Sixteen Years After the Passage of the U.S. Semiconductor Chip Protection Act: Is International Protection Working?

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Abstract

Sixteen years ago, the U.S. Congress passed the Semiconductor Chip Protection Act ("SCPA") in an attempt to provide national protection from chip piracy to U.S. chip manufacturers and encourage international efforts to reduce chip piracy worldwide. In this Article, the author evaluates the SCPA's effectiveness. The author concludes that the Act has influenced foreign legislation and international treaty provisions, but has provided virtually no real chip protection. Instead, technological advances, market changes, and improvements in industry practice have protected chip manufacturers from chip piracy. Before reaching his conclusion, the author describes the origins of the SCPA and gives an overview of the Act, including general provisions and a criticism of the protected subject matter's scope. The author then compares foreign chip protection acts and international chip provisions with the SCPA, arguing that worldwide chip piracy has declined mostly for reasons unrelated to foreign chip legislation. While changes in technology and the market have mostly rendered chip protection laws obsolete in technologically advanced nations, the author concludes by hinting that such laws might be helpful in less technologically developed nations.

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I. Introduction

If most Americans were asked to name a product that utilizes a semiconductor chip, responses would probably include items such as a computer or a cellular phone. A few might mention calculators, VCRs, or television sets. Most people, however, would limit their answer to various high-tech devices with which they interact on a daily basis. While these answers are certainly correct, Americans in general fail to appreciate the prevalence of semiconductor chips and their increasing penetration into every aspect of our daily life.

Most people certainly recognize that electronic devices such as DVD players, laptops, and palm pilots all contain semiconductor chips, which are packaged integrated circuits ("ICs"). However, most are unaware that integrated circuits can be found in a wide variety of household products besides high-tech electronic equipment. Alarm clocks, cameras, lamps, air conditioners, and even common kitchen appliances, such as refrigerators and toaster ovens, may employ semiconductor technology. Outside the home, cars, airplanes, traffic lights, and railroad crossings may contain ICs. In short, the importance of ICs has grown recently to encompass products never before imagined. The future will only see further expansion of this list.

Americans would not be so reliant on ICs but for the astonishing advances in semiconductor technology over the past thirty years. For example, when Intel first introduced its microprocessor in 1971, it contained only 2,300 transistors. After thirty years of development, today's Pentium processor contains over fifty-five million transistors, a two million percent increase over the first generation. ICs have also shrunk in size. For example, the gate length of certain ICs has gone from 10 microns—roughly one-fifth the thickness of a hair strand—to 0.18 microns or less, approximately one-thirty-fifth the size of a red blood cell. As scientists have been able to fit faster ICs onto smaller surface areas, more products have incorporated ICs into their design, allowing them to function more efficiently and perform enhanced operations. Scientific obstacles, however, are not the only barriers the industry has had to overcome in the race to develop new and improved semiconductor chips.

Ever since the early 1970s, chip pirates have quickly produced copies of semiconductor chips at vastly reduced prices by copying chip designs and avoiding the expensive research and development phase. This problem has been particularly notorious in the United States where, until 1984, there was virtually no intellectual property protection for the IC layout,[1] which cost millions of dollars to design and develop. Due to the scant protection for IC layouts, by the late 1970s, chip piracy grew to become a serious problem for the chip industry. As a result, the manufacturers of ICs sought some sui generis (of its own kind or class) form of intellectual property protection for this backbone of modern technology.

In 1984, in response to complaints by the semiconductor industry, the U.S. Congress realized that some form of protection was needed for the semiconductor industry and passed the Semiconductor Chip Protection Act ("SCPA"). After the passage of the SCPA, many industrialized countries quickly adopted their own laws protecting integrated circuit layouts. International agreements also began to emerge as countries worked together to ensure IC protection around the world. For the first time since the invention of the semiconductor chip, IC manufacturers were granted protection for their design layouts in most of the developed world.

Ironically, by the time these provisions were in place, they were largely obsolete. Despite substantial pirating around the world, companies in countries that passed such legislation did not bring suit against alleged infringes. In the United States, there is only one appellate court decision regarding the SCPA, and courts in other countries with similar legislation seldom invoke these acts. This Article attempts to explain these developments.

Beginning with the original justifications for the SCPA, Part II of this Article discusses why a sui generis form of protection was deemed necessary for semiconductor chip manufacturing and why patents, copyrights and trade secrets were insufficient to protect the layout of integrated circuits or mask works. Part III summarizes the SCPA, including its general provisions, the protected subject matter, the infringement analysis, the reverse engineering defense, and international reciprocal protection provisions. Part IV compares the SCPA to other significant foreign integrated circuit topography protection acts.

Parts V and VI discuss the Washington Treaty on Intellectual Property in Respect of Integrated Circuits ("IPIC"), the Agreement on Trade Related Aspects of Intellectual Property Rights ("TRIPS"), and the North American Free Trade Agreement ("NAFTA") provisions related to integrated circuit topographies. Part VII analyzes the reasons—primarily technological and economic—why chip piracy has declined recently despite lack of enforcement under the SCPA and foreign chip protection acts. Finally, Part VIII argues that the international chip protection laws still serve an important deterrent function in the developing world. First, however, it is useful to examine the reasons why the SCPA was originally passed in the mid-1980s.

I. Sui Generis Protection of Semiconductor Chips: Why Congress Deemed Chip Protection Necessary and Why Patent, Copyright, and Trade Secret Laws Were Insufficient

The need for a sui generis form of protection developed primarily as a result of chip piracy, which threatened to undercut the vitality of the semiconductor industry. Chip pirates could sell identical chips for lower prices than could the companies that originally designed them. This caused legitimate companies that engaged in chip research and development to cut prices to compete with pirated chips, which deprived legitimate companies of the funds needed to carry out further research and development to build the next generation of chips.[2] Legitimate companies could not get adequate chip protection under patent, copyright, or trade secret law, so Congress provided a sui generis form of protection.

Before examining the nature of sui generis protection required for integrated circuits, it is important to first understand integrated circuit manufacturing and patenting processes in the semiconductor industry.[3]

First, a distinction must be made between semiconductor devices and integrated circuits. A semiconductor device is an electronic device that contains a semiconductor material, whereas an integrated circuit is made up of many semiconductor devices. While silicon is the most commonly used semiconductor material, other semiconductor materials, such as germanium, may be used to make semiconductor devices. Compounds from periodic table groups IIIa and Va;[4] and IIb and VIa[5] elements are also semiconductor materials that are used in semiconductor devices. All these materials are called semiconductors because their conductivities vary between those of an insulator and those of a conductor, depending on the material's purity level. They do not conduct electricity if the applied voltage is below a certain threshold voltage, but they do conduct electricity if the applied voltage exceeds the threshold voltage. As stated above, semiconductor devices make up the building blocks of integrated circuits. The manufacturing processes are described in detail in the Appendix.

Integrated circuits are comprised of numerous building blocks, each block being patentable. The U.S. Patent & Trademark Office ("PTO") grants hundreds of utility patents on these individual semiconductor devices each year.[6] On the other hand, utility patent protection for the entire integrated circuit is often inadequate. Since an integrated circuit contains hundreds or thousands of semiconductor devices, a claim to an integrated circuit would have to cover hundreds or thousands of individual elements. Consequently, a patent claim that attempts to recite an entire integrated circuit may be hundreds of pages long. Clearly, such a narrow claim would provide almost no protection. Even if one sought such narrow protection, writing a patent application supporting a claim with thousands of elements would be extremely complex, cumbersome, and expensive. Obviously, integrated circuits are not easily described in a patent specification or the claims.

Beyond being impractical to file in the United States, it may take several years to obtain an integrated circuit patent from most patent offices worldwide. This is unacceptable given that an integrated circuit's useful commercial life may be less than one year.[7] Some authors even suggest that the PTO would not provide patent protection for integrated circuit layout because all layouts may already be considered obvious variations of prior layouts under patent law.[8] The cumbersome, time-consuming nature of filing combined with extremely narrow protection often makes utility patent law an insufficient form of protection for integrated circuits.

Other forms of existing intellectual property protection are also inapplicable to integrated circuit layouts. Design patents protect the ornamental, but not the functional, aspects of an article of manufacture described in its drawings.[9] Since integrated circuit layout is more functional than ornamental, design patent protection is generally inapplicable to integrated circuits.

As with design patents, a functionality doctrine in copyright law prohibits protection of integrated circuits.[10] The Copyright Office has refused to register integrated circuit topographies because they are considered utilitarian.[11] Besides, copyright law would provide exclusive rights for an unreasonably long time for a functional article of manufacture, and therefore would not be appropriate to apply to integrated circuits.[12]

Finally, trade secret law cannot be used to protect most integrated circuits because an integrated circuit layout may be reverse-engineered. Reverse engineering is a complete defense to a claim of trade secret misappropriation.[13] As a result, trade secret protection generally becomes unavailable several months after an integrated circuit is sold on the market because its layout can be reverse-engineered by the competitors.[14] An exact duplicate of the integrated circuit can be made without incurring trade secret misappropriation liability.[15] Given that patent, copyright, and trade secret law cannot adequately protect integrated circuit design, sui generis protection for integrated circuit topographies and layouts became necessary to the semiconductor industry in the late 1970s and the early 1980s.[16]

I. The U.S. Semiconductor Chip Protection Act

Due to the need for sui generis protection of integrated circuits, Congress passed the Semiconductor Chip Protection Act (SCPA) in 1984[17] after heavy lobbying by the semiconductor industry.[18] Since the SCPA was the first sui generis integrated circuit protection law in the world, Congress had no previous law to use as a model or template. Unfortunately, as a result Congress drafted an ambiguous statute.

I. General Provisions

The SCPA authorizes the owner of a "mask work" to reproduce the mask work, to import or distribute a semiconductor chip product in which the mask work is embodied, and to induce another to do the same for a period of ten years.[19] The SCPA also contains a first sale provision, permitting importation, distribution or disposition, but not reproduction of a chip, made by the mask work owner.[20] In other words, one can resell chips purchased from the manufacturer without further SCPA liability, but one cannot copy such chips.

Protection under the SCPA commences on the date that the mask work is either registered with the U.S. copyright office or is commercially exploited anywhere in the world, whichever occurs first.[21] The mask work falls into the public domain if it is not registered within two years from the date of first commercial exploitation.[22] In other words, a mask work owner that does not initially register the mask work has two years from the date of its first commercial exploitation to register the mask work if the owner wishes to bring an infringement suit. It is important to register the mask work because chip registration is the prerequisite for copyright protection of the mask work. It follows that registration is also a prerequisite for an infringement suit under the SCPA,[23] and is prima facie evidence of the facts stated in the certificate and that the applicant has met all SCPA requirements.[24]

Registration requires filing an application with the Register of Copyrights that contains a prescribed form,[25] and depositing four chips embodying the mask work—a rather burdensome requirement.[26] But, the most onerous registration requirement is that the mask work owner submit drawings or plots of each layer of the mask work.[27] There is one exception to this rule: If the mask work contains trade secret information, layers of the mask work may be blocked out from submitted drawings. No more than forty percent of all layers of a commercially exploited mask work (i.e., two out of five mask layouts) may contain withheld or blocked-out information.[28]

I. Protected Subject Matter

The SCPA generally protects mask works fixed in the semiconductor chip product, but not the integrated circuit layout or topography.[29] This view is not without controversy. A few authors argue that integrated circuit layout or topography is also protected. However, as discussed below, the SCPA most likely does not include layout or topography protection. A "mask work," according to the SCPA, is

> a series of related images, however fixed or encoded -
>
> (A) having or representing the predetermined, three dimensional pattern of metallic, insulating, or semiconductor material present or removed from the layers of a semiconductor chip product; and
>
> (B) in which series the relation of the images to one another is that each image has the pattern of the surface of one form of the semiconductor chip product.[30]

Given the mask work's statutory definition, the SCPA protects mask works that represent three-dimensional patterns in a semiconductor chip. However, the SCPA does not always provide protection to one- or two-dimensional patterns in a chip or in two-dimensional quantum semiconductor devices.[31] This means that an infringer could copy or pirate the layout or topography of one layer of a protected three-dimensional integrated circuit or semiconductor chip, without incurring SCPA liability, as long as the infringer did not copy the layout of any other layer of the protected product. A mask work may be created using a mask or a series of photolithographic masks, as described in more detail in the appendix.

