Tape-automated Bonding: Materials and Technologies

Tape automated bonding (TAB) technology is an important chip interconnection technique used in microelectronics packaging in addition to wire bonding and flip chip (Tummala *et al.* 1997). TAB technology has been widely used in low cost consumer products such as calculators, watches, cameras, smart cards, printers, VCRs, camcorders, and liquid crystal displays, as well as in high performance electronic systems such as desktops, notebooks, or large-scale computers. TAB technology provides several unique advantages over wire bonding or flip chip technique. These include capabilities of flexible, foldable packages, low profile, compact packages, high density, high I/O device packages, superior electrical, thermal, mechanical performance, advanced assembly options of surface mount technology (SMT) or chip-on-board (COB), and manufacturing advantages of mass production or reel-to-reel automation. Liquid crystal displays (LCD) have been a major application of TAB technology, especially in Japan (O'Mara 1993), because the technology provides a low profile, foldable, low cost interconnection between a LCD flat panel and its control printed circuit board (PCB). In this application, a driver chip is mounted on a flexible TAB tape, which connects a liquid crystal glass panel to a PCB. A transfer-bumped, tin-plated tape is commonly used with electroplated gold bumps attached to it. Anisotropic conductive film (ACF) is also used for the tape-to-glass connection to provide low-temperature, low-pressure bonding. In Europe, TAB technology has been applied in smart card manufacture, where an integrated circuit (IC) chip is packaged in a thin plastic card, like a credit card. In United States, TAB technology has been successfully applied for high I/O, fine-pitch packages for high performance electronic systems, like notebook or mini computers.

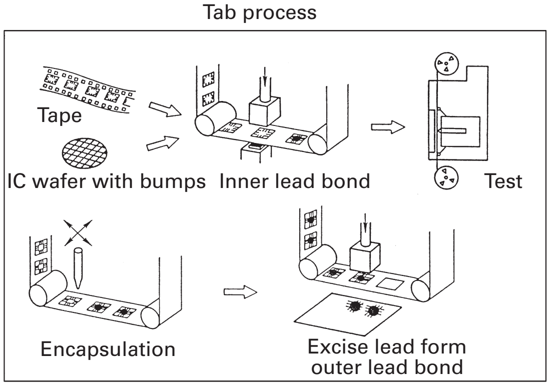

Figure 1
A typical TAB process includes tape design/manufacture, wafer bumping, inner-lead bonding, test/burn-in, encapsulation, excise/lead form, and outer lead bonding (Kang 1990).

1. *TAB Process*

A typical TAB process is shown schematically in Fig. 1, where several key steps are highlighted, such as wafer bumping, inner lead bonding (ILB), test and burn-in, encapsulation, and outer lead bonding (OLB). A common TAB manufacturing process starts with a proper design of tape structure and pattern, which matches with the IC chips to be interconnected. The most popular tape structure is planar one, which does not carry any bump structure on the beam leads of a TAB tape. Therefore, some kinds of bump structure are built on each bonding pad of an IC chip through a wafer bumping process. The bonding process where a diced IC chip is connected to each frame of a TAB tape is ILB. Most common ILB process is a gang or mass bonding where all the bumps on one chip are bonded to a TAB tape in one operation. Since most TAB tape has a two-layer structure, one conducting layer supported by a dielectric layer, a TAB package has an advantage of testing IC chips or burn-in them well before the packages are assembled to a PCB. This advantage is not usually available with wire bond or flip chip packages until they are assembled completely. Encapsulation of a TAB package is performed to protect an IC chip bonded to a TAB tape in a subsequent process as well as to improve the reliability of a whole package during service. The OLB process attaches a TAB package to a PCB. Due to the nature of fine pitch and flimsiness of a TAB tape, an integration of the OLB process into the conventional SMT process is challenging. This has been an impediment for TAB packages to become a dominant package choice in the PCB assembly line, although the technology provides numerous advantages mentioned earlier.

2. *Tape Manufacture*

Several TAB tape structures are schematically shown in Fig. 2, where the differentiation is made according to the beam leads: planar tape, bumped tape, transfer-bumped tape, and balltape. The planar tape with one metal layer is the most popular, which can be either two-layer or three-layer tape according to its manufacturing process. The two-layer planar tape is generally manufactured by plating a copper metal pattern on a dielectric film, such as polyimide, with a thin film layer of Cr for adhesion and a thin Cu layer as a plating base. After Cu plating, chemical milling process is applied to perforate a window structure in each frame. The three-layer tape consists of one Cu, an

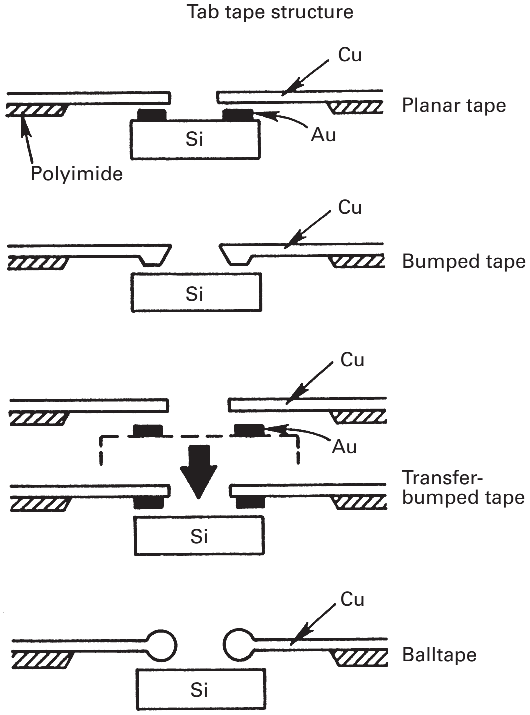

Figure 2
Several TAB tape structures are schematically shown according to the geometry of beam leads: planar tape, bumped tape, transfer-bumped tape, and balltape (Kang *et al.* 1994).

adhesive, and one dielectric layer laminated together to form a three-layer structure. A window structure in each frame is mechanically punched out from the dielectric film before the layers are laminated together. The conducting Cu lead pattern is generated by etching Cu layer according to the definition of a photo-resist layer applied. Since electroplating of Cu beam structure can be controlled better than chemical etching of a Cu foil to produce a conductor pattern, the two-layer tape has a finer conductor feature size than the three-layer one in general. Because of cost and yield issues associated with the wafer bumping process to be discussed later, a bumped tape is an attractive option. There have been several bumped tape structures reported: bumped-TAB tape (Kanz *et al.* 1979), transfer-bumped tape (Hatada 1990), and balltape (Ledermann 1991). Among them, the transfer-bumped tape is the most popular one in use. The transfer-bumped tape extensively used in consumer products such LCDs, TVs, cameras, watches, etc., is manufactured by plating gold bumps on a glass substrate. Gold bumps on the glass substrate are transferred onto a Sn-coated Cu planar tape by a Au–Sn eutectic bonding process. Gold bumps of 40–60 μm diameter and 20–25 μm height have been manufactured for a fine pitch interconnection.

