (showing the laser positioned in the first axis and directed at the glass element, *i.e.*, fused quartz in Fig. 2(b)).

4. Claim 4

Gupta-1992 discloses the limitation of Claim 4. Ex-1003, ¶¶203-04. Figure 7’s (Ex-1011, 153) x-axis shows normalized time and, based on the gold film thickness of 1 μm (*id.*, 152), wave speed $c=3230$ (*id.*, Table 2) and using Equations (6) and (7a), yields a stress wave of about 30 nanoseconds (ns). Figure 11 (*id.*, 157) shows that the stress wave lasts about 100ns. Figure 14 (*id.*, 163) also shows about 100ns in length for the stress wave. Figure 15 (*id.*, 164) shows that the major part of the experimentally measured stress wave to be about 30ns. These disclosed stress waves are within the claimed range. Ex-1003, ¶¶203-04.

5. Claim 5

Gupta-1992 discloses the limitation of Claim 5. Ex-1003, ¶205. As discussed in limitation [1.d] *supra*, it is a natural result and well-known that using fused silica, *i.e.*, quartz, as a “glass element” would produce a stress wave that comprises a rarefaction shock formation. *See id.*

6. Claim 6

Gupta-1992 discloses the limitation of Claim 6. Ex-1003, ¶206. Gupta-1992 states that the “laser spallation experiment has been developed to measure the strength of planar interfaces between a substrate and a thin coating (in the thickness range of 0.3-3 μ m).” Ex-1011, Abstract, Table 3 (showing SiC coating thickness of 0.3 μ m).

7. Claim 7

Gupta-1992 discloses the limitation of Claim 7. Ex-1003, ¶207. This is shown in Figure 2(b), where a “[t]hin glue layer (0.5-1 μ m thick)” between the fused quartz (“glass element”) and the P-55 substrate is shown. Ex-1001, Fig. 2(b).

8. Claim 8

Gupta-1992 discloses the limitation of Claim 8. Ex-1003, ¶208. Figure 2(b) shows fused quartz (“quartz”) positioned to the second side of the P-55 substrate (the “glass element”). Ex-1011, Fig. 2(b).

9. Claim 10

Gupta-1992 discloses the limitation of Claim 10. Ex-1003, ¶209. Gupta-1992 discloses a sample with a Si/SiC substrate/film interface and a laser spallation technique with interchangeable substrates. Ex-1011, Fig. 1 (identifying “Substrate Si Crystal, Pitch-55 Ribbon, etc.”), 165-67 (stating results for spallation experiment for a Si/SiC interface system); *see also* 142 (“[T]he technique can be used to

determine the strength of planar interfaces between coatings ($>0.3\mu\text{m}$ in thickness) and **substrates in general.**").

10.Claim 11

Gupta-1992 discloses the limitation of Claim 11. Ex-1003, ¶210. This is shown in Figure 2(b), where another layer of fused quartz ("constraining element" or "Q") is disposed adjacent to the other layer of fused quartz (on the free side of the "glass element"). Ex-1011, Fig. 2(b); *see also* Fig. 1 (identifying "confining fused quartz plate"), 144 (identifying "fused quartz confining plate (Q)").

11.Claim 12

Gupta-1992 discloses the limitation of Claim 12. Ex-1003, ¶211. This is shown in Figure 2(b), where an energy absorbing gold film (F) layer is disposed between the layer of fused quartz ("constraining element" or "Q") and the other layer of fused quartz (the "glass element"). Ex-1011, Fig. 2(b); *see also* Fig. 1 (identifying "energy absorbing gold film"), 144 (identifying "fused quartz confining plate (Q)").

12.Claim 13

a. Limitation [13.pre]

To the extent the preamble is limiting, Gupta-1992 discloses the preamble. Ex-1003, ¶¶212-13.

As discussed for limitations [1.pre], [1.a] and Claim 2 *supra*, Gupta-1992 discloses a method for separating a thin test film ("a coating") from substrates with

a first and second side transversely disposed in a first axis, with the coating applied to a first side of the substrate in intimate facing contact, by a plasma-assisted chemical vapor deposition technique, on the free side of the substrate to form a film/substrate interface. Ex-1011, Fig. 1, 142-44, 163-64; Section VII.B.

b. Limitation [13.a]

Gupta-1992 discloses limitation [13.a]. Ex-1003, ¶¶214-15.

As shown in Figure 2(b), fused quartz is used as the confining layer, but an additional layer of fused quartz (“a glass element”) is also glued and positioned to the second side of the P-55 substrate (“positioning a glass element along the first axis on the second side of the substrate”). Ex-1011, 145, Fig. 2(b).

c. Limitation [13.b]

Gupta-1992 discloses limitation [13.b] for at least the same reasons presented for Claim 3 *supra* and shown in Figure 1. Ex-1003, ¶216.

d. Limitation [13.c]

Gupta-1992 discloses limitation [13.c]. Ex-1003, ¶¶217-18.

