FEATURES

Looking at Patent Law: Patenting a Trivalent Chromium Plating Invention: Obviousness Rejections – Not So Obvious

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Non-Obviousness

In a previous column, we discussed the requirements for obtaining a patent on an invention. In addition to fulfilling the requirements of usefulness, falling into one of the patentable statutory classes, and not anticipated by the prior art, an invention must be non-obvious in light of the prior art, specifically:

“A patent for a claimed invention may not be obtained…if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art…”

The non-obviousness requirement evolved over time as a common law requirement and was added to the patent statute in 1952. Obviousness rejections are generally based on a combination of multiple prior art references and are considered the most common reason for rejections of patent applications. After reading patents, many scientists, engineers, and technologists often conclude that most patented inventions are “obvious.” This notion may generally be attributed to hindsight bias.

To avoid hindsight bias, the definition of the “person having ordinary skill in the art” (PHOSITA) is critical. The PHOSITA is a hypothetical person who is assumed to be familiar with the relevant prior art at the time of the invention and has the capability of understanding the relevant scientific and engineering principles. In addition, the PHOSITA is a person of ordinary creativity and is not an automaton.

While the 1952 patent statute did not provide explicit guidance on making an obviousness determination, in 1966 the Supreme Court added clarity regarding obviousness considerations in a landmark case, Graham v. John Deere.

The Supreme Court noted that obviousness determinations begin with the following analysis:

1. Determining the scope of the prior art;
2. Ascertaining the differences between the claimed invention and the prior art; and
3. Resolving the level of ordinary skill in the pertinent art.

The level of ordinary skill in the art is determined by:

1. Type of problems encountered in the art;
2. Prior art solutions to those problems;
3. Rapidity with which innovations are made;
4. Sophistication of the technology; and
5. Educational level of active workers in the field.

As noted above, obviousness considerations are the most common basis for patent application rejections and are generally the most challenging to overcome. The 1966 Graham v. John Deere ruling suggested a number of factors that could point to non-obviousness:

1. Demonstration of commercial success;
2. Solution to a long felt but unresolved need;
3. Lack of success or failure of others;
4. Results that would be unexpected to one of ordinary skill in the art;
5. Demonstration of copying by others;
6. Success in licensing the invention;
7. Skepticism of experts.

While the Graham v. John Deere ruling added considerable clarity to obviousness determinations, the Supreme Court recognized the challenges associated with obviousness matters:

In this installment of the “Looking at Patent Law” articles, we discuss obviousness rejections in view of a case study of a trivalent chromium plating invention. We have chosen this invention to align with the sustainability focus of this issue of Interface. The article begins with a brief review of obviousness followed by a brief description of the trivalent plating invention. The article concludes with a case study of the inventions/patent applications related to the trivalent plating process with a focus on the obviousness rejections.
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(continued from previous page)

“What is obvious is not a question upon which there is likely to be uniformity of thought in every given factual context.”

An extensive legal review of case law from the Patent and Trial Appeals Board, the administrative adjudicatory board of the U.S. Patent and Trademark Office (USPTO), provides a detailed guide of successful arguments for rebuffing obvious rejections.8,9

Trivalent Chromium Plating Inventions

As a brief background, Faraday Technology, Inc. is a research, development, and engineering firm developing electrochemical innovations based on pulse/pulse reverse electrolytic principles. One of Faraday’s innovations is directed towards the development of a functional chrome plating process based on a trivalent chromium electrolyte to replace chrome plating from hexavalent electrolytes. Faraday’s trivalent chromium plating technology is the subject of a recently issued patent and the basis for the 2013 Presidential Green Chemistry Challenge Award.10 Faraday has been working on the trivalent chromium technology since the mid-1990s.

Chrome coatings plated from a hexavalent chromium electrolyte are widely used in both military and commercial markets due to their functional properties, such as hardness, sliding wear, and abrasion resistance. Due to its toxicity, the EPA lists hexavalent chromium as a “hazardous air pollutant” as it is a human carcinogen, a “priority pollutant” under the Clean Water Act, and a “hazardous constituent” under the Resource Conservation and Recovery Act.

Plating from trivalent chromium plating baths has been commonly practiced for decorative applications, such as car bumpers, plumbing fixtures, hubcaps, and the like. Trivalent chromium is found naturally in the environment and is not a known carcinogen. For decorative applications, the plated chrome coating is thin, typically <10 µm. In contrast, functional chrome coatings are thick (~4 mils) in order to provide the desired functional properties, such as wear resistance.11 As previously practiced, plating from trivalent chromium electrolytes was self-limiting, and thick coatings were not possible.