3. *Wafer Bumping*

The wafer bumping process can be classified according to its bump materials: gold, copper, aluminum, solder, and others (Kang *et al.* 1994). Gold bump has been the most popular for TAB technology since its introduction in 1970 (Triggs and Byrns 1971). Gold bump is usually made of two regions: thin film adhesion layers to aluminum metallization on IC chips and the main body of electroplated gold. The thin film structure consists of three layers: first an adhesion layer of Ti or Cr a few hundred angstrom thick, second a diffusion barrier layer of Cu, Pd, W, or Pt approximately 10 KÅ, and third a capping layer of gold a few thousand angstrom thick. The thin film layers also serve as a common ground for the subsequent electroplating of gold bumps. Either a photoresist or thick laminated resist layer is applied and developed onto a wafer to define windows for gold bump plating. To produce a soft gold bump, high-purity gold plating is required. Pulse plating can be used to obtain gold bumps with uniform bump height, consistent bump hardness, and flat bump surface morphology (Traut *et al.* 1990). Typical bump heights are in the range 15–25 μm. After gold bump plating, the photoresist layer is stripped off and the thin film layers are selectively etched. The final process is annealing of the gold bumps at an elevated temperature, such as 300 °C, to obtain a proper hardness (Kang *et al.* 1994). To reduce cost of gold bumps, copper bump has been introduced (Burns 1977). However, the difficulty of thermocompression bonding and additional processing steps required to protect copper surface have prevented copper bump from wide use for TAB technology. Aluminum bump was developed to replace the wet chemical processes used in gold or copper bump plating with a dry, physical process (Moskowitz *et al.* 1992). An aluminum bump consists of metals evaporated sequentially: first an adhesion layer of Ti or Cr a few hundred angstrom thick, then an Al body of 12–18 μm thick, followed by a capping layer consisting of Ti/Cu/Cu. The pure Al body can be replaced by an Al alloy with a small percentage of Cu, Ni, Cr, Ti, Si, or Fe (Brady *et al.* 1992). The relative softness of aluminum in contrast to gold or copper is beneficial because it permits good bonds to be made at the same time as the underlying chip structure is being protected from transmission of excessive forces during bonding. Solder bumps similar to those used in flip chip or controlled collapse chip connection (C4) have been applied for TAB interconnections with some modifications (Anderson 1992). Other bumps such as nickel (Tjhia and Nguyen 1992) or nickel–gold bumps (Baggerman and van

Gerven 1995) are also demonstrated for the TAB applications.

4. Inner Lead Bonding Processes

The TAB ILB process is generally determined by three factors: tape structure (planar vs. bumped), bump materials (gold, copper, aluminum, solder, etc.), and bonding tool (gang vs. single-point). Several popular options are schematically shown in Fig. 3. Gold–tin eutectic bonding occurs when a tin-plated copper tape is bonded to a gold-bumped chip. The first bonding step of the transfer bump tape is also identified to be the eutectic bonding. During bonding, heat and force are supplied by a thermode, which heats copper beams and simultaneously presses them down into gold bumps. The bond is formed by melting the tin layer to react with the gold bumps. A bonding temperature of 250–300 °C is required for a few seconds. The amount of force applied is proportional to the number of interconnections to be made. The thickness of tin ranges from 0.5 μm to 1.0 μm, while the height of gold bumps ranges from 15 μm to 25 μm. During the bonding, the reaction between tin and gold produces a gold-rich Au–Sn eutectic phase at the bond interface. The extent of the eutectic phase formed varies with the bonding time and temperature. Examples of thermocompression bonding are found when a gold-bumped chip is bonded to either a gold-plated or bare copper tape, or when a transfer-bumped tape is bonded to a chip with aluminum pads. Thermocompression bonding is a solid-state process, and therefore requires a considerable amount of force at an elevated temperature. This aggressive bonding condition often induces a large amount of plastic deformation within the bonding structure. When a bump material is as hard as copper or gold/copper, an excessive bonding force can be transmitted to the bonding pads of a silicon chip causing a mechanical damage such as chip cratering. However, since thermocompression bonding requires a certain amount of plastic deformation to achieve a reasonable bond, it is necessary to find an optimum amount of plastic deformation needed for a particular bonding structure. The bump hardness is therefore an important material property to be monitored in thermocompression bonding. The interrelationships among bump hardness, plastic deformation, and bond strength were reported during the thermocompression bonding of aluminum bumps (Kang 1998).

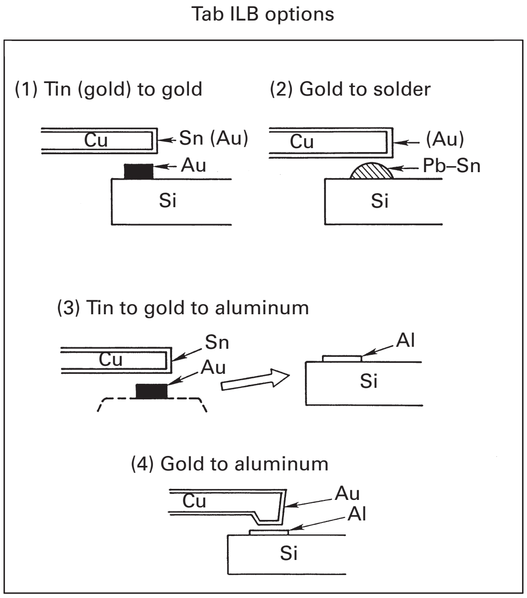

Figure 3
Several TAB ILB options are schematically shown such as gold-to-tin eutectic, gold-to-solder reflow bonding, tin-to-gold-to-aluminum transfer bonding, and gold-to-aluminum thermocompression bonding (Kang 1990).

