in this article we discuss the use of patent citation analysis to identify additional technology applications and potential collaborators or licensees for the patented technology. U.S. law stipulates\(^1\) that:

“[Patents] shall have the attributes of personal property.”

As we noted in a previous article\(^2\) in Interface, the analogy between real property and intellectual property (patents) can provide helpful perspective. Of particular relevance to patent citation analysis is the analogy between the deed of real property and the claims of a patent. The deed defines the boundaries of ownership by the owner of the real property. The patent claims define the boundaries of ownership by the assignee of the patent. Recall, inventors are generally obligated to assign patent rights to their employer.\(^3\) In the case of real property, modern surveying methods lead to precise determination of the boundaries of the real property described in the deed. In the case of a patent, the courts have recognized that language can be imprecise:\(^4\)

“The nature of language makes it impossible to capture the essence of a thing in a patent application [claim].”

Consequently, the intellectual property “boundaries” defined by the claims are often referred to as the “metes and bounds” of the patent. The “metes and bounds” description is derived from an early system of defining the boundaries of real property, where the boundaries are described by the local geography of the parcel of land and are therefore somewhat imprecise.

Related to our discussion of opportunity prospecting, when a prospective buyer initiates the purchase of a parcel of land, a search is conducted by a title company to ensure there are no previous owners or legal encumbrances on the real property. During this search, the title company identifies previous owners, current owners, and neighboring properties.

Analogously, when an inventor files a patent application, an examination of the prior art is conducted by the U.S. Patent & Trademark Office (USPTO) to ensure there are no previous owners of all or part of the claimed invention upon which the pending patent application would “trespass.” If prior art is identified that impacts the patentability of a patent application, then the inventor may limit the claims of her/his patent application in order to overcome said prior art. In addition, during the prior art search, the patent examiner identifies background or “neighboring” prior art patents, published patent applications and other publications. Consequently, inventors have the opportunity to become aware of a rich landscape of prior art during examination of their patent applications.

Similarly, after a patent application is published and/or subsequently issues, it becomes part of the prior art landscape. Consequently, once a Faraday patent issues, we find it valuable to review the prior art landscape of “backward” citations cited during the examination of the patent application. Additionally, we continue to monitor U.S. Patent & Trademark Office actions to identify “forward” citations where Faraday patents are referenced as prior art against subsequent patent applications. These forward or “referenced by” citations provide the basis for opportunity prospecting by analysis of this analogous prior art.

Herein we provide an actual case study illustrating the use of patent citation analysis to identify additional technology applications and potential collaborators or licensees for one of Faraday’s patented technologies. To begin the case study, we provide a brief background of Faraday Technology Inc. as perspective.

Our perspective is based on over 25 years of experience at Faraday Technology Inc., a research, development, and engineering company, that was founded in 1991 to conceive, develop, and commercialize novel electrochemical technologies based on pulse current/pulse reverse current (PC/PRC) electrolytic principles. Excellent reviews on PC/PRC plating are available in the seminal work edited by

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Puippe and more recently updated. Our unique approach to PC/PRC plating AND surface finishing are summarized as well and illustrated in the company vision:

“To develop robust and environmentally friendly electrochemical deposition and surface finishing processes based on simple electrolytes enabled by pulse/pulse reverse electric fields.”

The company’s mission is to conceive and commercialize electrochemical processes based on the PC/PRC technology platform. To support these activities, funding is obtained through the U.S. Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs. These programs consist of a Phase I feasibility demonstration activity followed by a Phase II technology development and validation activity. Once the Phase II development activity has been completed, commercialization of the technology for private sector use or transition of the technology for government use comes from private sector or non-SBIR government funding, respectively. Critically, while the SBIR/STTR programs represent a highly competitive source of technology demonstration and validation funding, these programs allow the small business to retain assignment of the inventions “conceived or first actually reduced to practice” with said funds.

We first demonstrated the effectiveness of PC/PRC surface finishing of automotive planetary gears by replacing a DC electrochemical deburring process based on ethylene glycol with a PC process using a low concentration aqueous salt solution. Building on the deburring results, we obtained Phase I and II SBIR funding from the National Science Foundation to demonstrate the ability to use PRC to electropolish nickel alloy coupons in low concentration aqueous salt solution. This work provided the basis for two patents assigned to Faraday.