Another problem with protecting only mask works is that several integrated circuit manufacturing steps do not require a mask.[32] For example, process steps such as ion implantation, polishing, spacer formation, lift-off, etch back and electron beam lithography are performed without a mask.[33] The SCPA arguably provides no protection to three-dimensional integrated circuit topographies if: (1) the layers or regions in later developed integrated circuits were created by maskless processes, and (2) as a result, the later developed integrated circuits are substantially different from the protected integrated circuit topographies created using mask works.[34] Under this interpretation, an alleged infringer could copy verbatim all layouts of a protected integrated circuit by using both maskless steps and masks. The alleged infringer would avoid liability by arguing that the inclusion of the unprotected topographies created without a mask renders the copied integrated circuit substantially different from the protected integrated circuit. This argument has not been raised to date.

In addition to the problems with the protected subject matter's scope, the subject matter the SCPA protects, i.e., three-dimensional mask works, has been described as confusing.[35] This confusion has ostensibly led other entities, such as the European Community, to adopt completely different language to describe the protected subject matter.[36] Others have argued that, despite its confusing language, the SCPA does protect actual chip design.[37]

Some authors rely on legislative history to support the proposition that the SCPA protects actual chip design.[38] In the hearings on the SCPA before the Subcommittee on Patents, Copyrights, and Trademarks of the Senate conducted in 1983, F. Thomas Dunlap, Jr. remarked that the bill covers the pattern of the chip, not just the mask work.[39] But, the matter is more complicated than it appears from the legislative history. Sections 901(a)(1) and 902 explicitly state that the protected subject matter is the chip product in which the mask work is fixed.[40] Despite legislative history, the statutory language indicates that the SCPA protects chips in which mask works are incorporated. The legislative history does not resolve whether a chip topography or layout that does not incorporate a mask work is protected under the SCPA.

Other authors argue that the words "however fixed or encoded" in section 901, when viewed together with the legislative history, indicate that the SCPA actually protects semiconductor chip products or integrated circuit topographies made with or without using a mask.[41] However, the legislative history relied upon for this argument merely states that the "mask work may be fixed in a set of masks . . . or may be fixed or encoded in other tangible form such as digitized representation of the mask work on magnetic tape."[42] This means that the mask image may be recorded on tape so it may later be converted to a mask. It does not mean that any digitally stored integrated circuit layout is protected by the SCPA, even if the layout is made without using a mask. As mentioned above, the plain language of the statute protects a "mask work"—it is hard to envisage that a "mask work" would include an integrated circuit topography made without a mask. The words "however fixed or encoded" do not lead to a different conclusion because they refer to the fixing of a mask work, not to the fixing of an integrated circuit topography. The statutory language, combined with a more literal reading of legislative intent, indicates that the statute protects the mask work when it is fixed in the semiconductor chip product (sections 901(a)(3) and 902), but does not protect the semiconductor chip product itself.

The Federal Circuit, in its single decision interpreting the SCPA, also seemed to indicate that the SCPA does not protect the chip itself. It held that the infringer must use mask works substantially similar to the protected ones to be liable under the SCPA.[43] Specifically, the Federal Circuit in *Brooktree* did not reverse the trial judge's jury instruction that in order to establish infringement, a mask work owner must show that defendant's mask works are substantially similar to a material portion of the mask works in the plaintiff's chips.[44] The court thus suggested that infringement analysis under the SCPA involved a determination of whether the protected mask work, and not the integrated circuit topography, was misappropriated.

I. Infringement Analysis and the Reverse Engineering Defense

The SCPA contains a liberal reverse engineering affirmative defense. Section 906(a) of the SCPA provides that it is not infringement for:

> (1) a person to reproduce the mask work solely for the purpose of teaching, analyzing, or evaluating the concepts or techniques embodied in the mask work or circuitry, logic flow, or organization of components used in the mask work; or
>
> (2) a person who performs the analysis or evaluation described in paragraph (1) to incorporate the results of such conduct in an original mask work which is made to be distributed.[45]

The reverse engineering defense was written into the SCPA due to the long-standing tradition of "second sourcing" in the semiconductor industry.[46] Second sourcing is when a purchaser of a chip requests two different suppliers to provide the supply of the requested chips. This process is beneficial to the industry because sometimes the first source for some reason can no longer produce, or refuses to produce, a vitally needed chip;[47] it is especially critical for national defense applications.[48]

Second sourcing aside, reverse engineering is also beneficial because it promotes the advancement of the state of the integrated circuit art by allowing competitors to improve on existing integrated circuits.[49] But, where there is a benefit to reverse engineering, there is a cost associated with the reverse engineering defense. The existence of a reverse engineering defense leads to the problem of distinguishing piracy from legitimate reverse engineering.[50] The problem is evinced by the many different tests that have been proposed by commentators to distinguish pirated mask works from original reverse-engineered mask works.[51] The variety of proposed tests makes it difficult for a reasonable competitor to ascertain the scope of its SCPA liability arising from reverse engineering. The uncertainty may discourage competitors from advancing the state of the art through reverse engineering to create new and improved integrated circuits because of a fear of infringement liability. The uncertainty may also help account for a lack of litigation under the SCPA because companies are loathe to invest hundreds of thousands of dollars in litigation costs when the outcome is uncertain.

It seems from the plain language of section 906(a) that a pirate may hide behind the reverse engineering defense. The section provides that a pirate who introduces minor changes or improvements to a pirated mask work, or who copies less than all of the protected mask work, would escape liability under the reverse engineering defense because the pirated chip would be "original."[52] The Federal Circuit diminished this possibility in the *Brooktree* decision. It held that infringement under the SCPA does not require that all parts of the accused chip be copied.[53] Specifically, mask works fixed in a chip were held to infringe a protected mask work even though the infringing mask works were only eighty percent similar to the protected mask work.[54] It follows from *Brooktree* that copying only portions of the chip or mask work may result in SCPA liability, despite apparent legislative history to the contrary.[55] In making its decision, the Federal Circuit turned to copyright law and the SCPA's legislative history to determine if infringement was present[56] since the SCPA lacks specific provisions about how similar the accused and protected mask works must be. Under the principles of copyright law, the accused chip was infringing because a material portion of the protected mask work had been appropriated, thus rendering the infringing chip (and presumably the mask work) substantially similar to the protected chip.[57]

Two problems remain with the Federal Circuit's reliance on copyright law. First, the appropriateness of applying copyright law, which protects aesthetic rather than functional designs, remains in question since mask works are functional. Second, the interpretation of infringement under the SCPA remains uncertain even after *Brooktree* because the courts have yet to articulate a certain standard for finding infringement under the SCPA.[58]

The uncertainty with respect to the SCPA faced by semiconductor manufacturing companies is evident from the *Brooktree* decision. The defendant, in raising the reverse engineering defense, relied on the SCPA's legislative history which noted that legitimate reverse engineering will always yield a paper trail.[59] Regardless, the Federal Circuit held that the presence of an extensive paper trail did not establish a reverse engineering defense as a matter of law, despite the defendant's assertions to the contrary.[60] While the paper trail may constitute evidence of independent effort, it may also indicate the infringer's failure to create an original mask work based on the reverse-engineered protected mask work.[61]

I. International Reciprocal Protection Provisions

Sections 902 and 914 of the SCPA spurred the development of a worldwide regime for protection of semiconductor chips and integrated circuit topographies.[62] Section 902 is a reciprocity provision, which grants protection to foreign-made integrated circuits and chips only if the foreign country affords similar protection to chips made by U.S. semiconductor manufacturing companies. Section 914 is a transitional provision that allows the Secretary of Commerce to extend protection to countries making a good faith effort and reasonable progress toward adopting laws that protect mask works or integrated circuit topographies.

Under section 902(a)(1), the mask work fixed in a semiconductor chip product is eligible for protection under the SCPA if

> (A) the owner of the mask work is a national or domiciliary of the United States, a stateless person or a national, domiciliary or sovereign authority of a nation that is a party to a treaty affording protection to mask works to which the United States is also a part; or
>
> (B) the mask work is first commercially exploited in the United States; or
>
> (C) the mask work comes within the scope of the presidential proclamation issued under 902 (a)(2).[63]

The President[64] may issue a proclamation under 902(a)(2) to extend protection to imported mask works if the President determines that the exporting country provides the same amount of protection to U.S. mask work owners as it does to that country's mask work owners, or the same amount of protection to U.S. mask work owners as provided by the SCPA.

Section 914 was intended to be a temporary stopgap measure which allowed the Secretary of Commerce[65] to issue an order extending protection to foreign nationals or governments under the SCPA. Section 914 states:

> (a) Notwithstanding the conditions set forth in subparagraphs (A) and (C) of section 902(a)(1) with respect to the availability of protection under this chapter to nationals, domiciliaries, and sovereign authorities of a foreign nation, the Secretary of Commerce may, upon the petition of any person, or upon the Secretary's own motion, issue an order extending protection under this chapter to such foreign nationals, domiciliaries, and sovereign authorities if the Secretary finds—
>
> (1) that the foreign nation is making good faith efforts and reasonable progress toward—
>
> (A) entering into a treaty described in section 902(a)(1)(A); or
>
> (B) enacting or implementing legislation that would be in compliance with subparagraph (A) or (B) of section 902(a)(2); and
>
> (2) that the nationals, domiciliaries, and sovereign authorities of the foreign nation, and persons controlled by them, are not engaged in the misappropriation, or unauthorized distribution or commercial exploitation of mask works; and
>
> (3) that issuing the order would promote the purposes of this chapter and international comity with respect to the protection of mask works.[66]

From this provision, it is clear that if the Secretary finds that a foreign country is making a good faith effort to extend protection to U.S. mask work owners, is not engaged in chip piracy, and the order would promote the purposes of the SCPA and international comity, then protection under the SCPA may be provided to foreign nationals or governments. This provision has been criticized for several reasons.

First, a petitioner seeking section 914 protection may be required to submit statements, bills and correspondence from a foreign government to show that the government is making efforts to adopt appropriate legislation and that its nationals are not chip pirates.[67] In effect, the U.S. government is demanding access to foreign government documents and reserves the right to criticize the foreign government legislation. This may be viewed by some foreign governments as an usurpation of their sovereignty.[68]

Second, the lengthy public comment period delays the effect of protection and makes consensus hard to reach.[69] Another section 914 criticism is its one-sidedness. In effect, section 914 grants temporary protection to foreigners whose countries do not provide the same amount of protection to U.S. mask work owners as their own mask work owners. Nor do foreigners need to provide U. S. mask work owners protection on the same basis as does the SCPA, as required by section 902. Foreigners merely need to be making progress toward such protection. As originally drafted, section 914 was supposed to sunset out in 1987, but its effective date was extended to 1994.[70] The purpose of section 914 was to “encourage the rapid development of a new worldwide regime for the protection of semiconductor chips.”[71] Apparently, this purpose has been largely accomplished. Although protection has not been extended in some nations, many developing and industrialized countries have followed the lead of the United States in granting similar protection via their own domestic legislation. These developments are outlined in the following section.

I. Foreign Integrated Circuit Topography Protection Acts

Many developed countries with existing legislation protecting mask works or integrated circuits now receive permanent protection in the United States under section 902 of the SCPA.[72] Some industrialized countries began developing domestic legislation protecting mask works and integrated circuit layouts directly following the SCPA’s passage in 1983. Once the United States determined that these legislative efforts protected mask works owned by U.S. citizens, these countries received temporary protection under section 914 of the SCPA.[73] The following sections present various examples of laws passed in foreign countries that were awarded section 914 protection.