As discussed for limitation [1.d] *supra*, all structural limitations recited in Claim 1 are found in Gupta-1992. Ex-1003, ¶¶196-200. This element is inherently disclosed in Gupta-1992.

e. Limitation [13.d]

Gupta-1992 discloses limitation [13.d] for at least the same reasons presented for Claim 2 *supra*. Ex-1003, ¶¶201, 219.

13.Claims 14-19, 21

Gupta-1992 discloses the limitations of Claims 14-19 and 21 for at least the same reasons presented above for corresponding dependent Claims 3-8 and 11 for this Ground. *Supra* Claims 3-8 and 11 (regarding Claims 14-19 and 21, respectively). Ex-1003, ¶220.

14.Claim 22

Gupta-1992 discloses the limitations of Claim 22. Ex-1003, ¶221; *see* Claim 12 *supra*; Ex-1011, Fig. 1 (showing directing a laser pulse to an aluminum energy absorbing layer coated on the fused quartz (“the glass element”)), Fig. 2(b) (showing the energy absorbing layer on the free side of the fused quartz between a confining layer (“the constraining layer”) and the fused quartz).

E. Ground 5 – Gupta-1992 in View of Gupta-1993 Renders Obvious Claims 9 and 20

Gupta-1992 alone or in view of Gupta-1993 discloses or suggests the limitations of Claims 9 and 20. Ex-1003, ¶¶222-24. Gupta-1992 shows the fused quartz (“the glass element”) on both sides of the energy absorbing layer. *See* Ex-1011, Fig. 2(b). Though Gupta-1992 does not disclose the exact thickness of the fused quartz glass elements shown in the figures, a POSITA working on laser

spallation techniques for thin-film adhesion, and building a sample like shown in Figure 2(b) of Gupta-1992, would have been motivated to test and optimize the glass element thickness. Ex-1003, ¶¶222-24. A POSITA would have known that the fused quartz forms an advantageous rarefaction shock in a laser spallation technique, and would have been motivated to test different thicknesses within the claimed range to successful spall thin films using Figure 2(b) as taught by Gupta-1992. *Id.*, ¶222-23.

A POSITA also would have been motivated to look to Gupta's other work to determine the thickness and optimize Figure 2(b) to successful spall thin films as taught by Gupta-1992. *Id.*, ¶224. Gupta-1993 refers to the assembly of Gupta-1992 and confirms the fused quartz was 3mm in thickness. Ex-1013, 2406, 2410. Gupta-1993 further discloses testing the influence of using different thicknesses of elements of the laser spallation setup, including different fused quartz thicknesses within the claimed range. *See generally* Ex-1013.

A POSITA would have recognized the thickness of the fused quartz as shown in Figure 2(b) to be a design parameter for the laser spallation experiment, and would have been motivated to test different thicknesses to optimize the technique to achieve the successful spallation disclosed in Gupta-1992 using Figure 2(b). Ex-1003, ¶¶224. It would have been within the skill and ordinary creativity of a POSITA to test different thicknesses of the fused quartz glass element in Gupta-1992's configuration

and obvious to start with the 3mm for the fused quartz disclosed in Gupta-1993 for the glass element, which is within the claimed range. *Id.*

F. Ground 6 – Gupta-1992 Renders Obvious Claims 4, 6, 10, 15, 17, 23-24

1. Claims 4, 6, 10, 15, 17

As discussed *supra* (Section VIII.D), Gupta-1992 discloses specific points within the claimed ranges of Claims 4, 6, 15 and 17. To the extent PO argues these points do not anticipate these claims, these claims are rendered obvious in view of the same disclosures because they at least overlap with the claimed ranges and the '684 Patent does not disclose that the claimed range is critical to the operability of the invention. Ex-1003, ¶225.

Moreover, Gupta-1992 teaches that for each substrate system tested “[t]he coating could be successfully spalled off in all cases with appropriate levels of laser pulse energies.” Ex-1011, 165. It would have been within the skill and ordinary creativity of a POSITA to test and achieve the range of stress wave lengths in Claims 4 and 15 to spall thin films using Figure 2(b). Ex-1003, ¶¶226-28. A POSITA would have been motivated to do so based on Gupta-1992’s teachings of success spalling thin films by adjusting the laser pulse and the known development of rarefaction shocks. *Id.*; *see also infra* Claims 23-24.

Gupta-1992 further discloses a sample with a Si/SiC substrate/film interface and a laser spallation technique with interchangeable substrates. Ex-1011, Fig. 1,

142. A POSITA would have had the skill and ordinary creativity to also utilize a silicon substrate in Figure 2(b)'s configuration as claimed in Claim 10, and would have been motivated to do so to test different substrate/interfaces. Ex-1003, ¶¶226-27, 229.

A POSITA would have known of the capability to test coatings in the range of 0.3-3 μ m (and Claims 6, 17) as Gupta-1992 states that his experiments can measure the strength of the interface in that range. Ex-1011, Abstract; Ex-1003, ¶230. Gupta-1992 teaches how SiC coatings in this range can be made on the configuration of Figure 2(a) (Ex-1011, 163-66) and a POSITA would have been motivated to test different coatings thicknesses and have a reasonable expectation of success using the coatings disclosed in Gupta-1992 with Figure 2(b). Ex-1003, ¶¶226-27, 230.