For functional trivalent chromium plating to become a reality, several innovations are required. These include: 1) thick chromium coatings (>4 mils) comparable to hexavalent chromium plating; 2) equivalent properties to hexavalent chromium plating; and 3) a microstructure devoid of through-cracks similar to hexavalent chromium plating. While these attributes are all considered innovations by those familiar with chromium plating, as evidenced in the case study herein, an innovation is not necessarily granted patent protection as an invention. In fact, early attempts to patent the innovations associated with the trivalent chromium plating process were rejected by the USPTO as obvious in view of the prior art. We remind the reader that a patent is a legal document, not a technical document, and that what we might think is technically non-obvious (an innovation) is not the same as legally non-obvious (an invention). As always, please consult an attorney for clarification with regard to your particular case.

Recall from our previous article,12 the prosecution (examination) history of a patent application is publicly available in the file wrapper on the USPTO Patent Application Information Retrieval (PAIR) system.13 With the PAIR system as the primary source of information for this case study, we review the prosecution history and obviousness rejections associated with the trivalent chromium plating process.

Prosecution of Trivalent Chromium Plating Patent Applications

Utility Patent Application – Pulse Reverse Plating of Thick Chromium Coatings from Trivalent Chromium Electrolyte

Chromium plating from a trivalent chromium electrolyte (as well as hexavalent electrolyte) is generally <20% faradaic efficiency (eq. 1) with >80% (eq. 2) of the current resulting in hydrogen evolution:

\[
\text{Cr}^{3+} + 3e^- \rightarrow \text{Cr}^0 \\
2\text{H}^+ + 2e^- \rightarrow \text{H}_2 \uparrow
\]

We speculated that the self-limiting nature of trivalent chrome plating was related to the high pH at the interface due to the hydrogen evolution reaction (eq. 2). In order to electrodoposit thick chromium coatings from trivalent chromium electrolytes, Faraday hypothesized that by using an appropriately designed pulse reverse waveform the pH excursion at the interface could be avoided. Specifically, during the anodic reverse pulse the nascent hydrogen would be oxidized (eq. 3) or oxygen evolution (eq. 4) would occur:

\[
\text{H}_2 \rightarrow 2\text{H}^+ + 2e^- \\
\text{H}_2\text{O} \rightarrow \frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2e^- 
\]

In either case, the interface would be reacidified and chromium electrodeposition could continue. We demonstrated the ability to electrodoposit thick chromium coatings from a trivalent chromium electrolyte using the pulse reverse current approach.14 The resulting chromium coating exhibited the same or superior properties as coatings plated from a hexavalent chromium plating bath.

On June 9, 1997, we filed a utility patent application titled “Electroplating of Metals Using Pulsed Reverse Current for Control of Hydrogen Evolution.”15 A key figure from the patent application (08/871,599) depicts a pulse reverse current waveform (Fig. 1). The key concept is described in the abstract of the ‘599 patent application:

“Excessive evolution of hydrogen in electrolytic deposition of metals...can be controlled by using pulse reverse current...[to] consume at least some of the nascent hydrogen and prevent the local pH at the cathode from becoming excessively alkaline...[and] alleviates problems caused by metal-bearing-ions with hydroxide ions generated near the cathode by evolution of hydrogen.”

The utility patent application contained claims directed towards one statutory patent class, method (for pulse reverse plating of thick chromium coatings from a trivalent electrolyte).16 An exemplary independent claim18,19 from the patent application is:

Claim 1 (as filed in the ‘599 patent application). A method for electrolytic deposition of metals on a cathode substrate comprising:

i. immersing an electrically conductive anode and an electrically conductive cathode in an aqueous plating bath containing metal-bearing ions, hydrogen ions, and hydroxide ions, said metal-bearing ions being capable of migrating to said cathode and being discharged at said cathode and depositing metal thereon,

ii. passing an electric current from said anode to said cathode through said plating bath, whereby said metal-bearing ions carry a first fraction of said current by migrating to said cathode at said cathode and being discharged at said cathode, and said hydrogen ions being capable of migrating to said cathode and being discharged at said cathode to form hydrogen gas, whereby the concentration of said hydroxide ions in the vicinity of said cathode is increased, said metal-bearing ions being capable of reacting with said hydroxide ions in the vicinity of said cathode whereby deposition of said metal on said cathode is inhibited, and said cathode being inhibited, and said hydroxide ions in the vicinity of said cathode whereby deposition of said metal on said cathode is inhibited;
specify plating from trivalent chromium. Subsequent dependent claims included trivalent chromium as well as other metals plated at low current efficiency. The specification provided examples summarizing thirteen experiments of pulse reverse plating resulting in thick chromium coatings from a trivalent chromium electrolyte.