I. The Japanese Act

Japan was the first country to file for section 914 protection in 1984, only one year after the passage of the SCPA.[74] Japan soon received section 914 protection on the basis of enacting its own act entitled the Semiconductor Layout Act ("SLA") in 1985.[75] The SCPA and the SLA have many similarities. Both provide a ten-year term of protection and both allow a reverse engineering defense.[76] Furthermore, each are sui generis acts that specifically protect semiconductor chips or integrated circuits and require only registration of the chip rather than a description of the layout for protection.[77]

The SLA differs in form rather than substance from the SCPA. First, the SLA grants protection to all nonnationals,[78] unlike the SCPA which requires reciprocity.[79] This provision implies that the SLA is not designed to affect the laws of foreign countries, as is the SCPA, but merely to offer protection to integrated circuit layouts.[80] Second, the SLA provides broader protection because it protects semiconductor integrated circuits and integrated circuit layout[81] while the SCPA only protects mask works.[82] By not mentioning the manufacturing process in the scope of protection, the SLA extends protection to layouts made without masks[83] and facilitates the detection of infringing integrated circuits. The owner of an integrated circuit protected under the SLA need only reverse-engineer an allegedly infringing chip to determine if infringement is present under the SLA. By contrast, under the SCPA, the owner must extrapolate the mask work layout used to make the allegedly infringing integrated circuit to prove infringement.[84]

Third, unlike the SCPA, the SLA provides criminal penalties in addition to civil remedies for chip piracy.[85] This may lead to increased deterrence of chip piracy. Fourth, although the SLA only grants the registrant an exclusive right to make the integrated circuits after the protected integrated circuits are sold on the open market, it provides broader protection from contributory infringement than the SCPA.[86]

I. The European Community Directive

One year after the passage of the SLA, the European Community ("EC") issued a directive requiring its member nations to adopt national legislation for the protection of semiconductor topographies.[87] In response, the United States afforded EC members provisional section 914 protection under the SCPA.[88]

The minimum requirements of the directive are very similar to those of the SCPA. The directive requires protection of a semiconductor product's topography comprising a series of related images fixed in, and representing, the three-dimensional pattern of layers composing the product.[89] The directive also protects each image representing the pattern of the semiconductor product's surface at any stage in its manufacture.[90] The EC directive also requires the member countries to permit a reverse engineering defense, as does the SCPA.[91]

The definition of the subject matter protected under the EC directive provides better protection to integrated circuits than the definition used in the SCPA. As explained above, protection is desired for the patterns of individual layers making up a three-dimensional topography of an integrated circuit, which can be made with or without masks. Unfortunately, the SCPA only protects mask works representing three-dimensional patterns in a semiconductor chip, but fails to protect the actual patterns themselves. Since some patterns can be formed without masks , the SCPA fails to protect the actual integrated circuit layout that is the result of the production process. The definition suggested by the EC directive of protected subject matter therefore represents a further improvement over that of the SCPA.

Interestingly, the directive protects only a three-dimensional integrated circuit, and does not prevent copying the layout of a single layer.[92] This may be a distinction without a difference. Integrated circuit layers are developed by closely registering overlying and underlying layers. The topography of an underlying layer of an integrated circuit typically dictates the layout of the level overlying it. Therefore, if a pirate copies one layer of an integrated circuit, the pirate would probably have to copy at least another layer overlying or underlying the copied layer, thereby infringing protected three-dimensional subject matter.

I. Protection in the U.K. and Australia

The United States granted the United Kingdom and Australia provisional section 914 protection in 1985 even though neither of these countries had made significant progress at that time in passing sui generis laws for protection of computer chips.[93] Both countries claimed that their respective copyright laws offered sufficient protection of integrated circuit layouts.[94] As discussed below, the copyright protection provided to integrated circuits by the United Kingdom and Australia differs substantially from the protection provided by the SCPA. Nonetheless, the United States granted section 914 protection to these countries because section 914 does not require similarity between the laws of foreign nations and the SCPA, as long as these laws provide mask work protection.[95] The Commissioner of Patents and Trademarks determined that harmonization of law could take place at a later date through bilateral discussions,[96] and indeed that is what happened.

In 1989, the United Kingdom amended its Copyright, Designs and Patents Act.[97] First, it provides sui generis protection for semiconductor topographies.[98] The U.K. Act, like its Japanese and European counterparts, provides protection to two-dimensional or three-dimensional topographies fixed in a semiconductor product.[99] However, unlike the SCPA, it also protects the layer of material used in the manufacture of a semiconductor product.[100] The U.K. Act grants the owner of a protected topography design the right to make semiconductor products incorporating the topography.[101] Finally, the U.K. Act also contains a reverse engineering defense.[102]

In Australia, although the copyright law protects the computer code in an integrated circuit, the actual layout design of an integrated circuit is not covered by Australian copyright law.[103] Rather, in 1989, Australia passed the Circuit Layouts Act of 1989 as a sui generis form of protection for semiconductor topographies.[104] Australians adopted the act in anticipation of the finalization of the terms of the IPIC Treaty.[105] It was therefore modeled after the SCPA as well as other foreign circuit protection acts.[106] Much like the U.K. Act, the Australian Act grants protection to the original creator of the design layout for ten years.[107] It also gives the creator the right to exclusively manufacture and market semiconductor products using the protected topography during this ten-year period.[108]

I. The Korean Act

The Republic of Korea passed its own sui generis legislation for protection of the layout of semiconductor integrated circuits largely in response to domestic expansion of the semiconductor industry.[109] Korean semiconductor companies have recently captured a significant market share of the industry.[110] The Korean Act protects two- and three-dimensional layout designs of final and intermediate stage (i.e., in-production) integrated circuits.[111] Although the act also allows a reverse engineering defense,[112] some commentators have argued that a strict interpretation of the act prohibits commercial use of any integrated circuit that is a product of reverse engineering.[113] If this is true, then an original semiconductor chip or integrated circuit created by reverse engineering a competitor's integrated circuit may be sold commercially in the United States and in many EC countries but not in Korea or Japan.

Unlike the SCPA, the SLA, or the EC directive, the Korean Act provides for compulsory (i.e., nonvoluntary) licenses.[114] This act allows the Korean Minister of Trade, Industry and Resources to demand a license to copy integrated circuits from the manufacturers of the integrated circuit if the Minister finds that awarding the license is necessary to protect national security, to promote free competition, or to prevent abuse of the layout-design rights.[115]

The legislative measures in these leading developed countries indicate that SCPA sections 902 and 914 have largely accomplished their purpose in enticing other countries to pass legislation affording protection to integrated circuit layouts and mask works despite some objections to the perceived U.S. pressure.[116] Although many countries have received SCPA protection, five years after the passage of the SCPA, several developing countries continued to avoid drafting legislation to protect integrated circuit topographies or mask works. Thus, a multilateral solution was required.

I. The Washington IPIC Treaty

In late 1980s, the World Intellectual Property Organization ("WIPO") attempted to take the lead from the United States in harmonizing worldwide integrated circuit topography protection. In

1987, WIPO produced a first draft of an international treaty for the protection of integrated circuits based on several negotiating sessions.[117] After further adversarial negotiating sessions, and three more drafts, WIPO finally adopted the fifth draft of the treaty.[118] The fifth draft of the treaty was presented to the member nations at the WIPO diplomatic conference in Washington, D.C. in 1989. The treaty was dubbed the WIPO treaty on the protection of Intellectual Property in Respect of Integrated Circuits ("the IPIC Treaty").[119] The initial drafts of the IPIC Treaty were based on the SCPA. These drafts were objected to by some developing countries that wanted the treaty to include compulsory licenses and a dispute resolution forum that was not controlled by the United States or other industrialized countries. In response, the IPIC Treaty was amended to alleviate the concerns of the developing countries. These amendments, and various treaty provisions, doomed the treaty because they proved to be unacceptable to the United States and Japan.[120]

One of the IPIC Treaty amendments that was unacceptable to the United States allowed for any country to include compulsory (nonvoluntary) licensing provisions in its legislation.[121] Developing nations support compulsory licensing because of a belief that multinational companies would abuse monopoly powers granted by intellectual property protection laws to exploit the citizens of developing nations.[122] Some developing nations also lack a competent legal process and enforcement abilities. In these countries, a one time statutory fee is easier to administer than enforcing intellectual property rights.[123]

The compulsory licensing provision of the treaty does not directly conflict with the SCPA since compulsory licensing under the IPIC Treaty enabling provision is not mandatory. Nonetheless, U. S. intellectual property laws strongly favor granting exclusive rights to the owners of intellectual property. It is thought that the free market shifts ownership of intellectual property to the highest valued users and that strong exclusive rights in intellectual property will not hinder the free market in goods subject to intellectual property protection.[124] The U.S. patent laws do not contain a compulsory licensing provision.[125] The United States found the provision allowing compulsory licensing in foreign countries objectionable because it decreases the amount of protection granted to U.S. mask work owners abroad.

Another amendment unpalatable to the United States made the WIPO Assembly the forum for international dispute settlement concerning the treaty.[126] Because the developing countries wield disproportionate power compared to their economic strength under the WIPO Assembly's "one nation one vote" procedure, the WIPO dispute resolution forum was not acceptable to the United States.[127]

Another IPIC Treaty shortcoming was that the treaty did not provide compensation to mask or integrated circuit layout owners for "innocent infringement." Under the IPIC Treaty, a good faith buyer of an infringing chip without notice of infringement is insulated from liability for future importation or sale of the infringing chip.[128] The SCPA defines "an innocent purchaser" as a purchaser of a semiconductor chip product in good faith and without notice of protection (either actual notice or reasonable belief that a mask work is protected).[129] Unlike the IPIC Treaty, under section 907 of the SCPA, an innocent purchaser is liable for a reasonable royalty for importation or distribution of an infringing semiconductor chip product only after receiving notice of protection of the mask work embodied in the chip. On this point, the IPIC Treaty conflicted with the SCPA, which the United States found objectionable.

For all its differences with the SCPA, in other respects the IPIC Treaty has provisions that are similar to the SCPA, the SLA, and the EC Directive. The IPIC Treaty protects "layout-design (topography),"[130] which is defined as a three-dimensional disposition, however expressed, containing an active element and some interconnections prepared for an integrated circuit. The "integrated circuit" is defined as a product containing an active element and interconnections integrally formed in and/or on a piece of material and which is intended to perform electronic functions. There is no specific reference to semiconductor materials.[131] The IPIC Treaty thus allows protection of layout-designs incorporated into integrated circuits based on non-semiconductor materials[132] as well as mask works.[133] The rights granted under the treaty are the rights of reproduction of original topographies and the right to import, sell, distribute, or perform other acts deemed prosecutable by the member nations.[134] The IPIC Treaty does not require that national legislation contain sui generis protection; it implicitly allows for copyright protection instead of sui generis protection if the copyright protection is adequate to comply with the requirements articulated in the treaty's articles.[135] The IPIC Treaty also allows a broad reverse engineering defense, which includes commercial exploitation of original topographies based on information gained through reverse engineering.[136]

Other aspects of the treaty include national treatment and optional registration requirements for integrated circuits in order to be eligible for protection.[137] The IPIC Treaty is well and clearly drafted because it broadly defines an integrated circuit topography to include all kinds of integrated circuits and protects integrated circuit topography instead of the mask works used in making the integrated circuits.

Forty WIPO member nations voted for the IPIC Treaty. Despite the support, the treaty was rendered meaningless because the United States and Japan, the countries with the lion's share of world's integrated circuit production, refused to sign it. Only a few developing nations actually ratified the treaty.[138] As a result, the treaty in and of itself had almost no impact on the worldwide protection of integrated circuits.

I. TRIPS and NAFTA Provisions Relating to Integrated Circuit Topographies

The IPIC Treaty was revisited during the 1994 Uruguay Round of GATT. Although, the United

States had little to bargain with at the WIPO conference in Washington in 1989,[139] it had a big bargaining chip at the Uruguay Round: improved access to the U.S. market through lower tariffs and higher quotas for goods imported from developing countries. In return for improved access to the U.S. market, the United States demanded that developing countries enact strong intellectual property legislation to protect the rights of U.S. intellectual property owners in developing countries. This resulted in the Agreement on Trade-Related Aspects of Intellectual Property Rights ("TRIPS")[140] as part of the 1994 Uruguay Round of GATT.