The reflow bonding method used for TAB ILB is essentially an extension of the flip chip or C4 technology, which uses solder bumps to connect chips to a ceramic or polymeric substrate in multichip modules or chip-on-board applications. Various reflow methods are possible such as using a thermode (Cummings and Chase 1986), hot-gas (Anderson 1992), or laser energy (Crowley 1991). Since the thermal conditions of each reflow method are different, the kinetics of the reflow joining process are different, and thereby the resultant microstructures of the solder joints is expected to be varied. A typical solder joint produced by a hot-gas reflow process is shown in Fig. 4, where the solder joints are formed by partially melting the solder bumps. To control the interfacial reaction with the molten solder during the reflow bonding, a tape surface metallurgy such as gold–nickel-plated copper tape is recommended.

A single-point bonding scheme has been used to alleviate some of the shortcomings of the conventional mass-bonding scheme. The anticipated advantages of the single-point bonding method include: relief from stringent requirements of planarity and alignment, better control of bond force and temperature, flexibility in tape design, repair possibility, and low tooling cost (Dehaine 1994). Two single-point bonding methods have been demonstrated for TAB ILB applications: thermosonic and laser joining process. TAB thermosonic bonding is a modification of the well-established technique of thermosonic wire bonding in which heat and ultrasonic energy are applied together in addition to force to produce a solid-state diffusion bond. The laser bonding process has developed to circumvent a high bonding force used for thermosonic bonding. This is a noncontact process that is applicable for a high density TAB ILB (Hayward 1994).

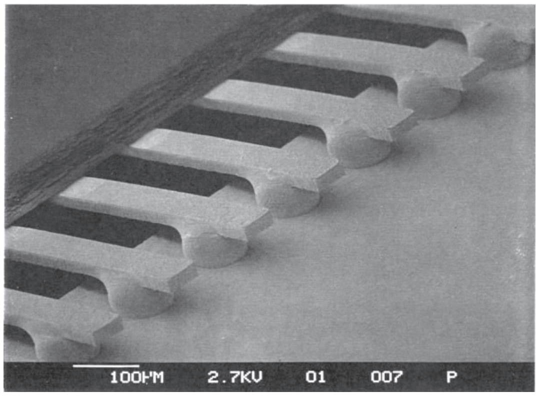

Figure 4
SEM micrograph showing solder bump joints produced by a hot-gas reflow process. The formation of good solder fillets around beam leads is noticed.

The conductive adhesive bonding method used in the LCD packaging is largely due to its advantages of lower temperature and finer pitch capabilities in comparison with the conventional solder technology. The conductive adhesive used for interconnecting IC driver chips to a TAB tape is called anisotropically conductive film (ACF). An ACF is a composite material made of conducting filler particles dispersed in an insulating polymer resin. The filler particles of a few micrometers in diameter are either solid metal powder, such as copper, nickel, solder, or plastic balls coated with metallic layers (Adachi 1993). The volume fraction of the filler particles is well below the percolation threshold value to provide an electrical conduction only in the vertical direction, not in lateral directions, when a few filler particles are trapped in between two conducting pads. Since this conductive adhesive bonding does not involve with any metallurgical bonds realized in solder joints, there are several issues such as low electrical conductivity, unstable contact resistance upon thermal exposure, and difficulty of rework.

5. *Encapsulation*

Encapsulation of an IC chip bonded on a TAB tape is performed to protect the IC chip from physical and chemical damages in the subsequent processing as well as from the environment during field services. An encapsulant, which is usually a mixture of a polymer resin and a filler material, is applied onto an IC chip by a syringe-type liquid dispensing system before the OLB process. Several encapsulation schemes are used such as face-coating, full encapsulation (or potting), and transfer molding. The face-coating covers only the top of a chip and the ILB areas, while the potting or full encapsulation covers the top as well as the sides of the chip. When a TAB module is mounted onto a lead frame as in the tape carrier package (TCP), the transfer molding method can be applied. Some important materials properties to be considered for encapsulating materials include: thermal coefficient of expansion (TCE), modulus of elasticity, residual stress, adhesion strength, ionic impurity content, moisture absorption rate, and resin curing characteristics. In order to reduce the TCE of an encapsulant, a filler material such as fused or crystalline silica particles are mixed with the resin (Wong *et al.* 1994). To control the modulus of elasticity and fracture toughness of a rigid epoxy resin, silicone rubber particles are added to the resin as a toughener (Prasad 1986). Good adhesion of an encapsulant to metallic and polymeric surfaces plays an important role in determining the long-term reliability of a TAB package. A low ionic content of chloride and fluoride is an important requirement, because they often induce the most common failure mechanism in microelectronic packages, namely, corrosion of aluminum or copper metallization (Engel *et al.* 1983).

6. *Outer Lead Bonding*

TAB packages are surface mountable to various substrates such as ceramic modules, PCB, metal core laminates, or flexible circuits. However, because TAB leads are flimsy and have a finer spacing, the assembly of TAB modules are not well integrated into the mainstream SMT. Several developments have been used to integrate the TAB packages into the SMT assembly line. The TCP developed for notebook or sub-notebook computers (Jain 1994) is a good example, where TAB technology is combined with lead-frame technology to interconnect a high performance microprocessor in the format of an advanced SMT package, fine pitch QFP (quad flat pack). The transfer molding method is used to produce a plastic package less than 2 mm in thickness with the 0.4 mm OLB pitch, which is assembled by the standard SMT (Levine 1995). This is the first large volume production of TAB packages for high performance applications in the United States. A complete new approach has been taken to solve the board-level assembly problem of TAB technology by a demountable TAB (DTAB) package (Pendse *et al.* 1994). The package consists of a TAB tape with a chip bonded to it by a bumpless ILB and encapsulated, an elastomer frame (planarizer), a plastic frame (aligner), a heat spreader, and a heat sink. The compressed elastomer and the spring stiffener on the back formed a series spring system that delivers the required force to the area array contacts. The package can be demounted simply unscrewing the four screws and assembling again if desired. Although DTAB package has solved the OLB assembly problem, it does not provide many advantages of TAB packages over the conventional SMT packages. Another approach is reported to solve the TAB assembly problem by combining TAB with ball grid array (BGA) technology, called tape ball grid array (TBGA), (Andros and Hammer 1994). The TBGA package is constructed by using a two-level metal TAB tape to fan out the die I/O. Both ILB and OLB are made by an area array interconnect using solder bumps or balls of a different composition. The ILB method employed is a fluxless partial reflow technique where the inner leads are gang bonded to solder bumps by using a hot air thermode. The TBGA offers a thin, light weight package that is still compatible with the standard SMT assembly process.