In our Information Disclosure Statement (IDS), we included earlier work by researchers at the National Institute of Standards and Technology (NIST) directed towards a functional trivalent chromium plating process based on direct currents or pulse currents (no reverse). The NIST process required a high temperature (~650°C) post-plating heat treatment to obtain the desired hardness.

The USPTO examiner rejected all claims of the ‘599 patent application as obvious based on the admitted prior art (NIST patents) in view of Loch (U.S. Pat. No. 4,666,567) and Tamhaukar (U.S. Pat. No. 5,242,535). Recall, obviousness rejections generally result from a combination of prior art references.

The examiner stated the NIST patents demonstrated that it was previously known to plate from a trivalent chromium electrolyte. Loch disclosed the use of pulse reverse current plating processes and in the range of pulse reverse parameters disclosed in the ‘599 patent application. Finally, Tamhaukar taught that nascent hydrogen produced during pulse reverse plating is oxidized during the reverse cycle.

The examiner concluded:

“The prior art of record is indicative of the level of skill of one of ordinary skill in the art…[and] it would have been obvious at the time of the invention...to have utilized reversed pulse plating...”

The examiner further stated that the choice of pulse reverse plating parameters was

“…a matter of routine optimization within the skill of the ordinary worker in the art.”

Note, in presenting an obviousness rejection, the examiner must “define” the hypothetical person having ordinary skill in the art (PHOSITA) at the time the patent application was filed based on the guidance presented above. After establishing the PHOSITA, the examiner then links the prior art references in order to reject each claim element of the subject patent application.

Curiously, Tamhaukar, et al. was directed towards plating copper for circuit board applications. Copper plating exhibits nearly 100% faradaic efficiency and hydrogen evolution (and its adverse effects) is not an issue. However, since Tamhaukar taught the use of reverse pulses to consume hydrogen during plating, the fact it was directed towards copper was irrelevant to its use in combination with other prior art for an obviousness rejection.

Finally, an important distinction of the ‘599 patent application and the NIST prior art was that the ‘599 patent application did not require a high temperature post-plating heat treatment to achieve the desired hardness. During an interview, the examiner indicated that reproducing the NIST results and comparing the hardness with and without the post-plating heat treatment might distinguish the ‘599 patent application from the NIST prior art. This would not distinguish from the other prior art and consequently this approach was not pursued.

Utility Patent Application – Promoting Microcracking During Plating of Chromium Coatings from Trivalent Electrolyte

Chromium plating from a hexavalent electrolyte exhibits discontinuous microcracks. In contrast, pulse reverse chromium plating from a trivalent electrolyte exhibits continuous through-cracks. While the properties of the trivalent pulse reverse plated chromium do not appear to be adversely impacted by the continuous through-cracks, the different visual appearance presents cause for concern for many applications.

The discontinuous microcracks in hexavalent-plated chromium have long been associated with the high tensile stress that develops in the coating during plating. Specifically, during hexavalent chromium plating, once the critical chromium deposit thickness (~5 µm) is reached, stress-relieving cracks occur in the deposit. As plating continues, new stress-relieving cracks occur in the coating at subsequent critical thicknesses. These stress-relieving cracks occur randomly. When plating thick chromium coatings (~4 mil) the cracks do not align, resulting in discontinuous microcracks.

In contrast, during trivalent chromium plating large compressive stresses accrue. However, the stress-relieving cracks occur after plating has been completed, resulting in continuous through-cracks. We demonstrated that we could form discontinuous microcracks by looping between various waveform parameters during trivalent chrome plating.

On August 9, 2006, we filed a utility patent application titled “Electrolytic Looping for Forming Layering in a Deposit of Chromium.” A figure depicting the discontinuous microcracks in prior art hexavalent chromium plated coatings from the patent application (11/501,551) is presented in Fig. 2. Figure 2 depicts a substrate [100] and a chromium coating [200]. The chromium coating contains discontinuous microcracks within the coating [304], from the substrate within the coating [306], and from the surface within the coating [302].