2. Claims 23-24

Gupta-1992 in view of a POSITA's knowledge discloses or suggests the limitations of Claims 23-24. Ex-1003, ¶¶231-33. Gupta-1992 discloses that "the stress itself is related to the time rate of production of thermal misfit, which in turn is proportional to the laser fluence in a pulse with a given duration." Ex-1011, 155-56. Gupta-1992 further discloses that in each substrate system tested "[t]he coating could be successfully spalled off in all cases with appropriate levels of laser pulse energies." *Id.*, 165. Thus, Gupta-1992 discloses that the stress generated at the

coating/substrate interface depends on the power of the laser source, and it can be adjusted to successfully spall off a coating for any system. Ex-1003, ¶231. Gupta-1992 discloses high interface stress values, in the range of 3.7 to 10.5 GPa for the Si/SiC system, and discloses these limitations. *Id.*; Ex-1011, 141, Table 3.

To the extent PO argues that Gupta-1992 does not disclose or suggest that the stress generated by the stress wave exceeds approximately 1.0 or 2.0 GPa for the configuration of Figure 2(b), these features would have been obvious to implement. A POSITA would have known how to vary the pulse energy to increase the stress generated at the coating/substrate interface and would have been motivated to do so to spall or fail different coating/substrate interfaces. Ex-1003, ¶232. It was known that peak stresses of gigapascals could be developed using lasers. *Id.*, ¶233; Ex-1007, 115; Ex-1020.

It was within the skill of a POSITA to adjust the laser energy to achieve a stress exceeding approximately 1.0 GPa or 2.0 GPa to induce failure in different coating/substrate interfaces, and a POSITA would have reasonably expected such an implementation to work successfully because such stress levels were well-known to be achieved in the art. Ex-1003, ¶233.

G. Ground 7 – Wang-2002 in View of Gupta-1992 Renders Obvious Claims 1-24

1. Claim 1

a. Limitation [1.pre]

To the extent the preamble is limiting, Wang-2002 discloses the preamble.
Ex-1003, ¶¶234-37.

Wang-2002 discloses a tensile spallation experiment to measure thin-film adhesion. Ex-1016, 75-77; Section VII.D. Figure 1 shows a schematic of Wang-2002's tensile laser spallation apparatus:

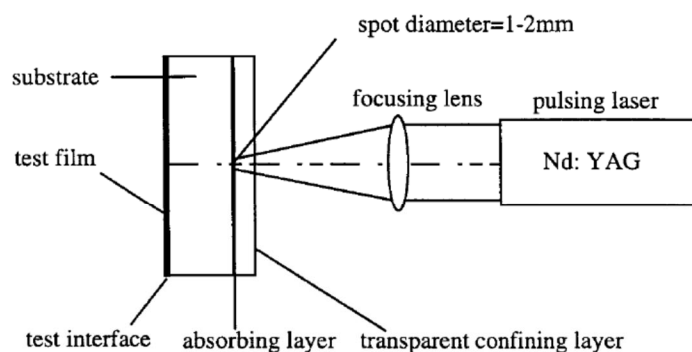


Fig. 1—Schematic of laser spallation technique: absorbing layer thicknesses are typically between 0.4 – 1.0 μm , test film thicknesses are between 0.6 – 3.0 μm and the substrate has a thickness between 400 – 6000 μm

The thin-film sample consists of a confining layer, an energy absorbing layer, a substrate, and test film (“coating”). Ex-1016, 75. Fused silica and silicon substrates were investigated and aluminum films were sputtered onto both sides of the substrate. *Id.*, Abstract, 76. A Nd:YAG laser pulse is incident on the aluminum absorbing layer sandwiched between the confining layer and the substrate to create a stress wave. *Id.*, 75, Fig. 1. The wave propagates toward the film/substrate interface

and is reflected back from the film surface into a tensile wave, which then loads the test interface in tension (“generating tensile stress between a substrate and a coating”). *Id.*

b. Limitation [1.a]

Wang-2002 discloses limitation [1.a]. Ex-1003, ¶¶238-39.

Figure 1 (annotated below) shows the thin-film sample is sequentially spaced along a first axis. *Id.*; Ex-1016, Fig. 1, Fig. 3. A substrate having a thickness is shown, with the thickness defined by a first side and a second side in the first axis (Ex-1003, ¶239):