Subsequently, we were approached by an engineer from a manufacturer of stainless steel valves for the semiconductor industry. The manufacturer employed conventional DC electropolishing as the final step for surface finishing of their stainless steel valves, fittings and tubular products. The conventional electropolishing process was based on the well-established viscous salt film paradigm and used a chilled electrolyte solution consisting of concentrated sulfuric/phosphoric acid as well as proprietary additives that may have included fluoride species.

Under a stage-gated research-for-hire activity, we demonstrated the ability to electropolish their stainless steel coupons using PRC in conjunction with a low concentration aqueous salt electrolyte. We subsequently demonstrated and validated the PRC electropolishing process on actual stainless steel products using an α-scale manufacturing apparatus in Faraday’s prototyping facility. For competitive reasons, the manufacturing company wanted to retain exclusive rights to the subject technology and we negotiated a “field-of-use” license consistent with Faraday’s business model. The field-of-use license was defined as follows:

1. Market – semiconductor
2. Product – valves and fittings
3. Material – stainless steel

The license was based on two patents (Fig. 1) covering the subject PRC electropolishing technology.

As noted above, we continuously monitor our issued patents to review backward prior art citations and identify forward prior art citations. Specifically, we define them as follows:

1. Backward prior art citations: Prior art cited by Faraday inventors and/or the USPTO examiner during the prosecution of the Faraday patent application,
2. Forward prior art citations: Citations of the Faraday patent as prior art by the inventors and/or the USPTO examiner during the prosecution of subsequent patent applications.

Fig. 1. Faraday patent nos. 6,402,931 and 6,558,231 licensed to valve manufacturer.

Field-of-Use (FoU) License
- Market – Semiconductor
- Product – Valves & Fittings
- Material – Stainless Steel
These citations are easily tracked using the USPTO website or “Google patents.” In Fig. 2, we illustrate the search results for U.S. patent no. 6,558,231 (referred to below as the ‘231 patent) using Google Patents accessed on September 12, 2017. From the first page, we see that there were eight (8) background or prior art “patent citations” during the prosecution of the ‘231 patent. This number does not change as a function of the date the Google Patents database is accessed. In addition, we see that there are twenty-nine (29) forward or “referenced by” citations as of the date the Google Patent database was accessed. Clearly, these forward citations can change with time as subsequent patent applications issue. For our trivia readers, U.S. patents always issue on a Tuesday. As we show in Fig. 5, German patents usually issue on a Monday. Patent applications are reviewed on a first-come, first-served basis. For the ‘231 patent, we downloaded the complete patent by selecting the “Download PDF” hyperlink. We downloaded the complete patent by selecting the “US7153411” hyperlink, a Google patent page displaying the ‘411 patent appears. We downloaded the complete patent by selecting the “Download PDF” hyperlink. By reviewing the claims, we determined that the ‘411 patent was directed towards the method or process statutory class. As illustrated in Fig. 2, the forward citations highlighted with the ‘411 patent indicates that the method or process is an electropolishing method. Additionally, as illustrated in Fig. 3/FIG. 2 of the ‘411 patent indicates that the electropolishing method is directed towards medical stents using pulse reverse waveforms. Finally, by comparing the claims, we noted that many of the dependent claims were directed towards strong acid electrolytes with additions of chelating agents. This approach is in contrast to Faraday’s approach to development of PC/PRC electrochemical processes based on simple aqueous electrolytes.