Articles 35 to 38 of TRIPS concern integrated circuit topography protection. Integrated circuit topography protection required by TRIPS is similar to that required by the IPIC Treaty, but with a few important differences. Article 35 incorporates by reference Articles 2 to 7 of the IPIC Treaty, except paragraph 3 of Article 6 which deals with compulsory licensing. All mention of compulsory licensing was eliminated from TRIPS because U.S. negotiators used access to the U. S. market as a carrot. They used this carrot to persuade the delegations from developing countries to eliminate from TRIPS provisions objectionable to the United States. The IPIC Treaty provision setting WIPO as the dispute resolution forum was also omitted from TRIPS. Finally, unlike the IPIC Treaty, TRIPS allows a party to recoup a reasonable royalty for "innocent infringement."

Article 36 of TRIPS qualifies Article 6, paragraph 1(a)(ii) of the IPIC Treaty, in that the right to import, sell, and distribute products containing the protected topography exists only insofar it continues to contain an unlawfully reproduced topography.[141] This correction is intended to emphasize that some topographies may only exist temporarily during production of the integrated circuit (i.e., an in-process, temporary topography).[142] These topographies may later be altered by subsequent process steps. TRIPS prevents reproduction of protected intermediate form topographies during manufacturing. But if the protected topography is obliterated or materially altered during subsequent processes, then the integrated circuit containing the altered topography may be sold, imported, or distributed without liability.

Paragraph 1 of TRIPS Article 37 mirrors section 907 of the SCPA in allowing recovery of a reasonable royalty for "innocent infringement."[143] An owner may recover from an innocent purchaser for disposition of an infringing integrated circuit after notice of infringement. This article has no corresponding provision in the IPIC Treaty. Paragraph 2 of TRIPS Article 37 incorporates by reference Article 31 of TRIPS, which allows the owner of intellectual property to recover a reasonable royalty when a national government appropriates protected property.[144] There is, however, one exception. According to Paragraph (c) of Article 31, a government may appropriate an integrated circuit for public, noncommercial use or to remedy an anticompetitive practice.[145] This provision does not have the broad scope of a compulsory license.[146] Article 1710 of NAFTA, binding Canada, the United States, and Mexico is identical in scope to TRIPS Articles 35 to 38, except that compulsory licenses mentioned in TRIPS Article 37 are expressly forbidden.[147]

Integrated circuit topography protection incorporated into TRIPS and NAFTA is superior to the protection incorporated into the SCPA. The TRIPS and NAFTA provisions protect integrated circuit topography and not mask works. The alleged pirated chip can be reverse-engineered and it can be readily determined whether it is a pirated copy by comparing it to the protected topography. In contrast, the SCPA only protects the mask work. Thus, the SCPA requires a second level of reverse engineering and extrapolation: the reverse-engineered chip topography has to be extrapolated back to determine what mask was used to make that chip and then the extrapolated mask work must be compared to the protected mask work. This might not prove feasible due to some semiconductor manufacturing methods or steps which do not utilize masks. Overall, TRIPS and NAFTA contributed to the harmonization of chip protection laws in different countries.

I. Chip Piracy Declines in the Developed World Despite Lack of Enforcement Under Sui Generis Acts

Despite the lack of enforcement under the sui generis acts, worldwide chip piracy has declined in the semiconductor industry since the 1970s.[148] Although these acts might have convinced chip pirates to abandon chip piracy in face of worldwide infringement liability, other unrelated factors better serve to explain chip piracy's decline. During the sixteen years subsequent to the passage of the SCPA, a number of technical, economic, legal, and industrial conditions have changed, rendering chip piracy practically moot in the industrialized world.

I. Technical Advancements

Given the rapid pace of progress in the industry, chip pirates are increasingly less competitive in international markets. Simply put, a chip pirate does not have the time or the resources to copy and market chips before improvements on the same chip are available on the market. Furthermore, only particular manufacturing apparatuses can make a particular kind of chip. Chip pirates often lack the equipment and the know-how required to make a certain kind of chip.

I. *Chip Pirates Cannot Keep up with the Speed of Progress in the Industry*

In the 1970s, the same simple chips were considered the industry standard for several years. This allowed chip pirates enough time to copy these chips and flood the market at cut-rate prices, taking away a portion of the market share from the original chip manufacturers.

However, the recent speed of progress in the semiconductor industry has decreased the ability of chip pirates to turn a profit.[149] A chip pirate cannot timely copy and market such complex chips in so short a time frame. By the time a pirate buys a chip made by a legitimate company, reverseengineers the chip, retools its plant, and works out any production problems, the legitimate chip maker would have already developed and marketed an improvement on the pirated chip. Therefore, the pirated chip would not be able to compete with the improved chip on the open market.[150]

I. *Incompatible Technologies Hinder Piracy*

In the 1970s, most companies used similar semiconductor manufacturing apparatuses and processes.[151] This standardized technology made piracy feasible by allowing a pirate to replicate a legitimate company's integrated circuit topography with the pirate's own equipment.[152]

Over the past decade, however, companies have initiated customized production of integrated circuits.[153] As a result, much of the semiconductor manufacturing equipment is tailored to very specific processes. The equipment is usually comprised of a set of unique vacuum chambers and robot arms used to create individual integrated circuits.[154] The way the chambers are laid out in a particular multi-chamber apparatus allows the chip manufacturer to mass-produce a highly specialized chip. For others to do the same, they would probably have to buy a new multi-million dollar machine or significantly retool an existing machine for the pirated topography.

Furthermore, although it is now possible to determine what process was used to manufacture a specific integrated circuit via reverse engineering, many of these processes are complex and difficult to discover.[155] The development and optimization of these processes may be a well-guarded trade secret of the original integrated circuit manufacturer. The pirates lack sufficient skill and time to reliably replicate these processes.[156] Therefore, even if a pirate misappropriates a topography or a mask layout, the pirate may not be able to manufacture the integrated circuit without access to expensive, custom-made manufacturing equipment and processing techniques of leading research companies.[157]

I. Economic Considerations

One significant result of these technological advancements has been skyrocketing production costs for semiconductor chips. Where pirates have been able to keep up with the technology, the expenses associated with this cutting-edge technology have been steadily increasing. Most of these costs are due to more complex and smaller chips. However, even the costs of reverse engineering the chip have become prohibitively expensive.[158] Also, specialization and customized chip development have forced pirates to either cater to these customized needs, foregoing profits reaped from economies of scale, or continue to produce less specialized chips and risk losing their entire market share. All of these factors have significantly contributed to reduce the profitability and prevalence of chip piracy.

I. *Chip Piracy Is an Unprofitable Enterprise*

Chip manufacturing costs have increased dramatically over the past ten years. In the 1970s, the cost of entry into the industry was fairly low.[159] For about $100,000, a chip pirating company could photograph each level of an integrated circuit topography with a high-magnification camera and then convert the photograph into a mask used to manufacture an integrated circuit.[160]

In order to be competitive in today's world market, however, semiconductor manufacturing companies need multi-chamber, ultra-high vacuum manufacturing apparatuses and clean rooms, both of which cost hundreds of millions of dollars.[161] Most semiconductor chip manufacturing facilities now cost up to a billion dollars to build.[162] Any company that spends a billion dollars to put up a plant is probably not going to engage in chip piracy by stealing a competitor's mask work or chip topography; it obviously has sufficient resources to develop its own integrated circuit topographies.

Furthermore, while almost any chip can be reverse-engineered, it costs substantially more to reverse-engineer complex chips. Topographies with individual component-widths of less than a micron can no longer be directly photographed by a high-magnification camera and converted into a mask.[163] While it is possible to image individual components with widths as small as a quarter-micron using optical photography, as feature sizes in modern integrated circuits continue to shrink below a quarter micron, photography becomes increasingly difficult and expensive, and requires the use of cumbersome inspection methods, such as scanning electron microscopy ("SEM").[164] Therefore, the reverse engineering costs weed out prospective pirates with low operating budgets.

One final cost that has recently developed to hinder piracy in the industry is an increased market demand for manufacturer technical support and bundles of services.[165] The chip pirates usually cannot—or do not want to—provide such a service. Thus, even if a pirate can sell the pirated chips at a profit, the pirated chips still cannot effectively compete on the market without the technical support and the bundle of services required by the customers.[166]

Finally, while the costs of production, reverse engineering, and customer service have increased substantially, the savings generated for pirates by stealing a mask work have decreased. In the 1970s, piracy yielded profits by allowing the pirates to avoid the expensive research and development ("R&D") phase and jump straight to production. However, R&D costs today have been reduced drastically due to advancements in computer technology. For example, most mask layouts are quickly and inexpensively generated by a computer given the desired integrated circuit parameters.[167] The computer generated layout can be developed faster than reverse engineering a chip.[168] Furthermore, the majority of layout designs are based on complementary

MOSFETs[169] ("CMOS"), and are similar to the previous generations of CMOS layouts, which are easily replicated by computers.[170] Therefore, by copying a topography, a chip pirate would only be able to eliminate a small percentage of the total chip costs.[171]

These heightened production costs, coupled with decreased savings from bypassing the R&D phase, have translated into lower profits for chip pirates. Lack of profit is probably the most important reason that chip piracy has declined.

I. *There Is No Market for Pirated Custom Made Chips*

In the 1970s, most chips were not manufactured for a particular end use or for an individual customer. All chips of a particular type (e.g., DRAM, logic, etc.) were fungible and chip customers were generally restricted to using fungible, general purpose chips.[172] This allowed the chip pirates to compete on the open market by selling low-cost chips that could be used in place of legitimately manufactured chips. Today, however, custom and semi-custom chips comprise nearly fifty percent of the logic chip market, and their market share is growing.[173]

The majority of semi-custom logic chips are called Application Specific Integrated Circuits ("ASIC"). An ASIC consists of hundreds or thousands of unconnected "gate arrays," which are groups of MOSFETs capable of performing a particular logic function.[174] These ASICs are "programmed" according to each customer's instructions.[175] The interconnected ASIC acts as a custom made logic chip when inserted into the customer's electronic device.[176] A close cousin of the semi-custom ASIC logic chip is the "mask ROM" (Read Only Memory) chip.[177] In a mask ROM, the characteristics of the semi-finished individual transistors are altered by ion implantation to make a memory device specifically suited to the customer's needs.[178]

All of these custom-designed chips are not fungible because there is no market for them outside of the specific user who has requested production. By the time the pirate could put a pirated customized chip on the market, the one customer who would be interested in the chip would have received its shipment of chips from the legitimate producer. Therefore, there is no market or profit in pirated custom or semi-custom chips.[179] A pirate would have to invest the same amount of research and development to create a custom or a semi-custom chip as a legitimate manufacturer in response to a customer's order. The increased market share of custom and semi-custom chips erodes the market share of fungible chips that are subject to chip piracy and represents another factor contributing to the decrease in chip piracy.

I. **Improvements in Legal Protection and Industry Practice**

Although legal protection and industry practice have not been as influential in deterring chip piracy as technical and economic considerations, they are not unimportant. Since the 1970s, there has been a demonstrable increase in patent protection,[180] as well as significant changes in industry practice seeking to deter chip piracy.[181] Patent rights have been more vigorously enforced worldwide.[182] Established companies have also altered their business activities and relationships in ways which significantly reduce chip piracy. These efforts have resulted in a notable decrease in chip piracy throughout the world.

I. *Patent Enforcement Hinders Blatant Piracy*

The simplest explanation for the decrease in chip piracy is the strengthening of worldwide patent protection, particularly in the United States. In the 1970s, chip piracy was a relatively low-risk venture due to lax patent enforcement by the Federal Courts and reluctance on the part of the U.S. semiconductor industry to even bring suits for patent infringement or trade secret misappropriation.[183] However, with the advent of the Court of Appeals for the Federal Circuit, patent rights are being enforced with greater regularity and certainty.[184] This increased patent enforcement has decreased chip piracy.