Figure 3 from the ‘551 patent application depicts the continuous through-cracks in prior art trivalent chromium plated coatings. Figure 3 depicts a substrate [100], a chromium coating [200], and... (continued on next page)
some discontinuous microcracks, [302], [304], and [306]. However, trivalent chromium coating also contains continuous through-cracks [308].

Figure 4 from the ‘551 patent application depicts the discontinuous microcracks resulting from looping between multiple trivalent chromium pulse reverse plating parameters. Figure 4 depicts a substrate [100], and a chromium coating [200]. The chromium coating is built up as layers [200a], [200b], [200c], and [200d] during looping between multiple plating parameters. The individual layers exhibit some discontinuous microcracks, [302], [304], and [306]. However, the individual layers also exhibit continuous through-cracks [308a], [308b], [308c], and [308d]. However, when the looping pulse reverse plating is complete, the continuous through-cracks within the individual layers generally do not align, resulting in the elimination of continuous through-cracks in the final chromium coating [200].

The key concept is described in the abstract of the ‘551 patent application:

“A method for depositing a metal...performing a first electrolytic process for a predetermined first period of time, performing a second electrolytic process for a predetermined second period of time and looping between the first and second electrolytic processes to form a coating of the metal on the substrate.”

The utility patent application contained claims directed towards one statutory patent class, method (for looping pulse reverse plating of thick chromium coatings without continuous through-cracks from a trivalent electrolyte). An exemplary independent claim, from the patent application is:

Claim 1 (as filed in the ‘551 patent application). A method for depositing a metal onto a substrate comprising the steps of: providing a plating bath including ions of said metal; positioning said substrate in said plating bath; performing a first electrolytic process for a predetermined first period of time; performing a second electrolytic process for a predetermined second period of time; and looping between said first electrolytic process and said second electrolytic process to form a coating of said metal on said substrate.

The italics emphasize how the solution of the abstract translate into claim language. Subsequent dependent claims specified the plated metal as chromium and the electrolyte as containing trivalent chromium ions. In addition, dependent claims specified a maximum number of through-cracks and various ranges of plating parameters. The specification provided six examples of looping experiments resulting in less through-cracks compared to a non-looping baseline experiment for pulse reverse chromium plating from trivalent chromium electrolyte.

In the initial Non-Final Office Action (NFOA), the USPTO examiner rejected the claims as obvious based on two technical publications, Jorgensen, et al.24 and Leisner, et al.25 These articles were directed towards looping between a first pulse reverse current electrolytic process and a second direct current electrolytic process to create alternating layers of crack and crack-free chromium deposits. Both of these activities were directed towards chrome plating from hexavalent electrolyte. In response to the NFOA, we amended independent Claim 1 to specifically identify chromium plating and to specify that the looping used pulse reverse waveforms, not direct current.

Claim 1 (as amended in the response to the NFOA in the ‘551 patent application). A method for depositing [a metal] chromium onto a substrate comprising the steps of: providing a plating bath including ions of said [metal] trivalent chromium; positioning said substrate in said plating bath; positioning at least one counter electrode in said plating bath; performing a first [electrolytic] pulse reverse current process for a predetermined first period of time; performing a second [electrolytic] pulse reverse current process for a predetermined second period of time; and looping between said first [electrolytic] pulse reverse current process and said second [electrolytic] pulse reverse current process to form a multi-layered coating of said [metal] chromium on said substrate.

Note, the bracketed “[ ]” text is newly deleted from the amended claim and the underlined “” text is newly inserted into the amended claim. With the amendment and supporting arguments, we were able to traverse the obviousness rejection based on the Jorgensen, et al. and Leisner, et al. prior art.

