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# Intellectual Property (IP) Challenges and Concerns of the Semiconductor Equipment and Materials Industry

## Protection of IP Rights is Essential for Sustaining Technological Advancement of the Semiconductor Device Industry

### EXECUTIVE SUMMARY

Protection of intellectual property (IP) rights is a serious area of concern for the semiconductor equipment and materials industry, which supplies critical enabling technologies to microchip manufacturers. In the highly competitive global business environment, IP protection is essential to the survival of the industry, allowing it to make the significant R&D investments needed to sustain technological advancement of the semiconductor device industry. Continued IP violations of various forms undermine the development of the next generation of equipment and materials required to meet the challenges of Moore's Law. Consequently, members of SEMI®, the global association representing the equipment and materials industry, have called for support of industry efforts to protect their IP rights.

In response to these calls by its membership, SEMI commissioned Nobleman Group to conduct a detailed study of various IP challenges facing the equipment and materials industry, and to assess the extent of IP violations and their impact on the industry. This white paper summarizes the results of this work, which is based on direct input from a large sampling of SEMI member companies, consisting of equipment, materials, subsystems, component, and automation systems suppliers of various sizes from Asia, Europe, and North America. Of 85 companies that were targeted, 49 participated in this study, which corresponds to a response rate of rate of ~ 58%. They represent 56.3% of the total annual sales of the entire equipment and materials industry (~ \$78 billion in 2006).

Close to 90% of the companies that participated in this study reported that they have experienced some form of IP violation, including infringement, counterfeiting, and theft of core technologies, core products, spare parts and components, trade secrets, and trademarks. Fifty four percent (54%) of companies characterized these infringements as serious to extremely serious.

These companies identified Taiwan, China, Korea, and North America as regions of the greatest concern. However, the form and nature of IP violations in each region vary and occur for different reasons, especially in the case of North America. In addition, about 53% of the companies report IP violations by their customers (i.e., chip-makers). However, due to its sensitive nature and concerns about antagonizing customers, this is a difficult topic for the supplier industry to address. In Asia, regional and customer IP violations appear to be closely linked.

Nearly 60% of the companies surveyed have taken legal action against IP violations. However, only 48% of them are satisfied with the outcome. Legal processes are slow, expensive, and unpredictable. Companies are concerned about costs and variability in the outcome of litigation.

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Over 60% of the companies report that they have experienced an adverse economic impact caused by IP violations, due to loss of sales and market shares, with estimated lost revenues amounting to a range of ~ 1% to 2.5% of the total annual sales of the industry. In addition, IP violations lead to pricing pressure and reduced average selling prices, resulting in further loss of revenues. Reduced sales caused by IP violations could lower shareholder and market value. Consequently, the total industry financial losses and damages amount to billions of dollars per year. This also in turn adversely affects the global and local economies through loss of jobs and reduced public revenues from taxes.

Strong and effective intellectual property protection is critical for SEMI member companies in all regions of the world and at all

customer sites. Countries must recognize that they will greatly benefit from strong IP policies, through attracting outside investment and encouraging innovation by domestic companies. In addition, it is critical to educate the device making customers on the value of IP to the equipment and materials industry. Customers themselves heavily invest in developing their IP and understand the cost to create IP. They should recognize the adverse impact of IP violations on their suppliers, and work with them to avoid any type of infringement. To address these issues, this paper provides a set of specific recommendations to SEMI that focus on expanding public policy efforts, working with governments for global IP protection, driving customer dialogue, working with SEMI member companies to promote a global culture of respect for the industry IP assets, as well as providing IP management education to its members.

## BACKGROUND

Over the past two decades, the semiconductor industry has been greatly transformed. This has been driven by the confluence of a multitude of significant worldwide trends, including:

- Advent of outsourcing (and off-shoring), primarily in the lower cost Asian markets,
- Rise of wafer foundries and the phenomenal growth of fabless chip suppliers,
- Emergence of Asia as the main manufacturing hub for advanced microchips,
- Challenges of managing an evolving and changing supply chain,
- Continued globalization of business,
- Emergence of several Asian countries as major economic powers, with strong technology and industrialization focus (especially China, India, Korea, Singapore, and Taiwan),
- Continued consolidation of the semiconductor industry,
- Transition of the semiconductor end markets into the consumer domain,
- Shorter product life cycles and the push for faster time to market,
- Ongoing customer (i.e., system and chip suppliers) quest for cost reduction,
- Increasing pricing and margin pressures across the supply chain,
- Acceleration of process and technology node migrations,
- Increasing complexity of process, equipment, and materials technologies, and
- Rising costs of R&D needed to meet the industry roadmap requirements and challenges.

These trends together with several critical compounding factors, greatly and adversely affect the highly valuable intellectual property (IP) assets of the semiconductor industry. These factors especially include:

- **Non-uniform and inadequate IP protection laws at the international level,**
- **Problematic and inadequate enforcement of IP rights in emerging markets,**
- **Disagreements about the validity and strength of certain types of IP within the industry,**
- **Expensive and protracted IP litigation proceedings, and**
- **Lack of an industry-wide consensus regarding ways to address IP-related issues.**

The combination of all these trends, factors, and challenges has led to an alarming rise in various forms of IP violations in the semiconductor industry. Consequently, protection of IP rights has emerged as a serious area of concern for the semiconductor equipment and materials industry, which supplies critical enabling technologies to semiconductor chip manufacturers. In order to offer these capabilities, companies make significant R&D investments, in the range of ~ 10% to 15% of their annual revenues. In recent years, the suppliers have been increasingly funding a larger portion of the escalating R&D costs needed for the continued success of the semiconductor device industry<sup>[1]</sup>.

In a competitive global business environment, IP protection is essential to the survival of the semiconductor equipment and materials suppliers. This enables the suppliers to make the significant R&D investments needed to sustain technological advancement of the knowledge-intensive semiconductor device industry. Continued IP violations in various forms threaten the development of the next generation equipment and materials required to meet the challenges of Moore's Law, by reducing the investments in the costly R&D needed to develop the IP behind these offerings. Furthermore, IP violations could lead to serious reliability, safety, and quality problems for the industry, which in turn could result in costly consequences and liability. These challenging conditions pose a serious threat to the well-being of the entire electronics supply chain, where IP has always been the main engine for its growth. In some cases, due to these issues

and further challenges caused by the pressures of the cyclical nature of the industry, a number of suppliers have even exited the market. Examples include major materials companies, such as Dow, which have left the electronic materials market.

Faced with these mounting challenges, members of Semiconductor Equipment and Materials International (SEMI), the organization representing the industry, have called on SEMI to support their efforts in IP rights protection and enforcement. In response to this request, SEMI commissioned Nobleman Group to conduct a study with the aim of developing this white paper on the IP challenges and concerns of the semiconductor materials and equipment industry.