Today, a large portion of integrated circuits contain individual semiconductor devices protected by device or method patents.[185] The U.S. Congress further expanded patent protection for integrated circuits in 1988 when it passed section 271(g) of the Patent Act making it an act of infringement to import a product made by a process patented in the United States.[186] Therefore, a chip pirate cannot copy the integrated circuits without infringing the patents protecting individual devices within the integrated circuit or the methods of manufacturing those individual devices.[187]

Although there has only been one case brought under the SCPA, it may not be because manufacturers rely solely on patent protection. Some authors have argued that the lack of litigation under the SCPA is due to the inherent uncertainties in the SCPA regarding the extent of the reverse engineering exception, and the substantial similarity required for infringement.[188] To the contrary, these uncertainties may have forced the industry to rely on the better-developed patent law.[189] Even though most chips have a short shelf life, broad patent claims on a basic invention result in a twenty-year “exclusive right” in future generations of chips which incorporate the claimed device feature or process step.[190]

Furthermore, patent cross-licensing agreements may have also reduced piracy. Due to the large size of the patent portfolios of large semiconductor companies, it becomes prohibitively expensive to investigate adequately all claims of infringement by competitors and litigate against the alleged infringers. Therefore, most semiconductor manufacturing companies enter into broad cross-licensing agreements with their competitors. These agreements allow unrestricted use of their technology in return for similar rights and/or cash from their competitors.[191] Some cross-licensing agreements include integrated circuit layouts.[192] Thus, copying of layouts and topographies is authorized by these broad cross-licensing agreements[193] and many former pirates are now respectable licensees.[194] This may also account for a lack of published opinions under the SCPA.[195]

I. *Established Companies Strive to Eliminate Chip Piracy*

Many of the established companies in the semiconductor industry abide by an informal anti-piracy code based on corporate ethics, a long-running practice in the industry. For example, companies that focus their business on reverse engineering chips and then selling the obtained information on the open market refuse to work with known computer chip pirates.[196] This is a significant deterrent to piracy since these companies have the capability of reverse engineering almost any chip to provide both the circuit layout specifications and possible processes and material analysis used to make those chips.[197] However, they will not reverse-engineer a chip for a client if they know that the client will be using the information to pirate chips.

I. *Integrated Circuit Manufacturing Becomes the Province of Respected Foundries and Close Manufacturer-Purchaser Relationships*

A large number of smaller companies in the semiconductor chip industry no longer manufacture their own chips due to the high cost of manufacturing.[198] Instead, these smaller companies focus on designing new chips, and then contract out the actual manufacturing process to "semiconductor foundries."[199] The foundries are large corporations with billions of dollars invested in modern chip manufacturing facilities. They retool these factories for each new generation of chips.[200]

The pirates, however, cannot turn to the foundries to manufacture pirated chips. Most foundries are respectable companies that will not deal with known chip pirates because the chip pirates harm the business of the foundries as well.[201] Association with pirates could negatively affect the foundry's reputation and client base. Furthermore, manufacturing pirated chips could also expose the deep pocket foundries to SCPA and patent infringement liability. Without access to the foundries for chip manufacturing, chip pirates are not able to market most modern, complex chips.

I. *Companies Choose not to Register Their Mask Works*

As discussed above, SCPA protection commences on the date of the first commercial exploitation of the mask work or on the date of registration of the mask work, whichever comes first.[202] However, failure to register the mask work within two years of commercial exploitation will place the mask work in the public domain.[203] Therefore, unless the mask work owner wishes to bring an infringement suit within the two-year period,[204] it is preferable for the mask work owner to wait two years from first commercial exploitation to register the mask work in order to retain a measure of secrecy for the topography.[205]

However, some companies choose to forego SCPA protection by never registering their mask work.[206] This decision has a sound basis. The registration requirements allow chip pirates to pirate an integrated circuit topography by merely requesting the mask layouts from the Register of Copyrights. The chip pirates may then sell the pirated chips in countries with weak or nonexistent intellectual property protection laws. They may even sell the pirated chips in countries with strong intellectual property laws without being detected since chip piracy is both difficult and expensive to detect.[207] Without disclosure of the mask work layouts to comply with the registration requirement, chip pirates would either have to pay hefty fees to companies that specialize in reverse engineering or spend time and effort reverse engineering the target chips themselves to obtain the desired topography and mask layouts. Inequities generated by the registration requirement have led to calls for the abolition of this prerequisite.[208]

I. The State of International Protection for Integrated Circuits

Many countries now provide some protection to integrated circuit layout or mask works. In the industrialized world, most countries passed sui generis legislation in response to the SCPA and their nationals were thus afforded protection under the SCPA.[209] Other countries, such as Poland, entered into bilateral accords with the United States to provide sui generis chip protection,[210] thereby receiving protection under SCPA section 902(a)(1)(A)(ii). Still other countries receive protection in the United States under provisional reciprocating legislation.[211] Although there remain some countries, largely developing countries, that have not made any effort to pass legislation reflecting the SCPA’s goals,[212] international agreements such as TRIPS may ensure compliance in these countries over the next few years.

As the majority of the world’s nations are signatories to the TRIPS agreement, they are required to pass legislation protecting integrated circuit topographies.[213] Upon passage of the legislation, they will be in compliance with section 902(a)(1)(A)(ii) of the SCPA, which provides protection to nationals of countries that are parties to a treaty affording protection to mask works of which the United States is also a party.[214] Therefore, even though section 914 of the SCPA sunset out in 1994, reliance on this provisional section is no longer necessary, since most foreign nationals from TRIPS signatory nations may now receive permanent protection in the United States under section 902(a) of the SCPA. Furthermore, presidential proclamations under section 902(b) of the SCPA that foreign nations provide adequate mask work protection should also no longer be necessary following TRIPS.

In the past decade, several multinational semiconductor companies based in different countries have formed alliances to best utilize their particular expertise.[215] This has lead to the global interdependence of the semiconductor industry.[216] Therefore, a multinational treaty such as TRIPS, mandating uniform integrated circuit topography protection across different nations, has become more important as semiconductor manufacturing moves into the developing world.

I. Economic Incentive for Piracy Remains in Developing Countries

The long time that it took Congress to pass the SCPA made the act substantially moot from the start.[217] However, semiconductor chip protection acts are not completely useless in the worldwide market despite the decline of chip piracy, particularly in developing countries. These acts provide important incentives to prevent companies and governments in developing countries from engaging in chip piracy. The recent incorporation of integrated circuit topography protection into TRIPS has only further enhanced the original goal of these acts.

The primary reason why chip manufacturers are concerned with the developing world is that it represents one area where chip piracy might still be profitable. For example, end users in developing countries probably would prefer outdated chips if they can be obtained for a significantly lower price. These users would probably be happy with a fifty MHz microprocessor if they could purchase it for a few dollars. It is entirely feasible that governments in developing countries may sponsor a pirate chip manufacturing factory that relies on reverse-engineered layouts or even layouts obtained from the registrations kept by the U.S. Register of Copyrights. Such a factory would contain the necessary manufacturing equipment bought or developed with government money. The chips made by a pirate factory would be sold domestically at a low price in order to start up a chip industry, supply the military, or supply domestic users of a developing country who cannot afford to pay the going international rates for the latest chips.

I. Potential Trade Sanctions under TRIPS Discourage Developing Nations from Supporting Integrated Circuit Piracy

Under TRIPS, developing countries that desire beneficial trade relationships with industrialized countries (e.g., higher quotas and lower tariffs) have to abide by the TRIPS agreement.[218] Therefore, these countries must provide minimal levels of intellectual property protection, such as integrated circuit topography protection provided in articles 35 through 38 of TRIPS. These articles have forced many developing countries who have no semiconductor chip manufacturing facilities to enact their own semiconductor chip protection acts.[219]

The TRIPS agreement also prevents the governments in these developing nations from blatantly sponsoring chip piracy. Although governments may allow chip piracy to continue by simply turning a blind eye, this provision will at least prevent the pirates from receiving funds directly from the government. Since governments are generally the biggest source of financing in developing countries, by effectively preventing these governments from sponsoring chip piracy, the potential for future chip piracy in the developing countries is greatly decreased.

Even though integrated circuit topography acts have been enacted in many developing countries as mandated by TRIPS, they will probably never be used for litigation purposes. However, they are significant in that they at least nominally prevent the governments of these countries from engaging in, or sponsoring, chip piracy. Therefore, incorporation of Articles 35 through 38 into TRIPS served a useful purpose for the future of the worldwide semiconductor industry.

I. Conclusion

Ever since the mid-1970s, the semiconductor industry has been an essential ingredient in the technological revolution. It was therefore appropriate for Congress to develop a sui generis type of protection for the industry in the mid-1980s when chip piracy was widespread, particularly considering the dearth of intellectual property law protecting IC layouts from chip piracy. Taking the lead, the SCPA induced other nations to promulgate their own integrated circuit topography protection acts. Although the provisions of these acts and related international agreements are somewhat different, at the very least, they all provide some type of protection to IC mask works.

Ironically, the SCPA and its counterpart foreign acts are rarely relied upon for relief in litigation for the reasons noted above. At the same time, despite this lack of enforcement, chip piracy itself has declined in response to significant economic and technological transformations in the industry itself. In fact, the only real piracy “threat” currently comes from the developing world, where economic conditions still exist that make piracy of older technologies profitable and attractive.

Sixteen years after the passage of the SCPA, it is difficult to say whether domestic and international chip protection is working. Piracy has been reduced since the mid-1980s, but it is uncertain whether such reduction in chip piracy has actually resulted from the SCPA and related foreign legislation. Nevertheless, regardless of the SCPA’s direct effect on chip piracy, international protection provided by the SCPA and other related acts will help to ensure that future creators of semiconductor chip products will be safe from chip piracy in the long run.

I. Appendix: A Summary of an Integrated Circuit Manufacturing Process[220]

Almost all integrated circuits consist of multiple semiconductor devices.[221] An integrated circuit is usually a single substrate that contains thousands or millions of interconnected semiconductor devices. The most common substrate is a disk-like silicon wafer having a diameter of six to twelve inches. The plurality of semiconductor devices making up the integrated circuit are simultaneously formed on the wafer by repeating three basic manufacturing steps: substrate doping, layer coating (deposition) and layer etching (removal).

An example of these steps will be illustrated with respect to the manufacturing of a metal oxide semiconductor field effect transistor ("MOSFET"), the most common semiconductor device that makes up a building block of integrated circuits. The function of a MOSFET is that of a switch which can be turned on or off by an input voltage. If this switch is connected on one end to a high or low voltage (digital 1 or 0), it will output that voltage in > response to the input.

The function of a MOSFET is analogous to a faucet. In a faucet, water flows from an input pipe toward a valve. If the valve is "on" or "open," water will flow out from the faucet. If the valve is "off" or "closed," water will not flow out from the faucet despite being present in the input pipe. In a MOSFET, the input pipe is called a "source," the output is called the "drain," the part of the pipe below the valve is called a "channel," and the valve is called a "gate electrode" or simply a "gate." The source and the drain are "doped" regions in the substrate. These regions are "doped" because they contain a small additional quantity of dopant atoms that are different from the host atoms of the substrate.

For example, for a silicon group IVa element substrate (from the periodic table of elements), the dopant atoms, such as boron, phosphorus and arsenic, come from groups IIIa or Va. Phosphorus atoms contain one extra electron than the silicon atoms of the substrate. Thus, if two separate regions of a silicon substrate are doped with phosphorus and a separate metal electrode is placed in contact with each of the two regions and a potential difference (i.e., voltage) is applied between the electrodes, then the extra electrons "donated" by the phosphorus "donor" atoms to the silicon substrate will flow like water down a pipe from the negatively biased "source" region to the positively biased "drain" region through the "channel" region between the source and drain regions.

The channel region, however, is usually doped with boron, which has one less electron than the silicon atoms of the substrate. Therefore, the electrons from the source do not reach the drain because they are trapped in the channel to restore charge neutrality therein. In this state, there is no source to drain electron conduction, and the transistor is deemed to be in the "off" state (an input of "1" results in an output of "0"). However, the transistor also has a third electrode, the gate, over the channel region in the substrate. When a voltage is applied to the gate, the resulting electric field allows the electrons to flow from the source to the drain. Therefore, a typical "depletion" MOSFET is "on" when a voltage is applied to the gate electrode (an input of "1" to the source results in an output of "1" from the drain).