The examiner responded with new obviousness rejections based on Faraday prior art, the original ‘599 trivalent chromium plating patent application (Faraday I) and a Faraday U.S. Pat. No. 6,309,528 (Faraday II).26 Faraday I was published on December 27, 2001, and was prior art to the ‘551 patent application. Faraday II was directed towards plating copper on printed circuit boards containing z-axis interconnects (through-holes and vias) of different sizes. Different pulse reverse waveforms were sequentially applied to plate the large interconnects (through-holes) followed by the small interconnects (vias).
The examiner stated that Faraday I teaches plating of chromium from a trivalent chromium electrolyte using pulse reverse current waveforms. Faraday II teaches copper plating by performing a first pulse reverse current process followed by a second pulse reverse current process. The examiner concluded that it would have been:

“...obvious to one having ordinary skill in the art at the time the invention was made to have modified the plating bath described by Faraday II with...trivalent chromium ions...[because] plating from a trivalent chromium bath would have had certain technical advantages as taught by Faraday I.”

Next the examiner turned to dependent Claim 10 from the ‘551 patent application. Dependent Claim 10 added a new limitation to Claim 1 specifying a maximum number of cracks resulting from the pulse reverse current looping process.

Claim 10. The method of Claim 1 wherein said coating has less than 50 cracks per centimeter formed continuously through said coating.

The examiner rejected dependent Claim 10 based on obviousness as well. The examiner relied heavily on common law precedent to support the obviousness rejection.27 Citing precedent and referring to the “less than 50 cracks per centimeter limitation,” the examiner stated28:

“...a method claim is not given weight when it simply expresses the intended result of a process step…”

The examiner continued that Faraday I teaches a similar method (pulse reverse plating of chromium from a trivalent electrolyte) and citing additional precedent29:

“...similar processes can reasonably be expected to yield products which inherently have the same properties.”

The examiner concluded, again citing precedent30:

“...the prior art motivation...may be different...while still supporting a conclusion of obviousness.”

In essence, the examiner’s basis for the obviousness rejection was that the prior art disclosed pulse reverse current plating of chromium from a trivalent chromium electrolyte and disclosed looping between different pulse reverse waveforms. The fact that the prior art was not directed towards obtaining microcracks was irrelevant because the microcracks (~50 per cm) were inherent to the process claimed in the ‘551 patent application. An important lesson is that your own prior art can count against your future patent applications; not just prior art from other inventors.

Utility Patent Application – Focused Patent Application Claiming Range of Pulse Reverse Parameters and Specifying the Components of the Plating Bath

Based on our experiences with the prior art obviousness rejections in the previous ‘559 and ‘551 patent applications, we changed our strategic approach regarding the pulse reverse functional trivalent functional chromium plating innovations. Specifically, we elected to file a patent application claiming a range of pulse reverse waveform parameters in conjunction with a specific plating bath. We elected to maintain specific waveform parameters and looping sequences to accomplish microcracking proprietary as trade secrets. As both patents and trade secrets may be licensed, this approach supported our licensing commercialization strategy.

Using this strategy, on August 14, 2015, we filed utility patent application titled “Electrodeposition of Chromium from Trivalent Chromium using Modulated Electric Fields” (14/826,971). The ‘971 patent application was preceded by and claimed priority to a provisional patent application (61/603,646) and a separate utility patent application (13/768,285). On October 16, 2018, U.S. Patent

FIG. 5. Pat. No. 10,100,423 Illustrating Pulse Reverse Waveform.

No. 10,100,423 was issued.31 The key figure from the ‘423 patent, presented in Fig. 5, is a pulse reverse waveform.

The patented process including waveform and trade secrets have been licensed to a chemical formulator. In a sense, we arrived at where we began. Specifically, initially we broadly claimed a pulse reverse waveform without specifying all the constituents of the trivalent chromium-plating electrolyte. The final patent more narrowly claimed a pulse reverse waveform in conjunction with a specific trivalent chromium-plating electrolyte. While the ‘423 patent was narrower than the original patent application, the ‘423 patent aligned with our trade secret and met our licensee’s commercialization objectives.

Summary

In this installment of our “Looking at Patent Law” series, we review the prosecution history of three patent applications directed towards a functional trivalent chromium plating invention. The case study begins with a review of obviousness rejections and the background associated with the development of the trivalent chromium plating process for functional applications. The prosecution history illustrates the role of the hypothetical person having ordinary skill in the art (PHOSITA) in the USPTO examiner’s analysis of obviousness. As illustrated in the case study, an innovation is not necessarily awarded patent protection and legal obviousness is clearly distinct from technical obviousness. Finally, alignment of patents with trade secrets can provide a viable commercialization path. With this case study, we hope to de-mystify the patent prosecution process and better prepare electrochemical and solid state scientists, engineers, and technologists to interact with their patent counsel regarding their inventions.

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