To summarize, based on this straightforward and simple preliminary analysis, we identified a potential new application, of which we were not previously aware, for Faraday’s PC/PRC process development activities. A more detailed understanding of the prior art citation of Faraday’s ‘231 patent application may be obtained by reviewing the file history of the prosecution of the ‘411 patent at the USPTO Patent Application Information Retrieval (PAIR) website portal. In Fig. 5, we illustrate the various documents within the “Image File Wrapper” for the ‘411 patent. These documents represent the correspondences between the USPTO examiner and the patent applicant during the prosecution of the subject patent application. These correspondences include the examiner’s prior art search, the examiner non-final and final rejection office actions, the applicant’s responses to non-final/final rejections, applicant’s amendments to claims, issue notification and so forth. Our review of the prosecution history of the ‘411 patent application indicates that Faraday’s ‘231 patent was used to support an “obviousness” (35 USC §103) rejection of the claims directed towards pulse reverse electropolishing. The ‘411 patent applicant modified their claims to include limitations to the pulse reverse electropolishing method, which then allowed the patent to issue. As discussed earlier, there still could be “freedom to operate” issues associated with the ‘411 patent. With this analysis of analogous patent art, we identified a new opportunity for our platform PC/PRC technology directed towards electropolishing of medical stents in simple aqueous electrolytes enabled by our pulse reverse current approach. We successfully pursued funding from the National Institutes of Health (NIH) SBIR program and were awarded Phase I and Phase II projects. With this funding, we demonstrated the feasibility of electropolishing medical stent materials (nickel-titanium) in simple aqueous electrolytes. Subsequently, we worked with a supplier of nickel-titanium wire for stent applications to demonstrate and validate the pulse reverse electropolishing process in an α-scale reel-to-reel electropolishing apparatus consisting of 300 and 5,000 foot wire spools. These activities led to a license of the same two patents licensed to the semiconductor valve manufacturer but for a different “field-of-use” defined as follows:

1. Market – medical
2. Product – wire based stents and shape sets
3. Material – nickel-titanium alloys

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In summary, we presented a case study for opportunity prospecting by analysis of analogous patent art (Fig. 6). The approach uses forward or “referenced” by patent citation analysis to identify examiner or applicant prior art citations of the patent of interest during the prosecution of subsequent patent applications. The prior art citation analysis was illustrated using the Google patent search but is also easily conducted using the USPTO patent Boolean search function. While the case study was based on the experience at Faraday Technology Inc., an electrochemical research, development and engineering company with an electrochemical platform technology, we believe the approach would be valuable for other businesses, universities and federal laboratories. More specifically, we suggest that electrochemical scientists, engineers and technologists consider the patent literature in addition to their review of the technical literature.

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References
1. 35 U.S.C. §261 Ownership; assignment.
2. E. Jennings Taylor and Maria Inman, “Looking at Patent Law: Why Are Patents Often Referred to as Intellectual Property?” Electrochem. Soc. Interface, 26(1), 41 (2017).
3. E. Jennings Taylor and Maria Inman “Looking at Patent Law: Why Is the Word ‘Right’ Mentioned Only Once in the Constitution of the United States?” Electrochem. Soc. Interface, 26(2), 45 (2017).

About the Authors

E. Jennings Taylor is the founder of Faraday Technology, Inc., a small business focused on developing innovative electrochemical processes and technologies based on pulse and pulse reverse electrolytic principles. Jennings leads Faraday’s patent and commercialization strategy and has negotiated numerous via field of use licenses as well as patent sales. In addition to technical publications and presentations, Jennings is an inventor on forty patents. Jennings is admitted to practice before the United States Patent & Trademark Office (USPTO) in patent cases as a patent agent (Registration No. 53,676) and is a member of the American Intellectual Property Law Association (AIPLA). Jennings has been a member of the ECS for thirty-eight years and is a fellow of the ECS and currently serves as treasurer. He may be reached at jenningstaylor@faradaytechnology.com.

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Fig. 5. Image file wrapper for Boston Scientific patent no. 7,153,411.

Commercial project to develop PRC
electrochemical deburring of carbon steel planetary gears in aqueous salt solution

NSF SBIR funds to demonstrate PRC
electropolishing of passive alloys in low concentration aqueous salt solution (SBIR funding enabled IP rights to be retained)

Faraday Patent 6,558,231

Faraday Patent 6,402,931

Commercial project to develop PRC
electropolishing of semiconductor valves in low concentration aqueous salt solution

Licensing deal for PRC
electropolishing of stainless steel valves

Boston Scientific Patent Application with broad claims around PRC Electropolishing

Citation analysis identified new opportunity!