## OVERVIEW

To assess the extent of IP violations and their adverse impact on the equipment and materials industry, Nobleman Group conducted a detailed study of various IP challenges facing the industry. This work relied heavily on collecting direct input from SEMI member companies about their experiences and concerns with IP problems. The data was collected through an in-depth, customized web-based survey and interview, conducted with the executives of a large representative group of the companies, consisting of equipment, materials, subsystems, and component suppliers of various sizes from Asia, Europe, and North America. This work was later followed with more focused interviews with a small sub-set of the participating companies, to examine select critical issues regarding regional and customer-related concerns, which emerged in the course of this study and the broader web-based interviews.

In close consultation with SEMI, 85 companies were identified for this study, accounting for over 70% of the total annual sales of the equipment and materials industry. The list of target companies covered a large group of SEMI members globally, representing a broad cross section across the value chain. This sampling provides a strong basis for developing a realistic picture of the IP issues facing the industry. Out of 85 suppliers targeted, 49 companies participated, corresponding to a response rate of ~ 58% and representing ~ 56.3% of the total annual sales of the entire equipment and materials industry (~ \$78 billion in 2006).

Due to the sensitive and extremely competitive nature of IP-related issues—especially as they relate to customers as well as regional, legal, and economic aspects covered in this study—many companies were initially reluctant to participate. In order to address and alleviate these concerns, it was decided to keep the names of all companies confidential. Furthermore, companies were assured that all individual responses would remain confidential and that no data would be provided that could identify the responses by any single company.

This study also examined the overall industry experience in the area of IP violations and explored ways of addressing the IP challenges and concerns of the equipment and materials industry. In addition, based on the input by respondents a set of recommendations were developed, with a special focus on the role

that SEMI could play in assisting its membership to improve the protection of their IP rights.

## OBJECTIVES OF THE STUDY

The primary objectives of this study were:

- **To study and analyze IP issues, challenges, and concerns in the semiconductor equipment and materials industry,**
- **To develop a fact-based summary of the IP violations and problems, specific to the global equipment and materials industry. Here, the primary goals were:**
  - **To determine and to understand the types and frequency of IP violations,**
  - **To assess supplier-customer IP concerns**
  - **To identify the regional concerns, including those of emerging markets.**
- **To assess the economic impact of IP violations on the equipment and materials industry and provide order of magnitude estimates of the costs to industry,**
- **To provide recommendations for and to identify the role that SEMI could play in addressing IP-related concerns, and**
- **To serve as a basis for further discussion on IP issues and concerns of the supplier industry.**

This white paper is designed to provide a framework for increasing the awareness of SEMI member companies, customers (chip-makers), and governments regarding the nature and scope of IP violations in the industry. An important goal is to enable the supplier industry to enhance dialogue with customer groups, governments, and within SEMI membership regarding the need for a joint commitment to IP protection throughout the semiconductor supply chain. Continued success of the semiconductor device industry depends on the ability of the equipment and materials industry to achieve a positive return on its IP assets and the costly R&D investments made in the next generation equipment and materials required to meet the challenges of Moore's Law<sup>[1, 2]</sup>.

The following sections offer an in-depth analysis of the IP challenges and concerns of the industry, based on the results of this study, including industry survey results and inputs, interviews, industry experience, and the research conducted by Nobleman. Detailed results of the survey portion of this work are provided in the Appendix (page 14).

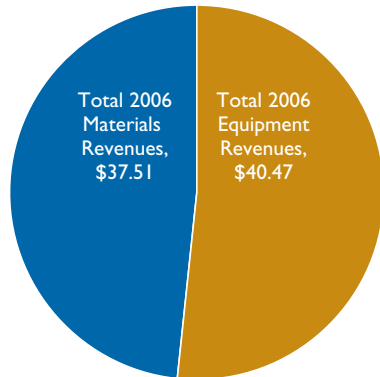
## Role of Intellectual Property in the Semiconductor Equipment and Materials Industry

IP in its various forms has always been an important foundation of the semiconductor equipment and materials industry. Massive investments by the suppliers in IP assets and corresponding research and development has seen the sector grow into a

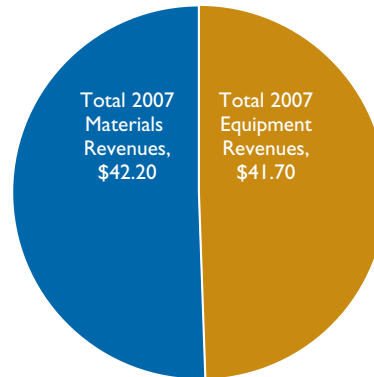
Figure 1

**Worldwide Semiconductor Equipment & Materials Sales  
(2006 Total: \$77.98B; 2007 Total: \$83.90B)**

**2006 Equipment & Materials Sales (US\$ B)**



**2007 Equipment & Materials Sales (US\$ B)**



[4]

nearly \$80 billion industry (Figure 1), directly employing an estimated 200,000 people worldwide.

Providing major competitive advantages, intellectual assets also provide huge value in other ways. They act as critical differentiators and rich sources of revenue, ensuring return on the investments made. The ability to translate IP into profits could increase the market value of a company well beyond its book value. The importance of IP assets necessitates effective management strategies for protection of IP and realization of its maximum potential value<sup>[3]</sup>.

Along with the great rewards of IP come risks and challenges that must be managed as part of a comprehensive strategy. The most troublesome aspect is the expensive and lengthy litigation for IP violations, due to potential infringement or improper use. As the globalization of the industry has accelerated, there are many concerns about IP rights and protection, counterfeiting, protectionism, bureaucracy, weak regulations, and ineffective enforcement of existing intellectual property laws. Consequently, IP protection has emerged as an ongoing and growing source of concern for the industry, which has to make huge investments in the development of its IP. The next section examines the nature and magnitude of these problems.

**IP CHALLENGES OF THE EQUIPMENT AND MATERIALS INDUSTRY**

Nearly 90% of the semiconductor equipment and materials companies surveyed have experienced some form of IP violation, with 54% characterizing these infringements as serious to extremely serious. Figure 2 (page 5) shows the types and degrees of IP violations experienced. These violations are in various forms of infringement, including counterfeiting, and theft, impacting core technologies, core products, spare parts and components, trade secrets, and trademarks.