7. *Summary*

TAB technology has been reviewed for microelectronic packaging applications. The technology attributes have been discussed in terms of its key processing steps such as tape manufacture, wafer bumping, ILB, encapsulation, and OLB. The advantages and disadvantages of the TAB technology have been discussed in comparison to other interconnect technologies. The materials issues are also discussed in light of manufacturability and reliability of TAB packages.

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S. K. Kang

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DECLARATION OF JUNE ANN MUNFORD

1. My name is June Ann Munford. I am over the age of 18, have personal knowledge of the facts set forth herein, and am competent to testify to the same.

2. I earned a Master of Library and Information Science (MLIS) from the University of Wisconsin-Milwaukee in 2009. I have over ten years of experience in the library/information science field. Beginning in 2004, I have served in various positions in the public library sector including Assistant Librarian, Youth Services Librarian and Library Director. I have attached my Curriculum Vitae as Appendix CV.

3. During my career in the library profession, I have been responsible for materials acquisition for multiple libraries. In that position, I have cataloged, purchased and processed incoming library works. That includes purchasing materials directly from vendors, recording publishing data from the material in question, creating detailed material records for library catalogs and physically preparing that material for circulation. In addition to my experience in acquisitions, I was also responsible for analyzing large collections of library materials, tailoring library records for optimal catalog

search performance and creating lending agreements between libraries during my time as a Library Director.

4. I am fully familiar with the catalog record creation process in the library sector. In preparing a material for public availability, a library catalog record describing that material would be created. These records are typically written in Machine Readable Catalog (herein referred to as “MARC”) code and contain information such as a physical description of the material, metadata from the material’s publisher, and date of library acquisition. In particular, the 008 field of the MARC record is reserved for denoting the date of creation of the library record itself. As this typically occurs during the process of preparing materials for public access, it is my experience that an item’s MARC record indicates the date of an item’s public availability.

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6. I have reviewed Exhibit 1017, "Tape-automated Bonding: Materials and Technologies" by S.K. Kang, et al as published in Encyclopedia of Materials: Science and Technology.

7. Attached hereto as Appendix KANG01 is a true and correct copy of the MARC record for Encyclopedia of Materials: Science and Technology as held by the Ohio University Library. I secured this record myself from the library’s public catalog. The MARC record contained within Appendix KANG01 accurately describes the title, publisher and ISBN number of Encyclopedia of Materials: Science and Technology. In comparing Exhibit 1017 to Appendix KANG01, it is my determination that Exhibit 1017 is a true and correct copy of "Tape-automated Bonding: Materials and Technologies" by S.K. Kang, et al as published in Encyclopedia of Materials: Science and Technology.

8. The 008 field of the MARC record in Appendix KANG01 indicates the date of record creation. The 008 field of Appendix KANG01 indicates the Ohio University Library first acquired Encyclopedia of Materials: Science and

Technology as of June 27, 2001. Considering this information, it is my determination that Encyclopedia of Materials: Science and Technology and therefore "Tape-automated Bonding: Materials and Technologies" was made available to the public shortly after June 27, 2001.

9. I have been retained on behalf of the Petitioner to provide assistance in the above-illustrated matter in establishing the authenticity and public availability of the documents discussed in this declaration. I am being compensated for my services in this matter at the rate of $200.00 per hour plus reasonable expenses. My statements are objective, and my compensation does not depend on the outcome of this matter.

10. I declare under penalty of perjury that the foregoing is true and correct. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: 7/29/2025

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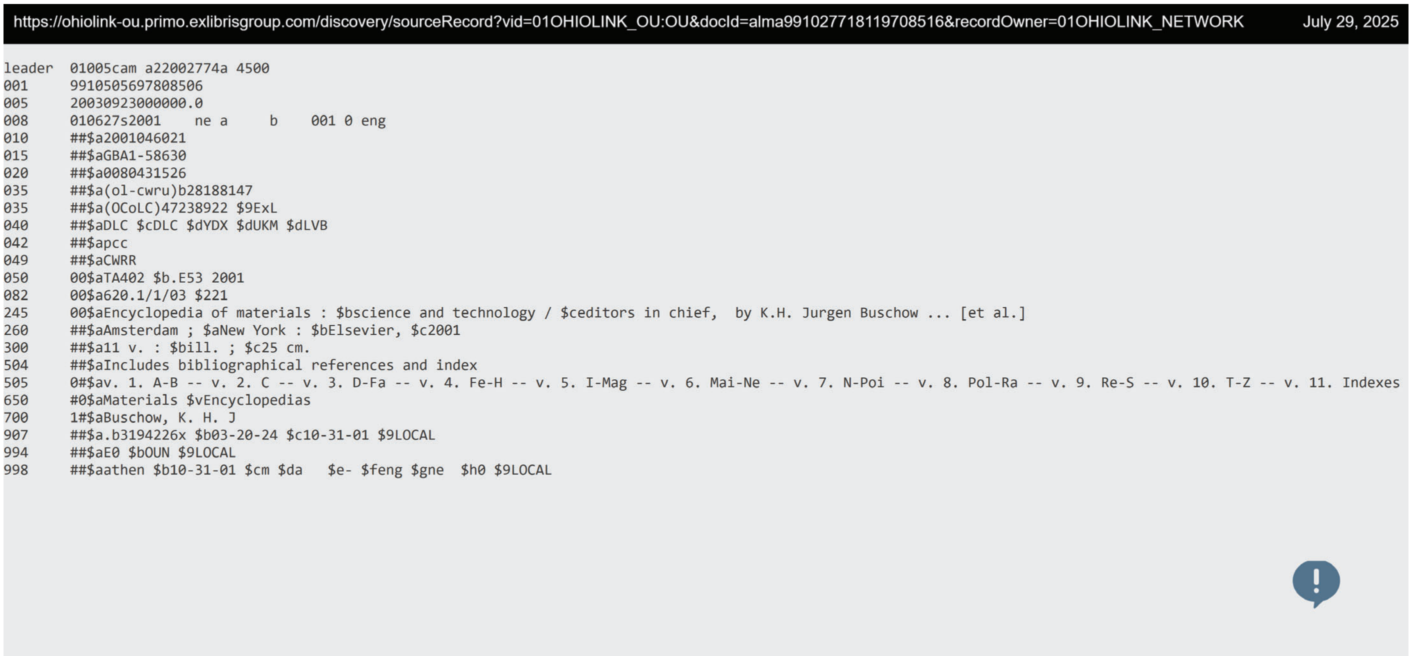