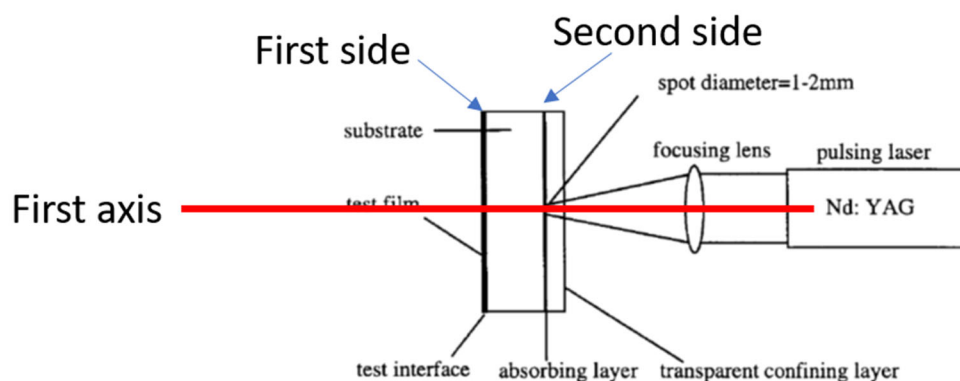


Fig. 1—Schematic of laser spallation technique: absorbing layer thicknesses are typically between 0.4 – 1.0 μm , test film thicknesses are between 0.6 – 3.0 μm and the substrate has a thickness between 400 – 6000 μm

Fused silica and silicon substrates were investigated, (Ex-1016, Abstract), including different thicknesses of the substrates. *E.g., id.*, 78-82.

c. Limitation [1.b]

Wang-2002 discloses limitation [1.b]. Ex-1003, ¶¶240-41.

Wang-2002 discloses using an aluminum film for both the absorbing layer and the test film (the “coating”). Ex-1016, 76. Wang-2002 discloses that an aluminum test film was sputtered onto the first side of the substrate. *Id.* This is shown in Figure 3:

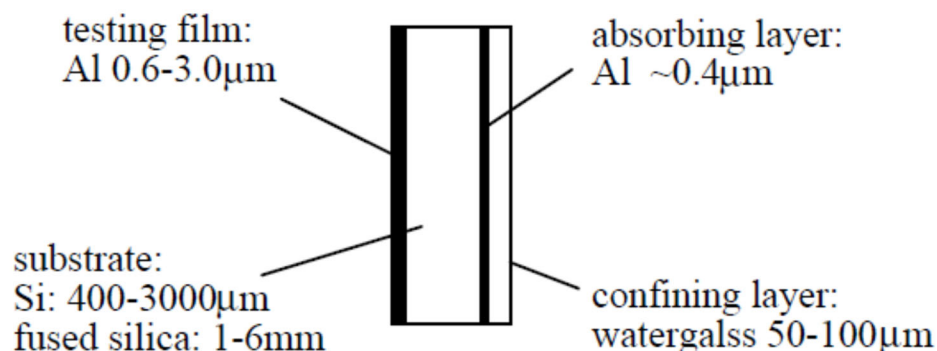


Fig. 3—Schematic of thin film sample for spallation experiment

The test film (“coating”) is shown applied to the first side of the substrate, including a silicon (Si) (“substrate”), such that the coating and the substrate are axially spaced along the first axis in intimate facing contact and form a film (“coating”)/substrate interface. Ex-1003, ¶241. The test film was 0.6-3 μ m thick. *Id.*, 77.

d. Limitation [1.c]

Wang-2002 in view of Gupta-1992 discloses or suggests limitation [1.c]. Ex-1003, ¶¶242-49.

Wang-2002 discloses that laser spallation techniques were developed to test a wide-variety of different combinations of substrate/interfaces. Ex-1016, 74-75

(“This technique was used to measure the tensile strength of a wide variety of metal/ceramic interfaces, and ceramic/ceramic interfaces with film thickness typically between 0.3-3 μm .”). Wang-2002 tested two different substrates. *Id.*, 75 (“Here we report on a series of spallation experiments for Al thin films on both (100) Si and fused silica substrates of varying thickness.”). Wang-2002 discloses that fused silica (“a glass element disposed on the second side of the substrate and axially spaced along the first axis”) is “an ideal material for studying the mechanics of the spallation test in that it is intrinsically strong” and the shock mechanism is advantageous for testing thin-film interface adhesion. *Id.*, 82.

Based on these teachings, a POSITA would have understood that Wang-2002 discloses that a variety of substrate/coating interfaces could be studied with the fused silica. *Id.*, Fig. 3; Ex-1003, ¶244. A POSITA would have envisaged a sample where the “substrate” (such as a silicon/coating interface) is positioned with the fused silica “glass element” on the second side to allow the adhesion strength of the interface to be studied, and Wang-2002 discloses this claim limitation. *Id.*

To the extent PO argues that Wang-2002 does not disclose or suggest fused silica (“a glass element”) on the second side of a substrate, it would have been obvious to implement Wang-2002’s fused silica glass element with a desired substrate as disclosed in Gupta-1992. Ex-1003, ¶¶245-249. Gupta-1992 is directed to tensile laser spallation techniques (Ex-1011, Abstract), so a POSITA would have

had reason to look to Gupta-1992's teachings when implementing tensile laser spallation technique and using fused silica to increase interfacial stress for thin films as taught by Wang-2002. Ex-1003, ¶¶246-47.