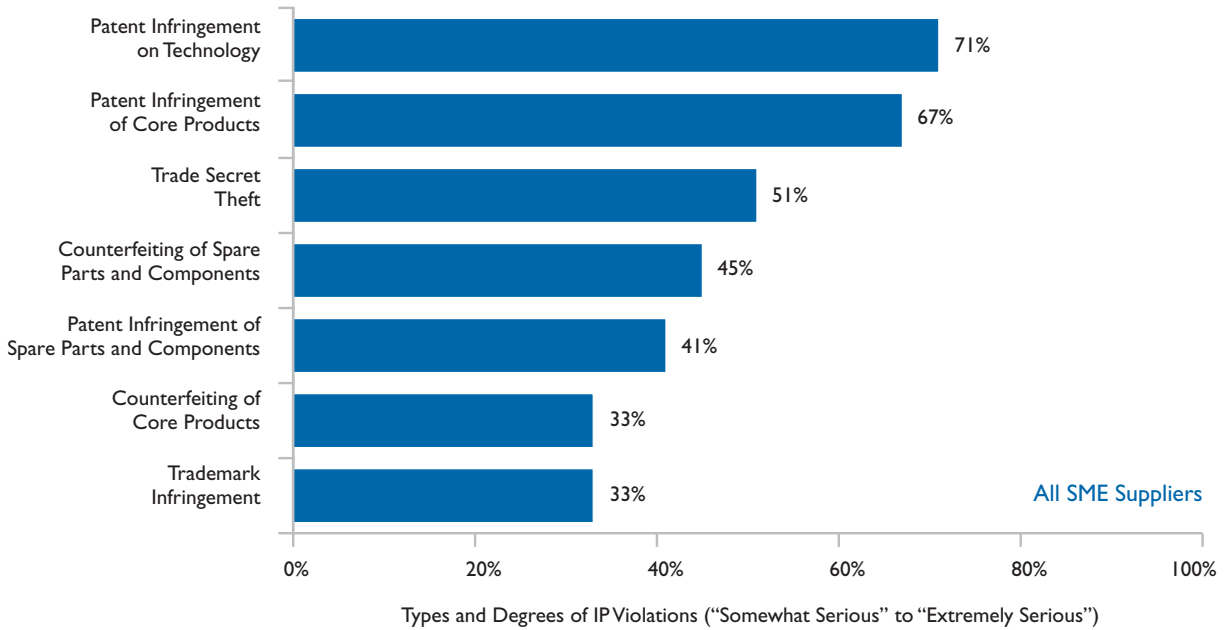
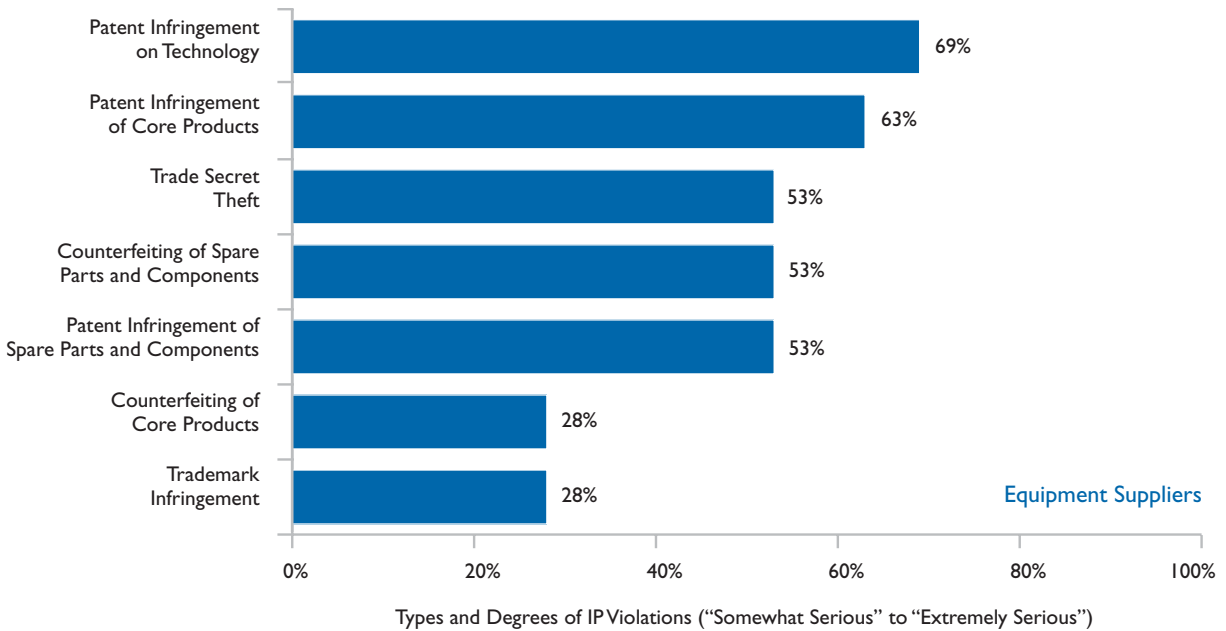
Although all segments of the equipment and materials industry to some degree have experienced all these types of IP violations,

the severity of the problems and the form and nature of each type of violation depends on the specific segment of the industry, as described in the following.

**Equipment Suppliers:** As shown in Figures 3, 4, and 5, the top concerns for all segments, including equipment suppliers, involve patent infringements of technology and core products (> 60%), followed by trade secret thefts (> 50%). In addition, the capital equipment (OEM) segment of the industry is suffering from counterfeiting and patent infringement of spare parts and components, and loss of revenues from the related maintenance and support services (Figure 3, page 5). Approximately 53% of equipment suppliers report problems with spare parts and components counterfeiting. This study did not examine the losses specific to the area of spares and services. However, an order of magnitude estimate of these losses is provided in the section of this paper relating to the economic impact of IP violations. Counterfeiting of core products and trademark infringements also occur, but to a lesser extent (28%).

**Materials Suppliers:** Patent infringements of technology and products are the most critical challenge facing materials suppliers. All materials suppliers that participated in this study reported that they have experienced this problem (Figure 4, page 6). Materials suppliers (with total annual sales of \$36.6 billion in 2006) are extremely vulnerable to IP violations against their core products and technologies, including counterfeiting. These usually occur through reverse engineering or trade secret thefts. Consequently, materials companies tend to place much more emphasis on IP protection rights. Therefore, it is not surprising that they spend a higher percentage of their revenues on IP management, as found in this study (> 3.6X the industry average).

**Sub-Systems/Components & Automation Suppliers:** The nature of IP challenges for sub-assembly, components, and automation systems suppliers falls somewhere between the equipment and materials suppliers, being much closer to the situation facing the equipment segment (Figure 5, page 6). In addition to patent infringements of technology and products (64%),

**Figure 2** Types and Degrees of IP Violations Experienced (All Segments)**Figure 3** Types and Degrees of IP Violations Experienced by Equipment Suppliers