A typical MOSFET consists of a doped silicon substrate, a source and a drain region in the substrate doped differently than the rest of the substrate, a source electrode and a drain electrode connected to the source and drain regions, respectively, a substrate region called the channel between the source and drain regions, and a gate electrode. A MOSFET also contains a "gate insulating layer" which is a thin insulating layer between the channel and the gate, insulating isolation regions in the substrate that separate one MOSFET from another, and interlayer insulating layers. The interlayer insulating layers prevent the source, drain, and gate electrodes from contacting each other and short circuiting the MOSFET. Each MOSFET has a gate width of less than a micron. For example, the latest Intel Pentium microprocessor has a gate electrode whose width is 0.18 microns. A human hair is several microns thick. Therefore, special manufacturing processes are needed to form such small devices which cannot be seen with the naked eye.

One process used to manufacture semiconductor devices, such as MOSFETs, is called photolithography. This process works similar to the well-known lithographic printing process. In photolithography, a photosensitive polymer called a photoresist is formed over the entire semiconductor wafer. The photoresist is then exposed to light or UV radiation through a mask. The mask is usually a transparent quartz plate with opaque regions. The opaque regions may be less than a micron in width. The light or UV radiation passes through the transparent regions of the mask but not through the opaque regions. The regions of a "positive" photoresist underlying the transparent mask portions are irradiated with the light or UV radiation become cross-linked (i.e., hardened), while the unirradiated regions of the photoresist, underlying the opaque regions of the mask remain uncross-linked.[222]

The photoresist covered wafer is then dipped into an etching solution. The etching solution preferentially dissolves only the uncross-linked portions of the photoresist layer. After the wafer is removed from the etching solution, it is only partially covered by the remaining cross-linked photoresist pattern. Such a wafer is then dipped into a different etching liquid that preferentially dissolves or etches the semiconductor, metal, or insulating layers below the photoresist patterns, but does not etch the photoresist patterns. Alternatively, the wafer may be inserted into a gas phase etching chamber and exposed to a halogen containing gas that dissolves the underlying layers but not the photoresist pattern. Thus, etching removes portions of layers or the substrate not covered by the photoresist pattern, but does not remove the material underlying the photoresist pattern. The photoresist pattern is then removed by exposing it to an oxygen containing plasma, which selectively etches the cross-linked photoresist pattern but does not etch the underlying semiconductor, metal, or insulating layers.

A MOSFET may be manufactured by the following method. After isolation regions are formed in the silicon substrate, a gate insulating layer, such as silicon oxide, is formed over the entire surface of the silicon wafer. Thereafter, an aluminum or doped polycrystalline silicon gate layer is formed over the gate oxide layer. A photoresist is formed over the gate layer. The photoresist layer is exposed to light or UV radiation through a “gate” mask. This mask has opaque regions whose shapes correspond to the gate electrodes of the hundreds or thousands of MOSFETs to be formed on the wafer. The exposed photoresist is dipped into an etching liquid to remove the irradiated areas leaving a photoresist pattern over areas of the gate layer that will form gate electrodes. The wafer is exposed to a liquid or gas etchant which etches the gate layer but not the photoresist pattern. The etchant removes portions of the gate layer that will not be used in the gate electrodes of the MOSFETs to leave portions of the gate layer covered by the photoresist pattern. After the photoresist pattern is removed, the gate electrodes formed by etching remain on the surface of the wafer.

After the gate electrodes are formed, the source and drain regions of the plural MOSFETS are formed in the silicon substrate. These regions are formed by ionizing a boron, phosphorus, or arsenic gas and directing the ions at the wafer.[223] Since the gate electrodes are already formed and mask the channel regions, the dopant ions are only implanted into the silicon substrate on either side of the gate electrodes. This doping process is “self-aligned” because a mask is not used. The gate electrodes serve as the masking regions.

The interlayer insulating layers, such as silicon oxide and/or silicon nitride, are then formed over the entire wafer, covering the gate electrodes and the exposed source and drain regions in the substrate. The insulating layers are then planarized to create a flat surface by chemical-mechanical polishing. In this process, the wafer is placed on a polishing pad, and the top on the insulating layer is removed by polishing. This process also does not use a mask.

Afterwards, the photolithography step is repeated. A second photoresist is formed on the insulating layer. The photoresist layer is patterned to expose insulating layer regions overlying the source and drain regions. Via holes are then formed through the insulating layer by exposing the uncovered portions of the insulating layer to a liquid or gas etchant. A first layer of metal is then formed over the insulating layer, filling the via holes and contacting the source and drain regions of the MOSFETs.

A third photolithography step is then performed to pattern the first metal layer into source and drain electrodes. A second interlayer insulating layer is then formed over the electrodes, via holes to the electrodes are patterned, and an interconnection metal layer is formed and patterned over the second insulating layer. An integrated circuit may have up to six interlayer insulating and metal interconnection layers to interconnect the MOSFETs and other devices formed on the wafer to form an integrated circuit.

An integrated circuit topography is the layout or arrangement of semiconductor device parts at each particular level. For example, a MOSFET containing integrated circuit has a substrate level topography, a gate level topography, and plural upper level metal interconnection level topographies.

An integrated circuit is then “packaged” into a semiconductor chip. A package is a metal, plastic, or ceramic housing which holds the integrated circuit. It is the familiar “black box” that is attached to circuit boards inside the computer. The package has metal pins that can be connected to a socket in a circuit board, thus providing a path for electrical signals to and from the integrated circuit through the circuit board. The pins are connected to the integrated circuit by thin metal lines called leads inside the packages.

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1 . John G. Rauch, *The Realities of Our Times: The Semiconductor Chip Protection Act of 1984 and the Evolution of the Semiconductor Industry*, 3 Fordham Intell. Prop. Media & Ent. L.J. 403, 413-14 (1993). While IC manufacturers may patent individual semiconductor devices, they may not patent the layout of an entire integrated circuit. Copyright also fails to protect these layouts because they are functional rather than aesthetic. Finally, trade secret does not protect ICs since the layouts can be reverse-engineered after the chip is sold on the open market.

2 . *See id.*

3 . The following discussion of semiconductor device manufacturing is described in detail in many textbooks. *See, e. g.*, 2 Stanley Wolf & Richard N. Tauber, Silicon Processing for the VLSI Era (1990).

4 . Group IIIa and Va compounds include compounds such as gallium arsenide, a compound of gallium and arsenic, which exhibits semiconducting properties. Gallium is a group IIIa element and arsenic is a group Va element.

5 . Group IIb and VIa compounds include compounds such as zinc selenide, a compound of zinc and selenium.

6 . Individual transistors, such as metal oxide semiconductor field effect transistors (MOSFETs) and other simple devices, such as DRAMs (dynamic random access memory comprising a plurality of MOSFETs, each connected to a solid state capacitor) and SRAMs (static random access memories comprising four to six MOSFETs and zero to two resistors) that make up the building blocks of integrated circuits are protected by patents. The patents even cover the appearance of the individual devices if the appearance has a functional advantage. *See, e.g.*, U.S. Patent No. 5,874,356 (issued Feb. 23, 1999) (granting protection of vias in insulating layers having a zig-zag or battlement cross-section, where this cross section shape results in improved metal adhesion in the via). The PTO also granted numerous patents on the shape of DRAM capacitor electrodes. Such electrodes preferably have a tortuous, twisted shape to maximize their surface area to achieve an improve capacitance. Therefore, sui generis protection is not required to protect individual semiconductor devices, such as MOSFETs and capacitors, because their appearance and layout may be described by words of a claim.

7 . *See* Robert L. Risberg, Jr., *Five Years Without Infringement Litigation Under The Semiconductor Chip Protection Act: Unmasking the Specter of Chip Piracy in an Era of Diverse and Incompatible Technologies*, 1990 Wis. L. Rev. 241, 252 (1990); *see also* Jonathan H. Lemberg, *Semiconductor Protection: Foreign Responses to a U.S. Initiative*, 25 Colum. J. Transnat'l L. 345, 348 (1987).

8 . *See, e.g.*, Carl A. Kukkonen, III, *The Need to Abolish Registration for Integrated Circuit Topographies Under TRIPS*, 38 IDEA 105, 107 (1997); *see also* Lemberg, *supra* note 7, at 347-48; Terril G. Lewis, Comment, *Semiconductor Chip Process Protection*, 32 Hous. L. Rev. 555, 564 (1995); Risberg, *supra* note7 , at 251-52.

9 . 35 U.S.C. § 171 (1994).

10 . Mazer v. Stein, 347 U.S. 201, 215-16 (1954); Carol Barnhart, Inc. v. Economy Cover Corp., 773 F.2d 411, 414-17 (2d Cir. 1985); *see* Kukkonen, *supra* note 8, at 107-08.

11 . *See* Rauch, *supra* note 1, at 409.

12 . Lemberg, *supra* note 7, at 349.

13 . Henry H. Perritt, Jr., Trade Secrets: A Practitioner's Guide 231 (1994).

14 . Some companies focus their business exclusively on reverse engineering semiconductor chips and selling reverse-engineered layouts. *See, e.g.*, the website for Semiconductor Insights, Inc., *at* http://www.semiconductor.com/ services/ services.html (last visited Nov. 10, 2000).

15 . Perritt, *supra* note 13, at 108; *see also* Kukkonen, *supra* note8 , at 108.

16 . *See* Lewis, *supra* note 8, at 563 (discussing the U.S. semiconductor manufacturers' claim that pirating of their chips by foreign competitors was costing the U.S. semiconductor industry millions of dollars).

17 . 17 U.S.C. §§ 901-914 (1994).

18 . Rauch, *supra* note 1, at 409-14.

19 . 17 U.S.C. §§ 904, 905 (1994).

20 . 17 U.S.C. § 906(b) (1994).

21 . 17 U.S.C. § 904(a) (1994) (noting industry testimony about extensive piracy).

22 . 17 U.S.C. § 908(a) (1994).

23 . 17 U.S.C. §§ 908(f), 910(b)(1) (1994).

24 . 17 U.S.C. § 908(f) (1994).

25 . Mask Work Protection, 37 C.F.R. § 211.4(b)(1) (1999).

26 . 17 U.S.C. § 908 (1994).

27 . Mask Work Protection, 37 C.F.R. § 211.5(b)(1)(ii) (1999).

28 . *Id.* § 211.5(c)(1).

29 . The reliance on protection of mask works instead of topographies was understandable in 1984. At that time, most of the research and development effort went into creating masks and the pirating of masks could therefore save the pirate a bulk of their research costs. In contrast, the present day percentage of research and development costs expended on creating masks has been reduced compared to other research and development expenses, because of the use of computer-aided design tools that automatically create mask layouts. *See* Lewis, *supra* note 8, at 566. Therefore, pirating of masks is not as prevalent today considering the relatively low production costs due to technological advancements.

Nevertheless, even if pirating of mask works were prevalent today, the SCPA would not protect them because it is hard to catch or to detect pirating of protected mask works. If a semiconductor company suspects that one of its competitors pirated its mask work, it would first reverse-engineer the competitor's integrated circuit located on a semiconductor chip to determine the topography at each level of the allegedly pirated integrated circuit. The company would then have to extrapolate the layout of the competitor's mask from the reverse-engineered topography. This is actually a fairly difficult and expensive task. Steps such as polishing may alter the topography after it has been processed using a mask. Therefore, it would be unclear what mask layout was used to originally create the reverse-engineered topography. The second reverse engineering step adds an extra burden of proof on the company to prove infringement of its mask work to a court or jury.

30 . 17 U.S.C. § 901(a)(2) (1994). However, the legislative history indicates that the SCPA does not protect mask works whose designs are mandated by function (i.e., when a functional chip cannot be made except by using the pattern in question). This is similar to the merger and scenes à faire doctrines in copyright law. Hrayer A. Sayadian, *Substantial Similarity and Reverse Engineering Under the Semiconductor Chip Protection Act: Their Bite is Worse Than Their Bark!*, 19 J. Corp. L. 103, 112-13 (1993).

31 . Kukkonen, *supra* note 8, at 112 n.36.

32 . *See infra* Appendix.

33 . *See id.*

34 . *See* Lemberg, *supra* note 7, at 360.