A POSITA would have looked to Gupta-1992 for guidance as Gupta-1992 discloses (as mentioned by Wang-2002, Ex-1016, 74) using laser spallation techniques to test various substrate/film interfaces and discloses experiments for testing various substrates. Ex-1011, Abstract, 142 (“[T]he technique can be used to determine the strength of planer interfaces **between coatings** (>0.3 μm in thickness) **and substrates in general**”). Gupta-1992 shows bonding fused quartz to the second side of a desired substrate for testing. *Id.*, Fig. 2(b). Wang-2002 discloses using fused silica to increase the interfacial failure in thin films in laser spallation techniques. Ex-1016, 82. Gupta-1992 and Wang-2002 disclose the same use of glass elements and substrates to test thin films. Ex-1003, ¶¶247-48.

A POSITA would have been motivated to combine Wang-2002's disclosure of the advantages of fused silica with Gupta-1992's disclosure of testing different substrates to position the fused silica on the second side of a desired substrate/coating interface, and with a reasonable expectation of success, as Gupta-1992 in Figure 2(b) shows how to create a sample with fused silica on the second side of a desired substrate. *Id.*; Ex-1011, Fig. 2(b); Ex-1016, Fig. 3. This would have

been a mere combination of known components and technologies, according to known methods, to produce predictable results. Ex-1003, ¶¶248-49.

e. Limitation [1.d]

Wang-2002 discloses limitation [1.d]. Ex-1003, ¶¶250-52.

Wang-2002 teaches “the development of decompression shock in fused silica substrates, which results in very high tensile stresses at the interface.” Ex-1016, Abstract. Rarefaction shocks in fused silica glass were known. *See id.*, 78 (citing Ex-1021). Wang-2002 discloses that in fused silica, the initial stress pulse generated at the absorbing layer evolves into a shock after traveling a short distance and “an initial fall time of a few nanoseconds has **reduced to zero.**” *Id.*, 78-80. A POSITA would have understood that the fused silica propagates a shock wave and a “decompression shock” to be a “rarefaction shock.” Ex-1003, ¶251.

Wang-2002 discloses, like the '684 Patent, that the fused silica (“glass element”) propagates and modifies the stress waves in tensile laser spallation experiments to generate a tensile stress between the substrate and coating. Ex-1016, 82 (“The existence of the shock created a large stress at the film interface, promoting failure.”); Ex-1003, ¶252.

2. Claim 2

Wang-2002 discloses the limitation of Claim 2. Ex-1003, ¶253. Wang-2002 discloses that a decompression shock in the fused silica substrate created a large

stress at the film interface, promoting failure to separate the coating from the substrate. Ex-1016, 82; *see also* Abstract (“This shock enhances the failure of thin film interfaces, especially in thicker samples.”); 75 (“The laser energy is increased until a longitudinal wave is generated with an amplitude sufficient to fail the film/substrate interface.”).

3. Claim 3

Wang-2002 discloses the limitation of Claim 3. Ex-1003, ¶254. This is shown in Figure 1 (annotated):

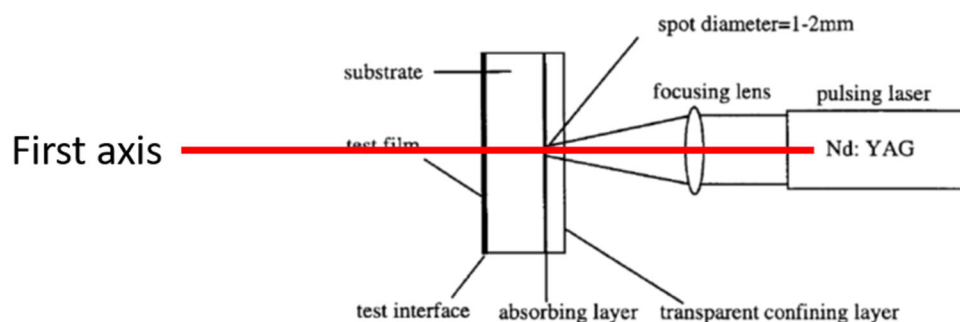


Fig. 1—Schematic of laser spallation technique: absorbing layer thicknesses are typically between 0.4 – 1.0 μm , test film thicknesses are between 0.6 – 3.0 μm and the substrate has a thickness between 400 – 6000 μm

Ex-1016, 76. Wang-2002 discloses an Nd:YAG laser pulse is incident on the metallic absorbing layer sandwiched between the confining layer and the substrate. *Id.*, 75. Wang-2002 thus discloses the propagation of the stress wave by the fused silica (“glass”) as a result of impingement by the Nd:YAG laser shown in Figure 1 directed in the first axis. *See id.*

4. Claim 4

Wang-2002 discloses the limitation of Claim 4. Ex-1003, ¶255-260. Wang-2002 discloses a stress wave between 10 to 30ns, which depends on the duration of the laser pulse used and the substrate material. Ex-1016, 78 (“The fringes develop over 20 to 30ns in fused silica, whereas in Si, the full waveform was confined to a duration of about 10ns comparable to the duration of the YAG pulse”). This falls within the claimed range. Ex-1003, ¶255.