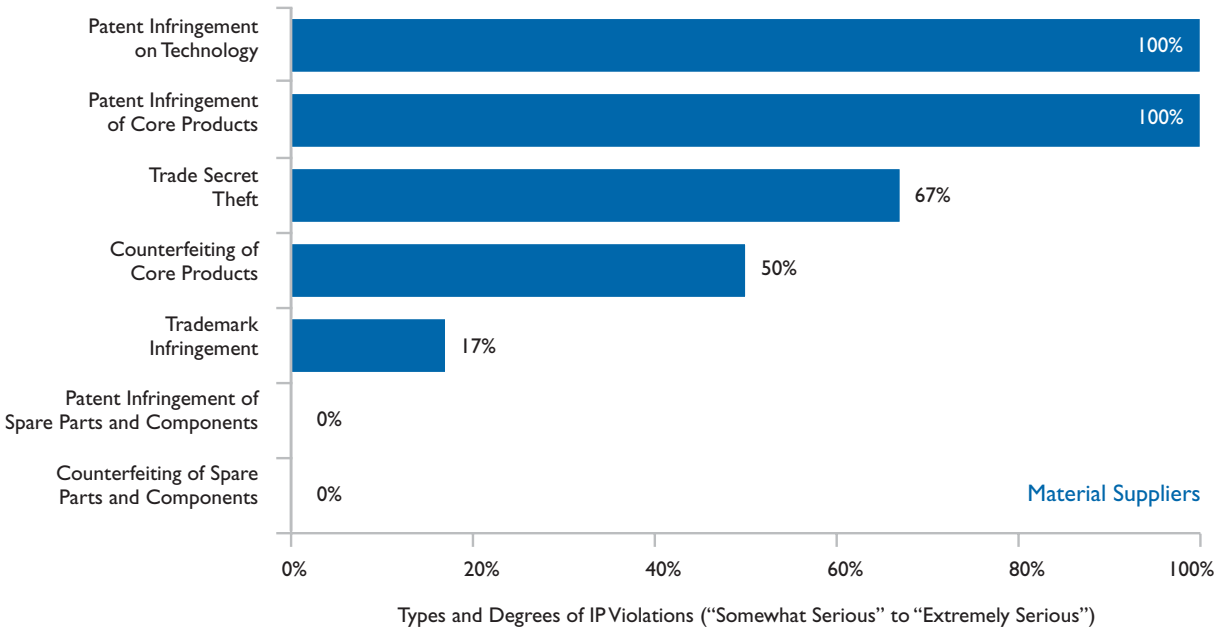
this segment of the industry is also facing IP violations involving trademark infringements (55%) and counterfeiting of spare parts (45%) and core products (36%).

It is important to understand the regional aspects of these problems, as well as the extent and nature of IP violations by customers, which are covered in the next two sections.

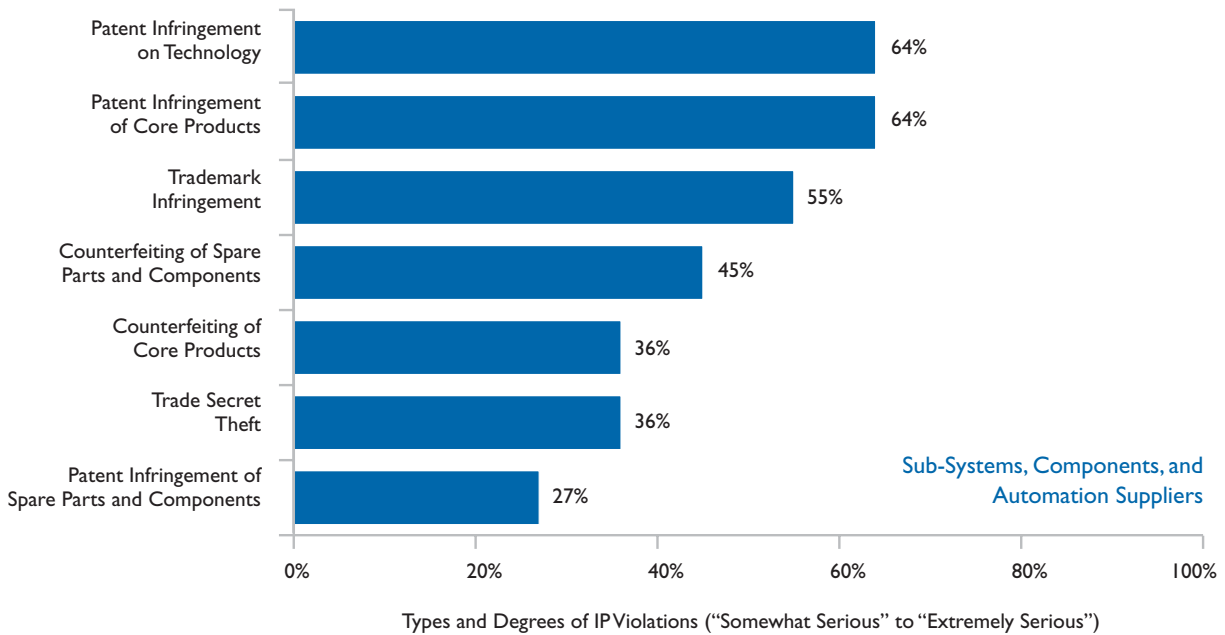
## REGIONAL IP CONCERNS

This study revealed that IP violations exist in all regions, with Taiwan (72%), China (71%), Korea (66%), and North America (64%) cited as areas of the greatest concern (Figure 6, page 7), and Japan (33%) and Europe (28%) as regions of least concern. Depending on the region (Figure 7, page 7), according to a

**Figure 4** Types and Degrees of IP Violations Experienced by Materials Suppliers



**Figure 5** Types and Degrees of IP Violations Experienced by Sub-Systems, Components, and Automation Suppliers



majority of companies these regional IP violations are getting worse in Korea (37%), Taiwan (25%), and China (22%).

One must note that the form and nature of IP violations in each region vary and occur for different reasons. In particular, it is important to examine the key differences between Asia (Taiwan, China, and Korea) and North America. While there are serious concerns about the inadequate protection of IP rights in many

parts of Asia, North America has traditionally been strong in this area due to legal protection and the high penalties for infringements. As a consequence, generally companies in the North America region refrain from intentional IP violations. Still, North America is considered by more than 60% of companies as a major region of concern for IP violations, which may be surprising to some people. For the most part, this is for different reasons than those related to Asia, including:

Figure 6

## Regional IP Concerns

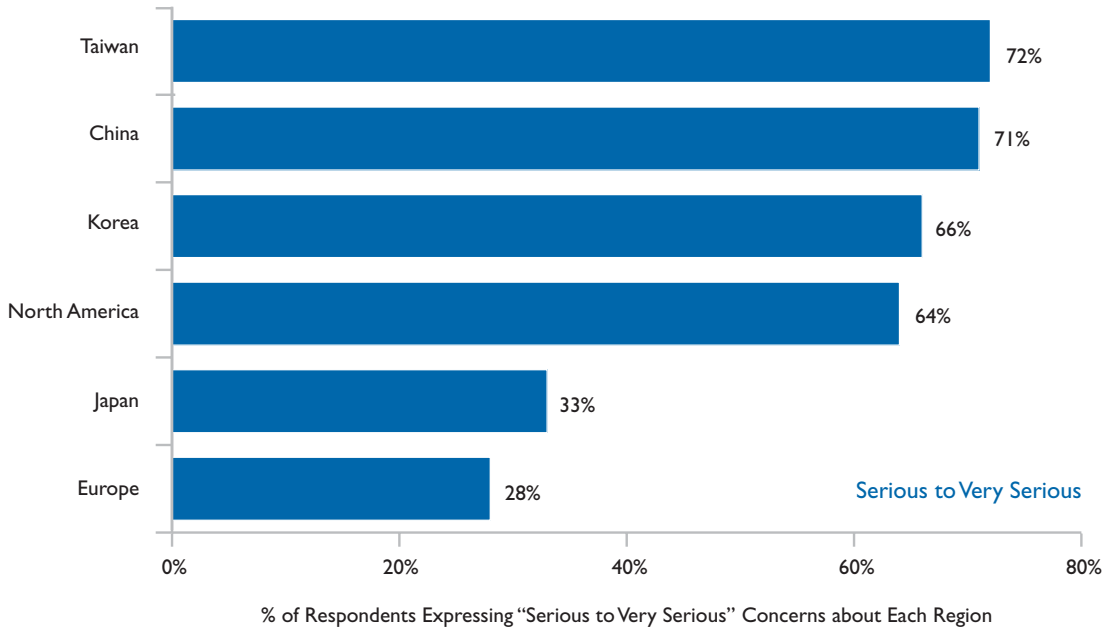
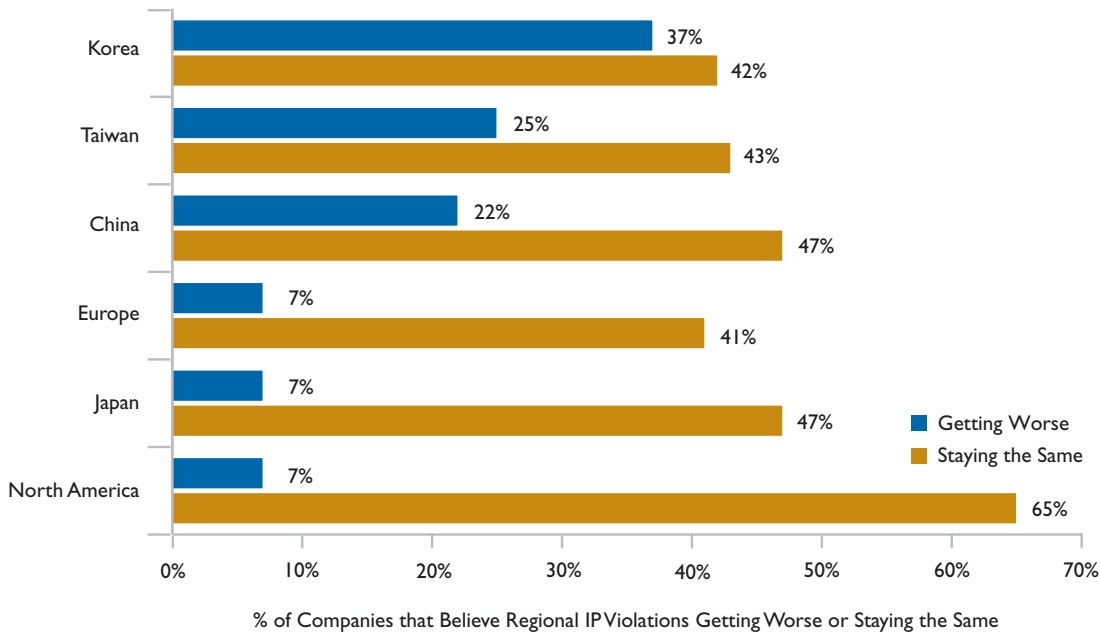


Figure 7

## Trends in Regional IP Violations



- Disputes about the validity of some patents, or certain claims,
- Challenges against weak IP,
- Trade secret thefts, often by former employees, or
- Unintentional infringements.

In some cases, IP violations may occur simply because the infringing party may not have been aware of its existence. However, in

many cases, the validity of the patent behind the IP is in dispute. This is especially true if the IP is not broad, fundamental, or strong and companies feel that they could challenge it and have the resources to do so. This is an area of concern for smaller companies and startups that lack sufficient resources to pursue and challenge IP litigations, especially against larger competitors.

The slow pace and high costs of the legal system, together with the high degree of uncertainty over the outcome of IP litigation tends to further encourage these conflicts and amplify this

problem. In addition, if the IP is weak some companies with sufficient financial resources may challenge it, especially as it relates to the obviousness test, novelty of the idea, or prior art.

Therefore, in differentiating IP issues in each region, it is important to note that to a large extent IP infringement in North America is a byproduct of the “hotbed of innovation” nature of the high tech environment in the US, combined with the litigious nature of the North American IP system and the issues raised by patents drawn too broadly (e.g. Lemelson case).

The intensely competitive business environment has led equipment and materials companies to protect their technical advancements and products with significant portfolios of IP. Companies headquartered in North America, Japan, and Europe are the source of over 95% of all semiconductor equipment and materials produced in the world, with many of them having served the industry for a long time. Furthermore, their products are complex and each may contain a large number of various forms of IP, including patents, trade secrets, trademarks, know-how, best-known methods (BKMs), software, drawings, and other forms of IP assets. Consequently, companies in Europe, Japan, and North America own a huge portion of the IP in this space.

On the other hand, companies in China, Korea and Taiwan provide only a small percentage of total worldwide equipment and materials, with many of them being relatively smaller and newer entrants in the field. Most of them focus on serving the domestic market, and do not actively participate in the international markets. Usually, they are supported and encouraged by strong domestic chipmaking customers. To some extent, this condition may explain the regional IP violations as they relate to Asia.

Increasingly there is general agreement among many governments on the need to protect IP rights. However, protection of IP rights in some parts of Asia remains a serious problem. In particular, the aggressive economic development goals of countries in the growing and emerging markets in Asia, such as China, India, Korea, Singapore, and Taiwan pose challenges in the area of IP rights, which to some extent may be unintended and unforeseen. Development related priorities could slow down enactment of stronger IP laws and weaken the enforcement of existing IP legislation, which in turn could create conditions leading to further IP violations. Lack of uniform enforcement of IP rights protection laws by the local governments in China is a serious issue, as they may not follow the central government’s vision in these areas.

Many companies report unsatisfactory outcomes from legal action against IP violations in these regions (see box, above right). Due to the sensitivity of these cases and customer concerns, companies that provided these examples prefer to stay anonymous. Furthermore, they would not provide any specific information regarding the parties involved, or any additional identifiable details.

The public domain case of FormFactor vs. Phicom in Korea on advanced probe cards provides an example of these regional IP-related issues and their complex nature [5, 6, 7]. FormFactor

### Regional Legal Actions (Real Examples — Suppliers View)

**Example 1:** In Korea, a supplier took action against patent infringement and had to face an invalidation trial against the patent, where the court did not reflect the case properly and rendered a negative and non-qualified decision lacking full consideration of all arguments.

**Example 2:** A supplier pursued trade secret and non-compete complaints against former employees and a competitor in Singapore to no avail.

**Example 3:** An SME supplier began to take action against a customer; but was forced to withdraw, because they received a strong indication from the customer that this would strongly harm the customer-supplier relationship.

asserts that the probe cards that Phicom sold to Hynix in 2004 infringed on its patents. Faced with recent setbacks in pursuing its case in Korean courts, in November 2007 FormFactor filed a formal complaint with the United States International Trade Commission (ITC), which has emerged as an international entity used not just by US based suppliers, but also by non-US companies.