Fig. 6. Case study of opportunity prospecting.

Commercial project to develop PRC
electropolishing of Nickel-Titanium (Nitinol) stents in dilute acid solution

Licensing deal for PRC
electropolishing of Nitinol stents and shape sets

Commercial project to develop PRC
electropolishing of Nickel-Titanium (Nitinol) stents and shape sets in dilute acid solution

Boston Scientific Patent issued with limited claims around PRC Electropolishing

Allowance

Amendment

Rejection of Claims

‘411 broad claims for PRC Electropolishing rejected based on ‘231 patent

4. Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 535 U.S. 722 (2002).
5. J. C. Puipe and F. Leaman, Theory and Practice of Pulse Plating, AESF, Orlando, Florida (1986).
6. W. E. G. Hansel and S. Roy, Pulse Plating, Leuze Verlag KG, Germany (2012).
7. E. J. Taylor, “Adventures in pulse/pulse reverse electrolytic processes: explorations and applications in surface finishing,” *J. Appl. Sur. Fin.*, 3(4), 178 (2008).
8. E. J. Taylor, M. E. Inman, H. M. Garich, H. A. McCrabb, S. T. Snyder, and T. D. Hall, “Breaking the Chemical Paradigm in Electrochemical Engineering: Case Studies and Lessons Learned from Plating to Polishing.” *Advances in Electrochemical Science & Engineering: Electrochemical Engineering: The Path from Discovery to Product*, Volume XVIII to be published (2018).
9. 35 U.S.C. 201 (1980) Definitions, Bayh-Dole Public Law 96-517, December 12, 1980.
10. E. J. Taylor and M. Inman, “Electrochemical Surface Finishing,” *Electrochem. Soc. Interface, 23*(3), 51 (2014).
11. J. J. Sun, J. J. Sun, L. E. Gebhart, R. P. Renz, E. J. Taylor, and M. E. Inman, “The application of CM-ECM technology to metal surface finishing” in *Proceedings North American Manufacturing Research Institution of the Society of Manufacturing Engineers*, MR00-209 NAMRC XXVIII May 24-26, Lexington, KY (2000).
12. P. A. Jacquet, “On the anodic behavior of copper in aqueous solutions of orthophosphoric acid” *Trans. Electrochem. Soc.*, 69(1), 629 (1936).
13. E. J. Taylor and P. Miller, “Innovation case studies at an R&D company... alignment of technology, intellectual property and financial matters,” *Les Nouvelles XXXVI* (No. 2), June (2001).
14. C. Zhou, E. J. Taylor, J. J. Sun, L. E. Gebhart, and R. P. Renz, “Electrochemical machining method using modulated reverse electric fields,” U.S. Patent No. 6,402,931, issued June 11, 2002.
15. E. J. Taylor, “Sequential electromachining and electropolishing and the like using modulated electric fields,” U.S. Patent No. 6,558,231, issued May 6, 2003.
16. http://patft.uspto.gov/netahtml/PTO/search-adv.htm, last accessed: Oct. 2017.
17. https://www.google.com/?tbm=pts&hl=en, last accessed: Oct. 2017.
18. E. Jennings Taylor and Maria Inman, “Looking at Patent Law: Patentable Inventions, Conditions for Receiving a Patent, and Claims,” *Electrochem. Soc. Interface, 26*(3), 44 (2017).
19. https://portal.uspto.gov/pair/PublicPair, last accessed: Oct. 2017.
20. E. J. Taylor, M. E. Inman, T. D. Hall, and B. Kagajwala, “Electropolishing of Passive Materials in HF-Free Low Viscosity Aqueous Electrolytes,” *ECS Trans.*, 45(8), 13 (2013).
21. H. Garich, T. Hall, S. Lucatero, S. Snyder, M. Inman, E. J. Taylor, and L. Kay, “Electrochemical Polishing of Nitinol and Other Medical Alloys in Aqueous Electrolytes Using Pulse/Pulse Reverse Electric Fields,” Paper 1248 presented at The Electrochemical Society Meeting, Chicago, IL, May 24-28, 2015.