35 . Charles R. McManis, *International Protection for Semiconductor Chip Designs and the Standard of Judicial Review of Presidential Proclamations Issued Pursuant to the Semiconductor Chip Protection Act of 1984*, 22 Geo. Wash. J. Int'l. L. & Econ. 331, 338-39 (1988).

36 . *Id.*; *see also infra* section IV.

37 . *See* Lemberg, *supra* note 7, at 360.

38 . *See id.* at 360 n.117 (citing the SCPA legislative history).

39 . *See The Semiconductor Chip Protection Act of 1983: Hearings on S. 1201 Before the Subcomm. on Patents, Copyrights and Trademarks of the Senate Comm. on the Judiciary*, 98th Cong., 1st Sess. 81, 85-86 (1983) (testimony of F. Thomas Dunlap, Jr.).

40 . *See* 17 U.S.C. §§ 901-02 (1994).

41 . McManis, *supra* note 35, at 338.

42 . *Id.* at 338 n.41.

43 . Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 1555, 1564-65 (Fed. Cir. 1992).

44 . *Id.* However, the court used the words “chip” and “mask work” interchangeably later in the opinion without explaining the precise scope of the protected subject matter.

45 . 17 U.S.C. § 906(a) (1994).

46 . Sayadian, *supra* note 30, at 113.

47 . Lemberg, *supra* note 7, at 351; Lewis, *supra* note8 , at 598-99.

48 . Lewis, *supra* note 8, at 598.

49 . Sayadian, *supra* note 30, at 113; *see also* Rauch, *supra* note1 , at 406 (quoting the Federal Trade Comm’n, Bureau of Economics, Staff Report on the Semiconductor Industry (1977)).

50 . *See generally* Lemberg, *supra* note 7, at 351 (noting that the line between piracy and reverse engineering is not always clear, a subject of controversy during Congressional hearings).

51 . *See* Sayadian, *supra* note 30, at 116-17, 127-33 (describing the *Brooktree* paper trail and substantial identity tests and commentator-proposed tests, such as the originality test, the significant toil and effort test, the nontrivial differences test, and the fair use test to distinguish an original reverse-engineered mask work from a pirated mask work); *see also* Kukkonen, *supra* note8 , at 116-17 (describing the *Brooktree* paper trail and substantial identity tests, as well as the functional superiority test and the value added test).

52 . 17 U.S.C. § 906(a) (1994).

53 . Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 1555, 1564-65 (Fed. Cir. 1992).

54 . *Id.* at 1563.

55 . But *see* Sayadian, *supra* note 30, at 113, 123 (noting that the *Brooktree* district court and appellate court instructions to the jury reflected the intent of Congress, properly stating that copying a small but substantially similar part of a SCPA-protected mask work would constitute infringement).

56 . The legislative history indicates that the "substantial similarity" principle of copyright law should be used to determine infringement under the SCPA. Sayadian, *supra* note 30, at 108. There is a split in the circuits, however, about what constitutes "substantial similarity" with respect to copyrighted computer programs. *See id.* at 109-11.

57 . *Brooktree*, 977 F.2d at 1564; *see* Kukkonen, *supra* note 8, at 115 n.56. *But see* James Chesser, *Semiconductor Chip Protection: Changing Roles for Copyright and Competition*, 71 Va. L. Rev. 249, 284-85 (1985) (referring to S. Rep. No. 98-425, at 21-22 (1984), which explains that it is not feasible for a chip pirate to appropriate only part of a mask work because of economic considerations and the functional integration of the totality of the mask work). Therefore, before *Brooktree* a reasonable competitor may have believed that the reverse engineering defense prevents a finding of liability under the SCPA even when there is substantial similarity between the original mask work and the reverse-engineered mask work if the entire protected mask work was not appropriated.

58 . *See* Sayadian, *supra* note 30, at 124-25.

59 . *Brooktree*, 977 F.2d at 1567; *see also* Sayadian, *supra* note 30, at 115.

60 . *Brooktree*, 977 F.2d at 1570.

61 . *Id.* at 1569-70.

62 . *See* Kim Feuerstein, *Chips Off the Trade Bloc: International Harmonization of the Laws on Semiconductor Chips*, 2 Fordham Intell. Prop. Media & Ent. L.J. 137 (1992); *see also* Kukkonen, *supra* note 8, at 117 (noting that Congress included the section 914 reciprocity provision to "encourage the rapid development of a new worldwide regime for the protection of semi-conductor chips," and that Japan quickly filed a pre-SCPA enactment request for protection).

63 . 17 U.S.C. § 902(a)(2) (1994).

64 . *See* McManis, *supra* note 35, at 357 (noting that the president has delegated the proclamation authority to the Commissioner of Patents and Trademarks).

65 . *See id.* at 358 (noting that the Secretary of Commerce authorized the Commissioner of Patents and Trademarks to issue orders under 17 U.S.C. § 914).

66 . 17 U.S.C. §§ 901, 914 (1994).

67 . Feuerstein, *supra* note 62, at 145-46.

68 . *Id.*

69 . *Id.* at 146 (noting that the time period provided for public comment before the commissioner takes action may either encourage the harmonization of laws by encouraging interested parties to come forward and influence decisions on chip protection, or more voices may make consensus harder to reach).

70 . *See* 17 U.S.C. § 914 (1994).

71 . Kukkonen, *supra* note 8, at 117.

72 . McManis, *supra* note 35, at 358.

73 . *Id.*; Issuance of Interim Order, Interim Protection for Mask Works of Japanese Nationals, Domiciliaries and Sovereign Authorities, 50 Fed. Reg. 24,668 (1985).

74 . Kukkonen, *supra* note 8, at 117.

75 . *Id.*

76 . 17 U.S.C. § 906(a) (1994). *But see* Lemberg, *supra* note 7, at 362 (arguing that the SLA only protects reverse engineering for a purely academic evaluation—for example, unlike in the United States, the reverse engineering defense in Japan will not allow a manufacturer to include in its chips substantial portions obtained by reverse engineering of another's protected circuit layout).

77 . *See* Kukkonen, *supra* note 8, at 118.

78 . *Id.*

79 . *See* 17 U.S.C. § 902 (1994).

80 . The reciprocity provisions of the SCPA have subjected the act to criticism by some commentators. *See, e.g.*, Feuerstein, *supra* note 62, at 145-46 (noting that the SCPA is criticized as imperialistic and as pressuring other countries into adopting undesired legislation).

81 . Kukkonen, *supra* note 8, at 118 (defining the integrated circuit as a "product having transistors or other circuitry elements which are inseparably formed on a semiconductor material or on insulating material or inside semiconductor material, and designed to perform an electronic circuitry function").

82 . *See* 17 U.S.C. 901(a)(2) (1994).

83 . Kukkonen, *supra* note 8, at 118.

84 . This point was not explained in detail in *Brooktree Corp. v. Advanced Micro Devices, Inc.*, 977 F.2d 1555, 1565 (Fed. Cir. 1992).

85 . Kukkonen, *supra* note 8, at 118.

86 . *Id.* at 119.

87 . Council Directive 1987/54/EEC of 16 December 1986 on the Legal Protection of Topographies of Semiconductor Products, art. 1(1)(b), 1987 O.J. (L 24) 36.

88 . McManis, *supra* note 35, at 358.

89 . Kukkonen, *supra* note 8, at 121.

90 . *Id.*

91 . *Id.* at 122.

92 . *Id.*

93 . Feuerstein, *supra* note 62, at 147; Lemberg, *supra* note7 , at 369-70.

94 . Feuerstein, *supra* note 62, at 147; Lemberg, *supra* note7 , at 369-70.

95 . Feuerstein, *supra* note 62, at 147-48; Lemberg, *supra* note7 , at 369-70.

96 . Lemberg, *supra* note 7, at 371.

97 . *See* Copyright, Designs and Patents Act, 1988, c. 48, § 213 (Eng.).

98 . *See id.*; Kukkonen, *supra* note 8, at 122-23.

99 . *See* Copyright, Designs and Patents Act, 1988, c. 48, § 213 (Eng.); Kukkonen, *supra* note 8, at 122-23.

100 . *See* Copyright, Designs and Patents Act, 1988, c. 48, § 213 (Eng.); Kukkonen, *supra* note 8, at 122-23. Kukkonen criticizes the U.K. act for not protecting devices on nonsemiconductor substrates. However, the U.K. act does not preclude protection for semiconductor devices made on insulating substrates, such as thin film transistors

made on a glass plate for a liquid crystal display. The U.K. act does not protect nonsemiconductor devices which do not include any semiconductor layers therein, such as superconducting devices (e.g., SQUIDS, Josephson Junctions, etc.) and metal-insulator-metal (MIM) diodes.

101 . Kukkonen, *supra* note 8, at 124-25.

102 . *Id.*

103 . *See* The Copyright Act of 1968 (Austl.), *available at* http://www.austlii.edu.au/ au/ legis/ cth/ consol_act/ ca1968133 (last visited Nov. 10, 2000).

104 . *See* The Circuit Layouts Act of 1989 (Austl.), *available at* http://www.austlii.edu.au/ au/ legis/ cth/ consol_act/ cla1989203 (last visited Nov. 10, 2000).

105 . *See* Nintendo Co. Ltd. v. Centronics Syst. Pty. Ltd., 181 C.L.R. 134 (1994), *available at* http://www.austlii.edu.au/ au/ cases/ cth/ high_ct/ 181clr134.html (last visited Nov. 10, 2000).

106 . *See id.*

107 . *See* The Circuit Layouts Act of 1989 (Austl.), *available at* http://www.austlii.edu.au/ au/ legis/ cth/ consol_act/ cla1989203 (last visited Nov. 10, 2000).

108 . *See id.*

109 . Act Concerning the Layout-Design of Semiconductor Integrated Circuits (Korea).

110 . *See* David Roche, *Phoenix Rising: South Korea's Comeback*, The Asian Wall St. J., Sept. 4, 2000, at 6.

111 . Kukkonen, *supra* note 8, at 125-26.

112 . *Id.*

113 . *Id.* at 128.

114 . *Id.* at 120.

115 . *Id.* at 128.

116 . Feuerstein, *supra* note 62, at 148.

117 . *Id.* at 149.

118 . *Id.*

119 . World Intellectual Property Organization*:* Treaty on Intellectual Property in Respect of Integrated Circuits, May 26, 1989, 28 I.L.M. 1477 [hereinafter IPIC Treaty].

120 . Feuerstein, *supra* note 62, at 149.

121 . IPIC Treaty, *supra* note 119, art. 14 (enabling legislation which would allow a foreign government to grant licenses to make protected topographies to third parties despite the owners' refusal to grant such licenses in order to "safeguard a national purpose deemed to be vital" by the foreign government).

122 . Feuerstein, *supra* note 62, at 141.

123 . *Id.* at 141-42.

124 . *Id.* at 141.

125 . 35 U.S.C. §§ 1-376 (1994). Note that 35 U.S.C. § 181 (1994) authorized the Commissioner of Patents to prevent the grant of patent if the grant would be detrimental to national security. However, the patent applicant may be entitled to compensation under § 183.

126 . IPIC Treaty, *supra* note 119, art. 14.

127 . Feuerstein, *supra* note 62, at 150.

128 . IPIC Treaty, *supra* note 119, art. 6, § 4.

129 . 17 U.S.C. § 901(a)(7) (1994).

130 . IPIC Treaty, *supra* note 119, art. 6, § 1(a)(ii).

131 . *Id.* art. 2, § (i).

132 . As explained above, such integrated circuits may be based on superconducting materials or other materials, such as MIMs (metal insulator metal switches used in some liquid crystal displays).

133 . *See* Kukkonen, *supra* note 8, at 129. The term "however expressed" probably includes expressing topographies as masks or mask works protected by the SCPA used in manufacturing of the integrated circuits. Thus, it appears that the SCPA complies with the protected subject matter provisions of the IPIC Treaty.

134 . IPIC Treaty, *supra* note 119, art. 6, § 1.

135 . *Id.* art. 4.

136 . *Id.* art. 6, § 2.

137 . *Id.* arts. 5, 7.