Consequently, some companies hesitate to address the IP problem in the Asia Pacific region through direct legal remedies and do not take legal action in China or Korea. However, more recent experience suggests that progress is being made and more companies are experiencing some degree of success in protecting their IP rights in these countries. For instance, in this study a few companies reported success in asserting their IP rights in China and Korea. Therefore, despite these regional IP concerns, many IP experts recommend filing for IP protection in all regions of concern. Regional IP violations are closely linked with IP violations by customers, which are examined in the next section.

## IP VIOLATIONS BY CUSTOMERS

With ~ 53% of equipment and materials companies affected, IP violations by customers are seen as an extremely serious, but much less talked about issue. Violation of equipment and materials suppliers’ IP by their chipmaker customers is a difficult and frustrating issue. However, since the prevailing rule in the industry is that the supplier will not take legal action against its customers, suppliers feel helpless. This is due to fear of antagonizing customers and the high probability of losing all sales to them. Furthermore, cases of IP violations by customers are more difficult to prove. Device makers may wonder why the suppliers and SEMI have not come forward before, and are only now working on IP rights protection. The primary reason is that costs are rising and undermining investments into R&D and IP development. In addition, over the past two decades chip suppliers have pushed an increasing share and burden of R&D investments to their suppliers and now demand full turnkey solutions.

In many IP infringement cases in the regions of concern, there is a linkage to a customer. In some cases, the companies may take action against the parties that supply the infringing products to these customers, but this may still upset some customers.

In general, IP violations by customers are driven by their desire to reduce costs, especially in the areas of spare parts and upgrades, sub-systems, components, and consumables. In many cases, customers engage in seemingly harmless practices which lead to the violation of the IP owned by their suppliers. The following examples of real world practices may seem acceptable to customers because they are used to leverage competitive market forces to their advantage. However, they violate their suppliers' IP and their non-disclosure agreements.

- **Providing product details, parts specifications, and pricing information to third party companies to entice them to provide (infringing) spare parts and assemblies,**
- **Providing equipment and product access to competitors, and**
- **Passing along process parameters and process performance details to competitors.**

In some cases, joint development projects between the supplier and customer ultimately leads to IP violations, as evidenced by the following two real examples. Companies that provided these and other examples cited in this section would not provide information that is more specific.

In joint development projects, it is important to define the IP ownership clearly upfront. IP infringements in joint development situations are longstanding issues in the semiconductor industry, and have never been well resolved. However, due to increasing cost pressure from rising R&D investments this issue is coming to a head at this time. As stated earlier, equipment and materials companies make significant R&D investments (~ 10% to 15% of annual sales) and are increasingly carrying a heavier burden of R&D needs of the industry<sup>[1]</sup>.

Only a small number of customers commit deliberate IP violations, which may even include reverse-engineered materials, technologies, and equipment. More often than not, IP violations by these customers usually involve unauthorized sharing of confidential information with competitors. Sometimes in extreme cases, the competitor is an affiliate of the customer. Furthermore,

#### Actual Cases of IP Challenges in Joint Development Projects with Customers

- Case 1:** A supplier worked with a customer to develop a new system in which the supplier owned the IP. Customer provided the IP to competitors in order to compete on price.
- Case 2:** In a joint development work, the customer pre-empted the supplier by filing patents related to the equipment, even though this area was not the direct business of the customer.

it is widely believed that certain chip manufacturers in Asia routinely encourage local shops to copy the spare parts and products of their suppliers. These intentional IP violations include the following examples provided by the companies participating in this study:

- **Contracting with others to develop competitive infringing products,**
- **Providing information to competitors in enough detail, to allow them to copy and duplicate the technology and product, and**
- **Reverse engineering of products or chemistries, in order for local companies to manufacture infringing products**

The impact of these violations are particularly devastating to the materials suppliers, since they are more prone to infringements and counterfeiting of their products and technologies. The cases of IP violations by customers are more complex and the chance of successful litigation is low. Where possible, suppliers tend to take action against the infringing supplier that is working with the customer. However, there are some success stories from those who have had strong cases and have persisted (see box below).

#### Actual Examples of Successful Resolution to IP Violations by Customers

- Example 1:** A competitor, encouraged by a customer, had copied a product of a supplier. Litigation led to satisfactory result in assessed damages and permanent injunction.
- Example 2:** A supplier company shared the information regarding IP violation by a customer with their senior legal officer, which resulted in a negotiated agreement.

The next section provides a discussion of legal issues in relation to the protection of IP rights.

## LEGAL PROTECTION OF IP RIGHTS

Legal processes are slow, expensive, and the outcomes are unpredictable. There are significant concerns about variability in quality of examination of patents in different jurisdictions. In many cases, jury trials are not effective in understanding complex patent laws and patent applications. The equipment and materials industry is very concerned about the cost and variability in the outcome of IP litigation. Some companies in the industry find it difficult to decide whether to spend large sums of money to maintain a single patent suit when the outcome is so uncertain. Proper improvements in the patent process could remove the ambiguity of patent validity. In addition, enforceable penalties for infringements are important.

About 60% of the companies surveyed have taken legal action against IP violations, with ~ 48% of these achieving satisfactory

results. This explains why some suppliers decide not to take legal action against infringements. The main reasons cited by the companies for this decision include:

- **Unpredictable outcomes,**
- **High costs,**
- **Inconsistencies in global IP practices,**
- **Concerns about countermeasures,**
- **Customer relationships, and**
- **Concerns about the possibility that customers would be dragged into the process.**

All these factors, coupled with customer challenges and regional concerns, conspire to make the decision on taking legal action against IP violations extremely difficult.

Further complicating the picture, the US Supreme Court overruled the obviousness test in a recent decision on the KSR v. Teleflex case. This has introduced further uncertainty into the patent process in the US, which is expected to be clarified in the court over the next few years. It is also important to note that in the US, patent regulations could change significantly if the US "Patent Reform Act of 2007" becomes law.

The next two sections examine the costs of managing IP assets, IP-related litigation costs, and the economic impact of IP violations on the supplier industry.

## COSTS OF IP MANAGEMENT AND IP LITIGATION

The cost of maintaining a patent portfolio and managing the IP assets of companies is significant and escalating. Based on the results of this study, IP management costs for the supplier industry are estimated to be ~ 0.2% to 0.36% of annual sales (average: ~ 0.27%). For the entire industry, total costs of IP management are estimated to be in the range of ~ \$150M to \$280M per year (average: ~ \$215M).

Litigation expenses are additional costs which are not included in the above estimates. This study found that the average annual IP-related litigation expenses of the equipment and materials industry amount to ~ 0.13% to 0.27% of annual sales (average: ~ 0.2%), which is estimated to be between ~ \$105M to \$210M per year (average: \$160M). Only 24% of all companies report receiving payments for IP-related settlements in the range of ~ 0.04% to 0.11% of total sales (average: ~ 0.07%), estimated to amount to between ~ \$30M to \$90M for the entire industry (average: \$60M). Therefore, the industry incurs a net loss of ~ 0.09% to 0.16% of its annual sales because of IP litigation (~ \$75M to \$120M per year). This finding indicates that as a whole the industry is on the losing end of IP litigation. It also confirms the serious concerns raised by companies about the legal process.