To the extent PO argues these specific points do not disclose this limitation, this claim is obvious in view of the same disclosures because they at least overlap with the claimed ranges and the '684 Patent does not disclose that the claimed range is critical to the operability of the invention. Ex-1003, ¶256. In addition, Wang-2002 teaches successful investigations to achieve different stress wave lengths, all within the claimed ranges. Ex-1016, 78. It also would have been within the skill and ordinary creativity of a POSITA to achieve the claimed stress wave lengths and successfully spall thin films. Ex-1003, ¶¶257-60; *see also infra* Claims 23-24.

5. Claim 5

Wang-2002 discloses the limitation of Claim 5. Ex-1003, ¶261. Wang-2002 discloses a “decompression shock” was observed for all thicknesses of the fused silica. Ex-1016, 78, 81. Wang-2002 incorporates discussion of Barker (Ex-1021), which confirmed rarefaction shocks in fused silica. Ex-1016, 78, 82. A POSITA

would have understood that the fused silica propagates a shock wave and a “decompression shock” to be the claimed “rarefaction shock.” Ex-1003, ¶261.

6. Claim 6

Wang-2002 alone or in view of Gupta-1992 discloses or suggests the limitation of Claim 6. Ex-1003, ¶¶262-67. Wang discloses the test film (“coating”) for samples for the experiments was 0.6-3 μ m thick. Ex-1016, 77. To the extent PO argues these points do not disclose this claim, the claim is further rendered obvious in view of the same disclosures because they at least overlap with the claimed ranges and the ’684 Patent does not disclose that any claimed range is critical to the operability of the invention.¹⁴ Ex-1003, ¶¶262-63. In addition, Wang-2002 teaches successful investigations of different film thickness. *See* Ex-1016, 78. It also would have been within the skill and ordinary creativity of a POSITA to try different thin film <0.5 μ m thick. Ex-1003, ¶¶264-66.

It further would have been obvious to combine the teachings of Wang-2002 and Gupta-1992 to meet this limitation. Gupta-1992 states that the “laser spallation experiment has been developed to measure the strength of planar interfaces between

¹⁴ *See In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990) (finding a claimed range of “more than 5% to about 25% obvious in review of prior art that disclosed an abutting range of “about 1-5% carbon monoxide”).

a substrate and a thin coating (in the thickness range of 0.3-3 μm).” Ex-1011, Abstract. A POSITA would have turned to Gupta-1992 as discussed *supra* and would try thinner films ($<0.5\mu\text{m}$ thick) based on Gupta-1992’s disclosure of the claimed configuration Fig. 2(b) and teaching of successful testing of thinner coatings and Wang-2002’s teaching of the advantageous use of fused silica. Ex-1003, ¶267.

7. Claim 7

Wang-2002 in view of with Gupta-1992 discloses or suggest the limitation of Claim 7. Ex-1003, ¶¶268-69. Wang-2002 discloses that fused silica is “an ideal material for studying the mechanics of the spallation test.” Ex-1016, 82. A POSITA would have turned to Gupta-1992 as discussed *supra* for adding a desired substrate, and Gupta-1992 discloses fused quartz (the “glass element”) glued (“bonded”) to the second side of a P-55 substrate. Ex-1003, ¶268; Ex-1011, Fig. 2(b). It would have been obvious to apply the teachings of Gupta-1992 to bond a desired substrate to the fused silica and create the sample as shown in Gupta-1992’s Figure 2(b) for a tensile laser spallation technique. Ex-1003, ¶268.

A POSITA would have been motivated to combine the teachings of Gupta-1992 and Wang-2002 as Gupta-1992 shows a successful way in which a desired substrate can be bonded to fused silica. Ex-1011, Fig. 2(b) (showing thin glue layer between the fused quartz and P-55 substrate); Ex-1003, ¶269. This would have been

a mere combination of known components and technologies, according to known methods, to produce predictable results. *Id.*

8. Claim 8

Wang-2002 discloses the limitation of Claim 8. Ex-1003, ¶270. A POSITA would have understood that fused silica is the same as quartz in the context of laser spallation techniques and exhibits the same properties in a laser spallation technique. *See* Ex-1016, 75 (confirming testing of fused silica substrates).

9. Claim 9

Wang-2002 discloses the limitation of Claim 9. Ex-1003, ¶271-76. Wang-2002 discloses testing and using different thicknesses of fused silica, including 1531, 3063, and 6125 μm , that fall within this claimed range of thickness. Ex-1016, 81. To the extent PO argues these points do not disclose this limitation, the limitation is obvious in view of the same disclosures because they at least overlap with the claimed ranges and the '684 Patent does not disclose that any claimed range is critical to the operability of the invention. Ex-1003, ¶272.