138 . Feuerstein, *supra* note 62, at 149.

139 . The WIPO conference concerned only intellectual property issues, which were not of the highest importance to developing nations at that time. The United States could not leverage trade concessions desired by developing nations for promulgation of chip protection laws by the developing countries.

140 . Agreement on Trade-Related Aspects of Intellectual Property Rights, Apr. 15, 1994, art. 36, 108 Stat. 4809, 33 I.L.M. 81 [hereinafter TRIPS].

141 . IPIC Treaty, *supra* note 119, art. 6 did not qualify that product that no longer contains a protected topography could be sold, imported and distributed (but not manufactured) without liability.

142 . IPIC Treaty, *supra* note 119, art. 2, § (i) incorporated into TRIPS protection for integrated circuits in their final or intermediate (i.e., in-process) form.

143 . *See* TRIPS, *supra* note 140, art. 37.

144 . *See id.*

145 . TRIPS, *supra* note 140, art. 31 generally allows compulsory licenses for commercial purposes, except for semiconductor technology. This gives the semiconductor industry a special status under TRIPS, perhaps because of the failure of the United States and Japan to sign the IPIC Treaty containing the compulsory license provisions.

146 . For example, the doctrine of patent misuse, while clearly not a compulsory license, may still limit the rights enjoyed by patent owners in the United States.

147 . *See* the North American Free Trade Agreement, Dec. 17, 1992, § 1710, 107 Stat. 2057, 32 I.L.M. 612.

148 . Lewis, *supra* note 8, at 566; Risberg, *supra* note7 , at 241.

149 . For example, the speed of microprocessors increased nearly five-fold from 100 MHz to 1 GHz in just 3 years.

150 . Chips developed through reverse engineering should be contrasted with chips produced by pirates. A second, original chip developed from reverse engineering a competitor's chip is an improvement over the first, earlier-made reverse-engineered chip. The new second chip advances the state of the art without wasting research resources on reinventing the basics already developed for the first chip. Likewise, the second chip is an improvement on the earlier

chip and can compete on the open market with improved chips made by the manufacturer of the first chip, unlike the pirate-manufactured chip which offers no such advancements.

151 . Rauch, *supra* note 1, at 428.

152 . *Id.*

153 . *Id.* at 428-29.

154 . *See generally* Wolf, *supra* note 3.

155 . Risberg, *supra* note 7, at 256.

156 . *Id.* (arguing that process incompatibility was the most important factor responsible for the demise of chip piracy). However, pirates could still pirate the layout of an integrated circuit without using the incompatible, difficult to control, or secret processes or top of the line equipment to produce a chip that is somewhat inferior in quality or performance to the original chip. As discussed below, demand for such pirated, inferior chips may still exist in developing countries.

157 . Rauch, *supra* note 1, at 429.

158 . Telephone interview with Mike McLean, Engineer, Semiconductor Insights, Inc. (May 26, 1999).

159 . Rauch, *supra* note 1, at 406 (quoting the Federal Trade Comm'n, Bureau of Economics, Staff Report on Semiconductor Industry (1977)).

160 . Rauch, *supra* note 1, at 411-12.

161 . *See* Lewis, *supra* note 8, at 567.

162 . *See id.* at 608 n.426; Michael Maibach, *The Industrial Policy Cycle*, 5 Stan. L. & Pol'y Rev. 23, 27 (1993).

163 . For example, to reverse-engineer a Pentium processor, it would probably cost about a million dollars. Telephone interview with Mike McLean, Engineer, Semiconductor Insights, Inc. (May 26, 1999).

164 . E-mail from Mike McLean, Engineer, Semiconductor Insights, Inc., to Leon Radomsky (May 27, 1999) (on file with author).

165 . *See* Rauch, *supra* note 1, at 430-31.

166 . *See id.* Lewis argues that the most important reason for the decline of piracy is the increasing complexity of the manufacturing process. *See* Lewis, *supra* note 8, at 566. Lewis argues that pirates who copy their competitors'

layouts cannot fabricate an identical chip without knowledge of the complex manufacturing process. This may no longer be true today. Companies that specialize in reverse engineering can also deduce the process used to fabricate even the most complex chip based on analysis of the integrated circuit topography. *See generally Our Services*, Semiconductor Insights, Inc., (2000) *at* http://www.semiconductor.com/ services/ services.html (last visited Nov. 10, 2000).

167 . *See, e.g.*, Lewis, *supra* note 8, at 566; *see also* Risberg, *supra* note7 , at 273.

168 . Risberg, *supra* note 7, at 273. Of course, if a pirate lacks the integrated circuit parameters, computer aided design would be of little use compared to reverse engineering an existing chip containing certain parameters developed by a competitor.

169 . Metal oxide semiconductor field effect transistor, the most common basic block of integrated circuits.

170 . Lewis, *supra* note 8, at 567-68.

171 . Piracy is not profitable even for the simple DRAM chips because the majority of DRAM costs are in production rather than in research and development. Furthermore, DRAM profit margins are so small that a pirate probably cannot sell pirated DRAMs for a lower price than a legitimate manufacturer. *See* Rauch, *supra* note 1, at 430.

172 . Risberg, *supra* note 7, at 274.

173 . *Id.* at 274-76.

174 . *Id.* at 274. Other semi-custom chips are made by creating an integrated circuit by combining various standard cells (standard circuit elements for performing a routine logic function). Chip makers usually have a “library” of such standard cell layouts, and may combine individual cells into a custom integrated circuit similar to Lego blocks. *See* Gerard V. Curtin, Jr., *The Basics of ASICs: Protection for Semiconductor Mask Works in Japan and the United States*, 15 B.C. Int’l & Comp. L. Rev. 113, 133 (1992).

175 . A customer who desires to incorporate an ASIC into the customer’s electronic device specifies the unique or special function that the customer desires the ASIC to perform. The gate array manufacturer then retrieves a wafer containing the unconnected gate arrays and interconnects the gate arrays according to the customer’s request. *See* Risberg, *supra* note 7, at 274 n.173.

176 . Alternatively, if the customer possesses integrated circuit manufacturing capabilities, then the customer may perform the final gate array interconnection to manufacture the ASIC.

177 . Furthermore, the computer programs stored in ROM chips may be protected by copyright law, thus further thwarting chip piracy. *See* Apple Computer v. Franklin Computer Corp., 714 F.2d 1240, 1249 (3d Cir. 1983); *see also* Glynn S. Lunney, Jr., Note, *Copyright Protection for ASIC Gate Configurations: PLDs Custom and Semicustom*, 42 Stan. L. Rev. 163 (1989).

178 . There are also several other logic and memory devices which utilize gate arrays capable of being customized to meet a customer's specific needs. Customization methods include blowing fuses between certain interconnections, or making interconnections by creating new "antifuse" links by applying a laser or electrical current between two integrated circuit electrodes. *See The Antifuse Advantage in FPGAs: Single Chip High Performance Solutions*, *at* http://www.actel.com/ products/ antifuse/ index.html (last visited Nov. 10, 2000).

179 . Risberg, *supra* note 7, at 275.

180 . *Id.* at 267.

181 . *See, e.g.*, Rauch, *supra* note 1, at 413 n.48.

182 . *See* Rauch, *supra* note 1, at 406-13; Risberg, *supra* note7 , at 267.

183 . *See* Rauch, *supra* note 1, at 407; Risberg, *supra* note7 , at 267.

184 . Rauch, *supra* note 1, at 413 n.48; Risberg, *supra* note7 , at 267.

185 . *See* Lewis, *supra* note 8, at 580-82.

186 . 35 U.S.C. § 271(g) (1994).

187 . *See* Risberg, *supra* note 7, at 266.

188 . *Id.* at 262-63.

189 . *See id.*

190 . *See id.* at 266.

191 . *See* Lewis, *supra* note 8, at 605-06; Risberg, *supra* note7 , at 271.

192 . *See* Risberg, *supra* note 7, at 271.

193 . *Id.*

194 . *Id.* (noting that most companies considered "pirates" in the 1970s have now entered into cross-licensing agreements with companies that develop original chips and are no longer be considered pirates).

195 . *See* Lewis, *supra* note 8, at 607.

196 . Telephone interview with Mike McLean, Engineer, Semiconductor Insights, Inc. (May 26, 1999).

197 . *See, e.g.*, Semiconductor Insights, Inc. *at* http://www.semiconductor.com (last visited Sept. 23, 2000) (generally discussing the reverse engineering capabilities of a significant company in the industry).

198 . Lewis, *supra* note 8, at 586-87.

199 . *Id.* at 605-06; Rauch, *supra* note 1, at 430-31.

200 . *See generally* Rauch, *supra* note 1, at 407.

201 . *See id.* at 407-21.

202 . 17 U.S.C. § 904(a) (1994).

203 . 17 U.S.C. § 908(a) (1994).

204 . Registration is a prerequisite for initiating an infringement suit. 17 U.S.C. § 910(b)(1) (1994).

205 . Less than fifty percent of all layouts may be withheld or blocked out as a trade secret. Mask Work Protection, 37 C.F.R. § 211.5(c) (1999). This provision, thus, does not provide a sufficient amount of trade secret protection. While almost all chips can be reverse-engineered, reverse engineering is expensive. The expense provides a limited amount of protection from piracy, while the registration provisions substantially negate this protection.

206 . Intel apparently did not register its most recent mask works.

207 . *See* Timothy D. Howell, *Intellectual Property Pirates: Congress Raises the Stakes in the Modern Battle To Protect Copyrights and Safeguard the United States Economy*, 27 St. Mary's L.J. 613, 657-60 (1996).

208 . *See generally* Kukkonen, *supra* note 8.

209 . *Id.* at 128 n.132 (even Russia adopted sui generis topography protection in 1992).

210 . Feuerstein, *supra* note 62, at 154.

211 . *See* Kenneth R. Parks et al., *EU extends Protection for U.S. Chip Designs*, J. Proprietary Rts. No. 7-10, at 29 (1995). The United States and the European Union annually renewed provisional protection to chips originating in their respective countries from 1987 to 1995. Such provisional legislation is no longer necessary as of January 1, 1996, when the EU countries and the United States became signatories to TRIPS.

212 . *See* Jay A. Erstling, *The Semiconductor Chip Protection Act and its Impact on the International Protection of Chip Designs*, 15 Rutgers Computer & Tech. L.J. 303, 343-44 (1989); Kukkonen, *supra* note 8, at 128.

213 . *See* TRIPS, *supra* note 140, art. 35.

214 . Many developing countries are now in the process of drafting sui generis integrated circuit topography legislation in order to comply with TRIPS. For example, the Bulgarian government recently sought the review by the Central and East European Law Initiative (CEELI) section of the ABA to determine if its new topography protection act complied with TRIPS. *See Draft Law on the Topologies of Integrated Circuits for the Republic of Bulgaria: April 14, 1998*, *available at* http://www.abanet.org/ ceeli/ assessments/ Countries/ Bulgaria.html (last visited Nov. 10, 2000).

215 . Lewis, *supra* note 8, at 607-11.

216 . *Id.* at 611.

217 . *See* Rauch, *supra* note 1, at 405.

218 . *See* Erstling, *supra* note 212, at 344; *see also* 17 U.S.C. § 902 (1994).

219 . For example, Bulgaria recently proposed such an act which was reviewed by the CEELI committee of the ABA for compliance with TRIPS. Apparently, the only reason that Bulgaria proposed this act was in order to reap the trade benefits of TRIPS. *See Draft Law on the Topologies of Integrated Circuits for the Republic of Bulgaria: April 14, 1998*, *available at* http://www.abanet.org/ ceeli/ assessments/ Countries/ Bulgaria.html (last visited Nov. 10, 2000).

220 . *See generally* Wolf, *supra* note 3.

221 . Some integrated circuits utilize micro devices based on ceramics, biologically active materials, or metal-insulator-metal diodes. These solid state devices lack any semiconductor elements from the periodic table of elements, and thus cannot be considered to be “semiconductor devices.”

222 . In a “negative” type photoresist, irradiation of light or UV radiation uncross-links a previously cross-linked polymer, thus softening the irradiated regions.

223 . This doping method is called ion implantation.