## ECONOMIC IMPACT OF IP VIOLATIONS

The economic losses to various industries are also large and growing, as summarized for the sampling provided for benchmarking purposes in Table I [8,9,10]. According to the US International Trade Commission (ITC), ~ 5% to 7% of the world merchandise trade (of \$11,762B in 2006) is in counterfeit goods. The information provided by the Global Anti-Counterfeiting and Piracy Initiative of the U.S. Chamber of Commerce states that the global trade in illegitimate goods has increased to ~ \$650 billion annually. For example, the US Federal Aviation Administration (FAA) estimates that ~ 2% of all airplane parts used are counterfeit.

As discussed in previous sections, the semiconductor industry is also facing serious challenges regarding IP violations. A large majority of equipment and materials companies have experienced an adverse financial impact due to IP violations because of loss of sales and market share, with the total industry financial losses and damages amounting to billions of dollars per year. Usually, IP violations result in competitors being more effective, making it difficult to maintain product differentiation in the market. This would lead to an even further loss of market share and

**Table I Economic Losses Due to IP Violations**

Industry	Annual Losses (US\$ B)	Comments
<b>Software</b>	34	35% of all installed computer software are fake [Business Software Alliance and IDC Survey (2006)]
<b>Pharmaceutical</b>	32	< 1% in developed countries > 30% in developing countries > 50% from illicit websites [World Health Organization]
<b>Automotive</b>	12	250,000 Jobs Lost [U.S. Federal Trade Commission]
<b>Apparel &amp; Footwear</b>	12	
<b>Motion Picture</b>	6.1	
<b>Artistic Recordings</b>	4.6	

price erosion on key products, due to increased unfair competition. In addition, these violations could cause damage to the brand because of the low quality of the counterfeited parts or systems. To further compound the problem, these losses may lead to increased expenses and operating costs. Consequently, all these factors—in combination with the uncertainty of IP litigation outcomes—could affect investor confidence and analyst perceptions. This would translate into a reduced market value of the company, yet another financial loss that could far exceed direct sales losses.

Differentiation of product offerings by suppliers is a key sustaining factor in maintaining profitability. This is accomplished through investments in R&D and ownership of strong IP assets. A strong IP portfolio leads to many benefits, including:

- **Ability to offer differentiated products and services,**
- **Better, more capable, more reliable, and safer products,**
- **A strong position for cross licensing with other companies,**
- **Increased market share and correspondingly higher revenues,**
- **Higher average selling prices (ASPs) with higher gross margins,**
- **Additional profit and revenue streams from licensing fees and royalty payments,**
- **Increased shareholder and market value, and**
- **Expansion of the broader economy through creation of new jobs, preservation of existing employment, and increased public revenues via generation of taxes.**

This study assessed the magnitude of the economic impact of IP violations on the industry, and the results are summarized in the following. Noblemen would like to emphasize that the estimates provided in this paper are only order of magnitude estimates, not exact numbers and are mainly intended to help better understand the scope and seriousness of the problems. The following analysis indicates that, in aggregate, industry revenue losses due to IP violations could be in the range of ~ \$ 2 billion to \$4 billion per year. Based on a sampling of equipment and materials industry statistics, Noblemen estimates average sales of ~ \$396K per employee. Therefore, each 1% loss in industry annual sales (of ~ \$78B) would correspond to 1,970 lost jobs.

**a) Loss of Sales Due to Market Share Losses:** Over 61% of companies have experienced an adverse economic impact caused by IP violations, which they estimated to be in the range of ~ 1.6% to 2.5% in terms of market share loss (average: 2.1%). The corresponding lost revenues are estimated to be in the range of ~ 1% to 1.7% of the total

annual sales (average: ~ 1.3%). With ~ \$78 billion in total equipment and materials industry sales in 2006, these market share losses would amount to a range of ~ \$ 1 billion to \$2 billion per year. In the case of market share loss, most of the revenue streams are diverted from the IP owners to the IP violators, which may well include another member of the supplier industry. However, here the exception would be the area of counterfeit products, spare parts, or components, where the violators should not be considered a legitimate supplier.

The area of spares and services is a high margin business for the industry and typically amounts to ~ 5% to 10% of the annual revenues (of \$40.5B in 2006) for the capital equipment industry (i.e., a range of ~ \$2B to \$4B annually). Assuming a total annual sales loss of ~ 1% to 2.1% (as in the above ranges), annual revenue losses of spares and services would amount to at least ~ \$20M to \$85M. It is believed that actual losses may be much higher than these estimates.

- b) Loss of Sales Due to Pricing Pressures:** In some cases, IP violations may also lead to pricing pressure and reduced average selling prices (ASP), which would result in further erosion of the revenue base on top of the direct financial impact of lost market shares. It is difficult to accurately determine the magnitude of this mode of revenue loss, and this study did not quantify these losses. However, based on industry experience, price erosion tends to be significant (usually over 10%). If only 10% of the total industry sales were under such pricing pressure, for every 10% price reduction there would be an average of 1% hit on the total industry sales. Each percent of lost sales would amount to a \$780M reduction in the annual revenues of the equipment and materials industry. In the case of ASP erosion, the revenues would not be realized, and would be simply lost.
- c) Loss of Market Value:** Reduced sales and lower gross margins, due to market share losses and pricing pressure, could lower earnings per share (EPS). This would in turn lead to a lower market valuation and a reduction in shareholder value. Even with modest valuation multiples (e.g., 2x), this impact could result in a significant loss. For every 1% of lost revenues this hit could potentially exceed an amount equivalent to > 2% of the annual sales (or ~ \$1.6B).
- d) Other Impacts:** Infringed products could suffer from poor quality, lower reliability, and pose safety problems, which could be very costly and lead to serious injury and liability issues. It is also important to consider and include the impact of reduced R&D investments and lost market opportunities. Finally, one should also consider the overall impact on the global and local economies, due to lost tax revenues and job losses.

## CONCLUSIONS AND RECOMMENDATIONS

The semiconductor industry and its equipment and materials suppliers face serious and mounting challenges in IP protection, with adverse economic consequences for the industry. Increasing IP violations are driven by factors such as weak IP protection laws and weak enforcement and penalties in many regions of the world, outsourcing and off shoring in Asia, and the ongoing quest by the semiconductor industry for cost reduction in a consumer driven market. Efforts in development, management, and protection of IP have evolved into a costly global concern. This is due to the rising costs of R&D, increased pressure on return on R&D investments, escalating costs of IP management, and IP litigation costs. These conditions have put the industry at risk by undermining the incentives for and rewards of innovation. Semiconductor equipment and materials companies offer complex and advanced systems to a highly specialized market. Protection of IP assets is critical to the survival of suppliers. Continued violations of IP could undermine the development of new equipment and materials for the next generation semiconductor devices. In addition to the direct economic impact, it is imperative to consider the implications of the adverse effect of IP violations on a variety of other factors, including product reliability, safety, and quality.