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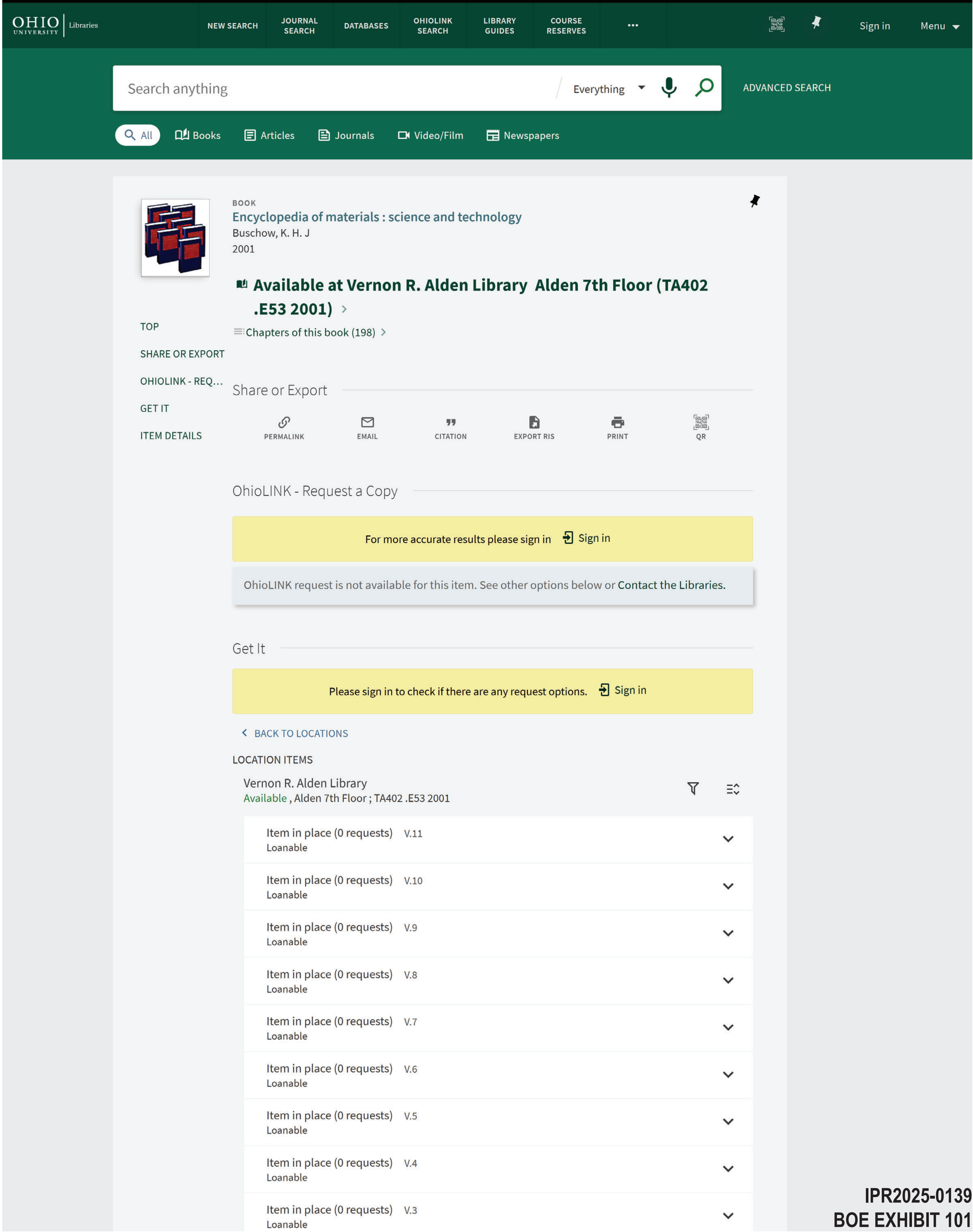