In addition, Wang-2002 teaches successful investigation of different fused silica thicknesses to optimize the desired result of spallation, all within the claimed range. *Id.*, ¶¶273-76. It would have been within the skill and ordinary creativity of a POSITA to test different thicknesses and optimize the thickness of the glass element disclosed in Wang-2002 in the configuration shown in Gupta-1992's Figure 2(b). *Id.*

10.Claim 10

Wang-2002 alone or in view of Gupta-1992 discloses or suggests the limitation of Claim 10. Ex-1003, ¶277. Silicon is identified as a material that can be used as a substrate in Wang-2002. *Id.*; Ex-1016, 75 (confirming testing Si substrates of varying thicknesses), Fig. 3. To the extent Wang-2002 does not disclose this limitation, as discussed *supra* for limitation [1.c], a POSITA would have been motivated to add a desired substrate to Wang-2002's fused silica configuration based on the teachings of Gupta-1992, which teaches using silicon substrates. Ex-1003, ¶277; Ex-1011, 163 (confirming testing Si single wafer substrate). It would have been within the skill and ordinary creativity of a POSITA to utilize a silicon substrate as claimed in Claim 10 with Wang-2002's fused silica. Ex-1003, ¶277.

11.Claim 11

Wang-2002 discloses the limitation of Claim 11. Ex-1003, ¶278. Wang-2002's experimental thin-film sample is shown in Figure 3, with a confining layer of waterglass ("constraining element") disposed adjacent to the fused silica ("glass element") (Ex-1016, 75-77):

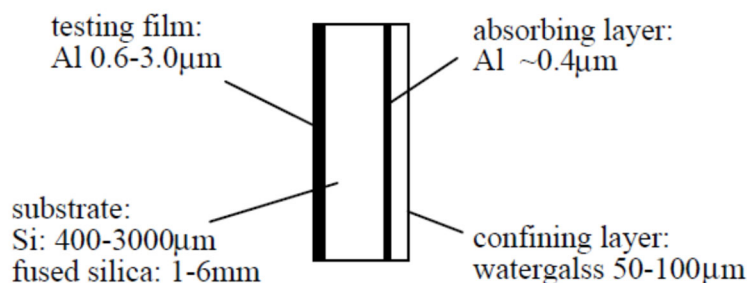


Fig. 3—Schematic of thin film sample for spallation experiment

12.Claim 12

Wang-2002 discloses the limitation of Claim 12. Ex-1003, ¶279. As shown *supra* in Claim 11, Figure 3 discloses an aluminum energy absorbing layer disposed between the waterglass constraining layer and the fused silica (“glass element”). Ex-1016, 75-77.

13.Claim 13

a. Limitation [13.pre]

To the extent the preamble is limiting, Wang-2002 discloses the preamble. Ex-1003, ¶¶280-81.

As discussed for limitations [1.pre], [1.a] and Claim 2 *supra*, Wang-2002 discloses a method for separating a thin test film (“coating”) from a substrate with a first and second side transversely disposed in a first axis, with the coating applied to a first side of the substrate in intimate facing contact, by sputtering an aluminum

film on the free side of the substrate to form a film/substrate interface. Ex-1016, 75-76, Figs. 1, 3; Section VII.D.

b. Limitation [13.a]

Wang-2002 in view of Gupta-1992 discloses or suggests limitation [13.a]. Ex-1003, ¶¶282-83.

As discussed for limitation [1.c] *supra*, to the extent Wang-2002 does not explicitly disclose that the fused silica is positioned along the axis on the second side of the substrate, such arrangement is implicitly disclosed because a POSITA would at once envisage the claimed arrangement or combination. To the extent PO argues otherwise, this would nevertheless have been obvious in view of Gupta-1992. *See* Limitation [1.c] *supra*.

c. Limitation [13.b]

Wang-2002 discloses limitation [13.b] for at least the same reasons presented for Claim 3 *supra* and shown in Figure 1. Ex-1003, ¶284.

d. Limitation [13.c]

Wang-2002 discloses limitation [13.c]. Ex-1003, ¶285-86.

As discussed in limitation [1.d] *supra*, Wang-2002 discloses using fused silica as the glass element and that a stress wave propagates and modifies through the fused silica into a rarefaction shock to generate a tensile force between the substrate and the thin-film coating. Ex-1016, Abstract, 78-80, 82.

e. Limitation [13.d]

Wang-2002 discloses limitation [13.d] for at least the reasons presented for Claim 2 *supra*. Ex-1003, ¶287; Ex-1016, Abstract, 75-76, 82.

14.Claims 14-21

Wang-2002 alone or in view of Gupta-1992 discloses or suggests the limitations of Claims 14-21 for at least the reasons presented for corresponding dependent Claims 3-9 and 11 in this Ground. *Supra* Claims 3-9, 11 (regarding Claims 14-20 and 21, respectively). Ex-1003, ¶288.

15.Claim 22

Wang-2002 discloses the limitations of Claim 22. Ex-1003, ¶289; *see* Claim 12 *supra*; Ex-1016, 76 (disclosing fused silica substrate), Fig. 1 (showing directing a laser pulse to an aluminum energy absorbing layer coated on the fused silica (“glass element”)), Fig. 3 (showing the energy absorbing layer on the free side of the fused silica between a confining layer (“constraining layer”) and the fused silica).