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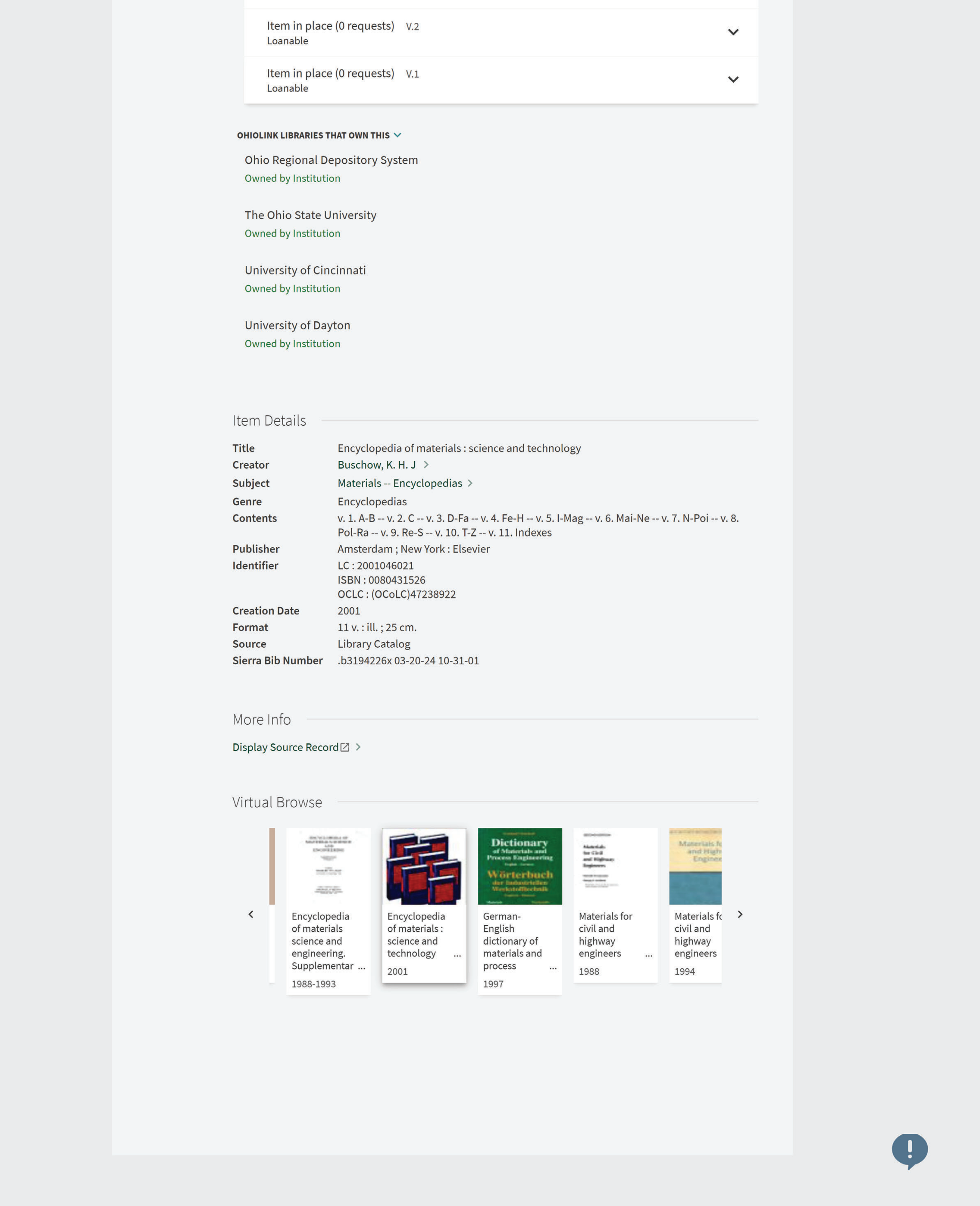

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Virtual Browse

Encyclopedia of materials science and engineering. Supplementar ...
1988-1993

Encyclopedia of materials : science and technology ...
2001

German-English dictionary of materials and process ...
1997

Materials for civil and highway engineers ...
1988

Materials fc civil and highway engineers
1994

June A. Munford
Curriculum Vitae

Education

University of Wisconsin-Milwaukee - MS, Library & Information Science, 2009
Milwaukee, WI

- Coursework included cataloging, metadata, data analysis, library systems, management strategies and collection development.
- Specialized in library advocacy, cataloging and public administration.

Grand Valley State University - BA, English Language & Literature, 2008
Allendale, MI

- Coursework included linguistics, documentation and literary analysis.
- Minor in political science with a focus in local-level economics and government.

Professional Experience

Researcher / Expert Witness, October 2017 – present
Freelance ● Pittsburgh, Pennsylvania & Grand Rapids, Michigan

- Material authentication and public accessibility determination. Declarations of authenticity and/or public accessibility provided upon research completion. Experienced with appeals and deposition process.

- Research provided on topics of public library operations, material publication history, digital database services and legacy web resources.

- Past clients include Alston & Bird, Arnold & Porter, Baker Botts, Fish & Richardson, Erise IP, Irell & Manella, O'Melveny & Myers, Perkins-Coie, Pillsbury Winthrop Shaw Pittman and Slayden Grubert Beard.

Library Director, February 2013 - March 2015
Dowagiac District Library ● Dowagiac, Michigan

- Executive administrator of the Dowagiac District Library. Located in Southwest Michigan, this library has a service area of 13,000, an annual operating budget of over $400,000 and total assets of approximately $1,300,000.

- Developed careful budgeting guidelines to produce a 15% surplus during the 2013-2014 & 2014-2015 fiscal years while being audited.

- Using this budget surplus, oversaw significant library investments including the purchase of property for a future building site, demolition of existing buildings and building renovation projects on the current facility.

- Led the organization and digitization of the library's archival records.

- Served as the public representative for the library, developing business relationships with local school, museum and tribal government entities.

- Developed an objective-based analysis system for measuring library services - including a full collection analysis of the library's 50,000+ circulating items and their records.

November 2010 - January 2013
Librarian & Branch Manager, Anchorage Public Library ● Anchorage, Alaska

- Headed the 2013 Anchorage Reads community reading campaign including event planning, staging public performances and creating marketing materials for mass distribution.

- Co-led the social media department of the library's marketing team, drafting social media guidelines, creating original content and instituting long-term planning via content calendars.

- Developed business relationships with The Boys & Girls Club, Anchorage School District and the US Army to establish summer reading programs for children.

June 2004 - September 2005, September 2006 - October 2013
Library Assistant, Hart Area Public Library
Hart, MI

- Responsible for verifying imported MARC records and original MARC cataloging for the local-level collection as well as the Michigan Electronic Library.

- Handled OCLC Worldcat interlibrary loan requests & fulfillment via ongoing communication with lending libraries.

Professional Involvement

Alaska Library Association - Anchorage Chapter

- Treasurer, 2012

Library Of Michigan
- Level VII Certification, 2008
- Level II Certification, 2013

Michigan Library Association Annual Conference 2014
- New Directors Conference Panel Member

Southwest Michigan Library Cooperative
- Represented the Dowagiac District Library, 2013-2015

Professional Development

Library Of Michigan Beginning Workshop, May 2008
Petoskey, MI
- Received training in cataloging, local history, collection management, children's literacy and reference service.

Public Library Association Intensive Library Management Training, October 2011
Nashville, TN
- Attended a five-day workshop focused on strategic planning, staff management, statistical analysis, collections and cataloging theory.

Alaska Library Association Annual Conference 2012 - Fairbanks, February 2012
Fairbanks, AK
- Attended seminars on EBSCO advanced search methods, budgeting, cataloging, database usage and marketing.

Depositions

2019 ● Fish & Richardson

Apple v. Qualcomm (Case No. IPR2018-001281, 39521-00421IP, IPR2018-01282 and 39521-00421IP2)

2019 ● Erise IP

Implicit, LLC v. Netscout Systems, Inc (Case No. 2:18-cv-53-JRG)

2019 ● Perkins-Coie

Adobe Inc. v. RAH Color Technologies LLC (Case No. IPR2019-00627, IPR2019-00628, IPR2019-00629 and IPR2019-00646)

2020 ● O'Melveny & Myers

Maxell, Ltd. v. Apple Inc. (Case No. 5:19-cv-00036-RWS)

2021 ● Pillsbury Winthrop Shaw Pittman LLP

Intel v. SRC (Case No. IPR2020-1449)

2022 ● Perkins-Coie

Realtek v. Future Link (Case No. IPR2021-01182)

2023 ● Fish & Richardson

Neuroderm Ltd. v. Abbvie, Inc (Case No. PGR2022-00040)

2023 ● Fish & Richardson

Nearmap US Inc. v. Pictometry International Corp. (Case No. IPR2022-00735)

2023 ● Fish & Richardson

Samsung Electronics v. MemoryWeb LLC (Case No. 39843-0136PS1)

2023 ● Pillsbury Winthrop Shaw Whitman LLP

Gravel Rating Systems v. Costco Wholesale Corp. (Case No. 4:21-cv-149-ALM)

2024 ● Willkie-Farr

Netflix, Inc. v. VideoLabs. Inc. (Case No. IPR2023-00628)

2024 ● Quinn Emanuel Urquhart & Sullivan

Purdue University v. Wolfspeed (Case No. 1:21-CV-840)

2024 ● Fish & Richardson

Dish Network v. Entropic Communications (Case No. IPR2024-00393)

2025 ● Perkins Coie

Amazon.com, Inc. v. Nokia Technologies Oy (Case No. IPR2024-00572)

2025 ● Fish & Richardson

Dish Network v. Entropic Communications (Case No. IPR2024-00373)

Limited Case and Clientele History

Alston & Bird

● Ericsson

v. Collision Communications (Case No. IPR2022-01233)

● Nokia

v. Neptune Subsea, Xtera (Case No. 1:17-cv-01876)

● Universal Electronics Inc

v. Roku Inc (Case No. IPR2022-00818)

Alavi & Anaipakos PLLC

● Stingray Group Inc. and Stingray Music USA, Inc.

v. Edwin A. Hernandez-Mondragon and Egla Corp. (Case No. 1:24-cv-21226-RAR)

Arnold & Porter

● Ivantis

v. Glaukos (Case No. 8:18-cv-00620)

● Samsung

v. Jawbone (Case No. 2:21-cv-00186)

Benesch Friedlander Coplan & Aronoff

- Voyis

  v. Cathx (Case No. 5:21-cv-00077-RWS)

Buchanan, Ingersoll & Rooney PC

- Google LLC, AT&T Service Inc., T Mobile USA Inc., Cellco Partnership, Ericsson Inc. & Nokia of America Corp.

  v. KT Corp & Pegasus Wireless Innovation LLC (Case No. IPR2025-00293)

Deschert LLP

- Smaxtec Animal Care

  v. ST Reproductive Technologies, LLC (Case No. IPR2024-00885)

Duane Morris

- Kangxi Communication Technologies

  v. Skyworks Solutions Inc. (Case No. IPR2025-00373)

- Microsoft

  v. Edge Networking Systems LLC (Case No. 1:24-cv-00215)

Erise I.P.
- Apple

  v. Ericsson Inc. (Case No. IPR2022-00715)

  v. Future Link Systems (Case No. IPRs 6317804, 6622108, 6807505, and 7917680)

  v. INVT (Case No. 20-1881)

  v. Navblazer LLC (Case No. IPR2020-01253)

  v. Qualcomm (Case No. IPR2018-001281, 39521-00421IP, IPR2018-01282, 39521-00421IP2)

  - v. Quest Nettech Corp (Case No. 2:19-cv-00118-JRG)
  - v. Telefonaktiebolaget LM Ericsson (Case No. IPR2022-00275)
  - v. Theta IP, LLC (Case No. IPR2024-00818)
  - v. THL Holding Company LLC (Case No. 1:23-cv-00548)

- Fanduel
  - v. CGT (Case No. 19-1393)

- Garmin
  - v. Phillips North America LLC (Case No. 2:19-cv-6301-AB-KS)

- Netscout
  - v. Longhorn HD LLC (Case No. 2:20-cv-00349)
  - v. Implicit, LLC (Case No. 2:18-cv-53-JRG)

- Sony Interactive Entertainment LLC
  - v. Bot M8 LLC (Case No. IPR2020-01288)
  - v. Infernal Technology LLC (Case No. 2:19-CV-00248-JRG)

- Tesla
  - v. Charge Fusion Technologies LLC (Case No. IPR2025-00032)

- Unified Patents
  - v. GE Video Compression (Case No. 2:19-cv-248)

Fish & Richardson

- Apple
  - v. AliveCor (Case No. 3:21-cv-03958)
  - v. LBS Innovations (Case No. 2:19-cv-00119-JRG-RSP)
  - v. Koss Corporation (Case No. IPR2021-00305)

  - v. Masimo (Case No. IPR 50095-0012IP1, 50095-0012IP2, 50095-0013IP1, 50095-0013IP2, 50095-0006IP1, 50095-0135IP1)
  - v. Neonode (Case No. 21-cv-08872-EMC)
  - v. Qualcomm (Case No. IPR2018-001281, 39521-00421IP, IPR2018-01282, 39521-00421IP2)
  - v. Resonant Sys. (Case No. 7:23-cv-00077-ADA)

- AsusTek Computer Inc.
  - v. Videolabs, Inc. (Case No. 22-CV-00720-ADA)

- Dell
  - v. Neo Wireless (Case No. IPR2022-00616)

- Dish Network
  - v. Entropic Communications, LLC (Case No. 2:2023-CV-01043)
  - v. Entropic Communications LLC (Case No. IPR2024-00393)
  - v. Realtime Adaptive Streaming (Case No. 1:17-CV-02097-RBJ)
  - v. TQ Delta LLC (Case No. 18-1798)

- Evapco Dry Cooling
  - v. SPG Dry Cooling (Case No. IPR2021-00688)

- Genetec
  - v. Sensormatic Electronics (Case No. 1:20-CV-00760)