16.Claims 23-24

Wang-2002 in view of a POSITA’s knowledge discloses the limitations of Claims 23-24. Ex-1003, ¶¶290-93.

Wang-2002 discloses that “[a] longitudinal stress wave of rise time comparable to that of the laser pulse is emitted from the absorbing layer.” Ex-1016, 75. Wang-2002 further discloses that “the maximum stress in the substrate and at the

film/substrate interface increase with increasing laser fluence.” *Id.*, Abstract. Thus, Wang-2002 discloses that the stress generated at the coating/substrate interface depends on the power of the laser source and it can be adjusted to successfully spall off a coating for any system.¹⁵ Ex-1003, ¶291.

Though Wang-2002 does not expressly disclose that the stress exceeds approximately 1.0 or 2.0 GPa, these features would have been obvious. A POSITA would have known how to vary the pulse energy to increase the stress generated at the coating/substrate interface, and would have been motivated to do so to fail different thin-film/substrate interfaces. *Id.*, ¶292. It was known that peak stresses of gigapascals could be developed using lasers. Ex-1007, 115; Ex-1020. It was also known that high interface stress values, in the range of 3.7 to 10.5 GPa, could be reached for a Si/SiC system. Ex-1011, 141, Table 3.

It was within the skill of a POSITA to adjust the laser energy to achieve a stress exceeding approximately 1.0 GPa or 2.0 GPa to induce failure in different coating/substrate interfaces, and a POSITA would have had a reasonable expectation

¹⁵ Gupta-1992 also shows that it was known the stress generated at the coating/substrate interface depends on the power of the laser source and it can be adjusted to successfully spall off a coating for any system. *See* Section VIII.F.

of success because such stress levels were well-known to be achieved in the art. Ex-1003, ¶293.

IX. THE BOARD SHOULD NOT DENY INSTITUTION UNDER § 314(a)

Collectively, the *Fintiv* factors weigh strongly against discretionary denial.

Factor 1 (Stay): Neither party has requested a stay. This factor is therefore neutral. *Sand Revolution II, LLC v. Cont'l Intermodal Grp. - Trucking LLC*, IPR2019-01393, Paper 24 at 7 (June 16, 2020) (informative).

Factor 2 (Proximity of Trial Dates): If IPR is instituted, the Board will issue its Final Written Decision before the district court reaches trial. Petitioner is challenging personal jurisdiction and has moved to dismiss. Ex-1022. In early February 2024, the district judge denied Boeing's motion to dismiss "pending the outcome of jurisdictional discovery." Ex-1023, 19. Afterward, the district judge set an April 1, 2024 "cut-off for jurisdictional discovery." Ex-1024. The Court subsequently said that "LST's second amended complaint—on the existing factual record—will be dismissed." Ex-1025. Thus, it is highly unlikely that the current district court case will even be pending by the time the Board issues its institution decision. Factor 2 weighs against exercising discretion to deny institution.

Factor 3 (Investment in Parallel Proceedings): Currently, "the most burdensome stages of the case[]—completing discovery, preparing expert reports, filing and responding to pretrial motions, preparing for trial, going through the trial

process, and engaging in post-trial motions practice—all lie in the future.” *IOENGINE, LLC v. PayPal Holdings, Inc.*, No. 18-452-WCB, 2019 WL 3943058, at *5 (D. Del. Aug. 21, 2019). The court has yet to schedule claim construction briefing or a *Markman* hearing. Ex-1026. Factor 3 weighs against exercising discretion to deny institution.

Factor 4 (Overlap of Issues): Given the uncertainty on a trial date, a Final Written Decision would likely issue before the trial is even scheduled to begin (*see* Factor 2). On this schedule, Petitioner would be estopped under 35 U.S.C. § 315(e) from asserting at trial that any challenged claim in this proceeding is invalid based on the same grounds in the Petition or any other ground that reasonably could have been raised in the IPR. There is no risk of adjudication of overlapping issues. Factor 4 weighs strongly against denial.

Factor 6: (Other Circumstances): The Petition presents compelling unpatentability challenges to the Challenged Claims, and Factor 6 weighs strongly against denial.

X. CONCLUSION

Petitioner requests institution of this Petition to cancel the Challenged Claims based on the above Grounds.

Petition for *Inter Partes* Review
U.S. Patent No. 7,487,684

Respectfully submitted,

Dated: April 1, 2024

By: /Elizabeth T. Bernard/

Elizabeth T. Bernard

Reg. No. 51,465

Counsel for Petitioner

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 7,487,684 contains, as measured by the word processing system used to prepare this paper, 13,806 words. This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the word limit.

Dated: April 1, 2024

By: /Elizabeth T. Bernard/

Elizabeth T. Bernard
Reg. No. 51,465
Counsel for Petitioner

CERTIFICATE OF SERVICE

I hereby certify that on April 1, 2024, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 7,487,684 and supporting exhibits to be served on the following parties via Federal Express:

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Petition for *Inter Partes* Review
U.S. Patent No. 7,487,684

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