- Huawei
  - v. Bell Northern Research LLC (Case No. IPR2019-01174)

- Kianxis
  - v. Blue Yonder (Case No. 3:20-cv-03636)

- LG Electronics

  v. Bell Northern Research LLC (Case No. 3:18-cv-2864-CAB-BLM)

- MediaTek

  v. MOSAID (Case No. IPR2024-00718)

- Metaswitch

  v. Sonus Networks (Case No. IPR2018-01719)

- Microsoft

  v. Throughputer Inc (Case No. IPR2022-00757)

- Mom Enterprises

  v. Ddrops Company (Case No. 1:22-cv-00332)

- MLC Intellectual Property

  v. MicronTech (Case No. 3:14-cv-03657-SI)

- Nearmap Inc

  v. EagleView Technologies (Case No. IPR2022-01009)

- Neuroderm Ltd.

  v. Abbvie, Inc (Case No. PGR2022-00040)

- Posco Co Ltd.

  v. Pascal Drillet et al. (Case No. IPR2025-00370)

- Realtek Semiconductor

  v. Future Link (Case No. IPR2021-01182)

- Quectel
    - v. Koninklijke Philips (Case No. 1:20-cv-01710)

- Samsung
    - v. Aire Technology (Case No. IPR2022-00877)
    - v. Bell Northern Research (Case No. 2:19-cv-00286-JRG)
    - v. Communication Technologies Inc (Case No. IPR2022-01221)
    - v. Jawbone Innovations (Case No. IPR2022-00865)
    - v. MemoryWeb LLC (Case No. IPR2022-00885)
    - v. Dodots Licensing Solutions (Case No. IPR2023-00701)
    - v. Telefonaktiebolaget LM Ericsson (Case No. IPR2021-00615)

- Texas Instruments
    - v. Vantage Micro LLC (Case No. IPR2020-01261)

- Xilinx
    - v. Sentient Sensors LCC (Case No. 1:22-cv-00173)

Goodwin Proctor

- Intel
    - v. Proxense, LLC (Case No. 6:24-cv-00283)

- Samsung Electronics
    - v. Mobile Data Technologies (Case No. 2:24-cv-00435)

- Taiwan Semiconductor Manufacturing Company Ltd.
    - v. Advanced Integrated Circuit Process LLC (Case No. 2:24-cv-00623)

Groombridge Wu

- Nearmap

  v. Eagle View Technologies Inc. and Pictometry International Corp. (Case No. 2:21-cv-00283-TS-DAO)

Irell & Manella

- Curium

Latham & Watkins LLP

- Apple

  v. Advanced Coding Research LLC

Leydig, Voit & Mayer, Ltd.

- Public Availability Consultancy

O'Melveny & Myers

- Apple

  v. Maxell (Case No. 5:19-cv-00036-RWS)

- Disney Media & Entertainment Distribution LLC

  v. Digital Media Technology Holdings, LLC (Case No. 2:22-cv-01642)

- Micron Technology Inc.

  v. Besang Inc (Case No. IPR2023-00900)

- Samsung

  v. Daedalus Prime LLC (1335 Investigation)

Perkins-Coie

- Amazon
  - v. Nokia (Case No. IPR2024-00847 and IPR2024-00848)
  - v. Nokia Technologies Oy (Case No. IPR2024-00572)
- Heru Industries
  - v. The UAB Research Foundation (Case No. IPR2022-01148)
- Intel Corporation
  - v. BeSang Inc. (Case No. IPR2023-00991)
  - v. BitMICRO (Case No. 5:23-cv-00625)
  - v. Telefonaktiebolaget L M Ericsson (Case No. IPR2024-00610)
- Realtek Semiconductor
  - v. Future Link (Case No. IPR2021-01182)
- r-pac
  - v. Adasa, Inc. (Case No. 1:2024cv06102)
- Twitter Inc
  - v. VOIP-Pal.com (Case No. 3:20-cv-02397-JD)
- TCL Industries
  - v. Koninklijke Philips NV (Case No. IPR2021-00495, IPR2021-00496 and IPR2021-00497)
- VusionGroup
  - v. Hanshow (Case No. IPR2024-00857)

Pillsbury Winthrop Shaw Pittman

- Intel

    v. FG SRC LLC (Case No. 6:20-cv-00315)

- Gravel Rating Systems

    v. Costco (Case No. 4:21-cv-149)
    v. Lowe's Home Centers (Case No. 4:21-cv-150)
    v. T-Mobile USA (Case No. 4:21-cv-152)
    v. Kohl's Inc. (Case No. 4:21-cv-258)
    v. Under Armor (Case No. 4:21-cv-356)

Quinn Emanuel

- Exact Sciences Corporation

    v. Geneoscopy, Inc. (Case No. IPR2024-00459 and IPR2024-1330)

- ServiceNow, Inc.

    v. InQuisient, Inc. (Case No. 22-900-CJB)

- Wolfspeed

    v. The Trustees of Purdue University (Case No. 1:2021-cv-00840)

Sheppard, Mullin, Richter & Hampton LLP

- Advanced Micro Devices, Inc and Pensando Systems, Inc.

    v. Concurrent Ventures LLC and Xtreamedge, Inc. (Case No. IPR2025-00478)

- Cadence Design Systems Inc.

    v. Semiconductor Design Technologies (Case No. 3:23-cv-01001)

Shook, Hardy & Bacon LLP

- HP Inc.

  v. Universal Connectivity Technologies (Case No. 1:23-cv-01177)

Stern, Kessler, Goldstein & Fox

- Preliminary Research

Wilmer, Cutler, Pickering, Hale and Dorr

- Apple

  v. Shunock (Case No. 1:23-cv-08598)

- Quest Diagnostics Inc., Haystack Oncology Inc. and Haystack Oncology GmbH

  v. Natera, Inc. (Case No. 1:23-cv-08598)

- Roche Diabetes, Inc.

  v. Trividia Health, Inc. (Case No. 1:24-cv-00668)

Willkie, Farr & Gallagher LLP

- Lenovo, Dell, HP

  v. Universal Connectivity Technologies Inc. (Case No. 2:2023cv00449)

- Neurent

  v. The Foundry, LLC (Case No. IPR2024-00669)

- Netflix, Inc.

  v. VideoLabs, Inc. (Case No. IPR2023-00628)