This study provides a better understanding of the extent of IP violations in the equipment and materials industry. It has identified troublesome elements of the problem, including customer infringement and regional concerns. It must be noted that IP violations could include items that are not patented, including originally designed parts and subsystems, which are still considered as IP assets. Intellectual property includes technology, designs, equipment, subsystems, components, spare parts, software, process recipes, materials, and best-known methods. Furthermore, IP violations may be illegal, or un-ethical, or both. Un-ethical IP violations that are not illegal present a serious challenge, because no effective mechanisms for enforcing these IP rights exist.

Considering that over 70% of new investments in wafer fabs are made in Asia, the findings of this study demonstrate the gravity of IP infringement issues that the industry is facing in these regions. Identifying these facts should help suppliers address these issues with their customers and together as an industry. In addition, these results will help SEMI member companies to benchmark their own views and experiences against those of the entire industry.

It is important to review and examine the main factors that lead to IP violations, which have been identified in this study, including:

- **Willful violations by low-margin counterfeiters, especially in Asia,**
- **Willful violations by small local firms with customer encouragement, mostly in Asia,**
- **IP violation by suppliers with implicit customer knowledge, which is a worldwide concern,**
- **Violation by suppliers without customer encouragement or knowledge,**
- **Trade secret thefts,**
- **Unintentional violations driven by the customer's desire to reduce costs,**
- **Infringement by competitors due to disputed IP,**
- **Weakness of the patents, or inability and**
- **Difficulty in keeping the IP confidential.**

IP violations in the supplier industry are committed by competitors, or counterfeiters, or former employees, or customers. In many cases, the infringement by competitors is due to their belief that the IP does not cover the application at hand and/or is not valid, or simply they are unaware of the existence of the disputed IP. In other cases, these infringements take place knowingly, mostly by small suppliers in the emerging markets. Misappropriation of trade secrets and violation of non-compete agreements are committed by former employees, with or without the knowledge of the new employer. Another source of IP infringement or trade secret theft is customers, which knowingly or inadvertently share the confidential information of their suppliers with their competition.

The following is a set of recommendations, including the role that SEMI could play in helping the industry address its IP challenges and concerns. These recommendations were based on analyzing and reviewing the inputs of participants in this study by Noblemen and SEMI, and convey the expressed needs of SEMI membership.

### Working with the SEMI Member Companies

The notion of IP rights refers to a broader category of rights than just the legal definition. It requires the use of good business ethics and a desire to improve the industry's behavior to enhance its future. Many IP-related disputes are among SEMI member companies themselves. Therefore, it is important to start addressing IP concerns from within member companies. It is recommended that SEMI work with member companies to promote a global culture of respect for IP assets in the semiconductor industry, and develop an industry IP code of conduct and best practices with the aim of avoiding infringement of intellectual property within the industry, and protecting sensitive information.

The globalization of the semiconductor business requires a global approach to IP management. Therefore, it is recommended that SEMI continue to provide IP management education to its members, and help the industry educate its workforce as to the value of IP to the company and the importance of strong IP management, and develop programs to deal with IP infringements. Providing a set of guidelines regarding IP agreements could also be beneficial to many members. Furthermore, SEMI should continue to develop and enhance the SEMI website dedicated to IP (<http://www.semi.org/IP>).

### Global IP Protection and Public Policy

Strong and effective intellectual property protection is critical for SEMI member companies in all regions of the world.

Governmental lobbying by SEMI on behalf of its members for stronger intervention would help to strengthen IP rights protection. It is recommended that SEMI expand its efforts on a solidified industry approach to infringement and increase its public policy efforts in the area of IP rights to ensure protection of the IP assets of its members. Especially, supplier companies are calling on SEMI to continue lobbying various governments and their regulatory bodies and working with countries in Asia, to encourage:

- **Improving legal means of IP protection,**
- **Establishment of effective enforcement policies, and**
- **Enhancing global cooperation on IP protection among various countries.**

Bilateral agreements between nations, such as the US-Korea Free Trade Agreement, could lead to greater cooperation in addressing concerns in this area and minimize trade friction.

Each region should consider ways of enforcing IP protection and ensure that IP best practices are taken seriously. Countries must recognize that they will greatly benefit from strong IP policies, through attracting outside investment and by encouraging homegrown innovation by domestic companies. It is recommended that SEMI work with each region and help them to closely examine the nature of the IP-related problems and concerns in their region and develop and implement ways of addressing these issues. This would encourage industry investment in long-term innovation in these regions.

The prevalence of litigation in the semiconductor industry is rising in North America<sup>[1]</sup>. Some reforms are needed to streamline the patent process, make it more manageable for companies both large and small, and globally more consistent. Many companies are calling for better control of filing at the patent offices, and international standardization of patent laws. The entertainment industry has been more successful in getting copyright laws amended to protect their business than technology companies have been in getting patent laws amended. The ability to protect IP, especially in emerging markets, with the objective of ensuring that rules are enforced equally, is critical. SEMI could assist its membership by working with various government and international entities towards establishing common global practices and standards for IP rights protection. This is an area where continued efforts by SEMI on behalf of its membership would have a great impact on protecting the interests of the equipment and materials industry.

### **Customer Dialogue and Education**

Customers (i.e., chipmakers) and the supplier industry need to work together to address a common, but little understood problem, namely IP violations by customers. In part, this may be occurring without customer understanding of the cost and impact on the suppliers and the R&D base. The issue of customer infringement had not been raised by the semiconductor equipment and materials industry before, not because the industry had not sought to protect R&D investment in IP through all available means, but because customer infringement

is a sensitive and difficult issue to address without customer support and cooperation.

The industry supplies the critical enabling technologies to device makers and heavily invests in R&D and IP assets. Customers need to recognize that by sharing confidential information with competing supplier companies, they are violating the IP rights of their own suppliers. It is critical to educate customers on the value of IP to the supplier industry. All customers invest in IP and understand the cost to create IP so it is believed that once they recognize the impact on their suppliers, they would be willing to work with them to avoid these types of violations. In this same spirit, the industry is cooperating on using scarce resources in R&D to address Moore's Law challenges and cannot afford to waste any resources needed to develop next generation technology<sup>[1]</sup>.

To address customer-related concerns, it is recommended that:

- **SEMI and customer organizations initiate a new and productive dialogue on how to address these problems for the good of the overall industry,**
- **Initiate and drive customer education on the value of equipment and materials industry IP to them, and**
- **Develop an IP code of conduct for the semiconductor supply chain.**

Continuity in IP protection policy across the industry and respect for innovation are critical for the success of the entire semiconductor industry. Chipmaking customers themselves are also facing IP violations and are engaged in efforts to combat IP infringements. This is supported by the fact that in May 2007 the annual joint statement of the World Semiconductor Council (WSC) called for strengthened IP protection. It urged governments to implement effective enforcement measures and to review and enhance these measures. It is in the best interest of customers and suppliers to cooperate against IP infringements, which is a common problem facing both groups and requires global cooperation in the semiconductor industry.

### **Spare Parts and Products Authentication**

It is recommended that SEMI and its membership work on developing effective and appropriate authentication techniques for spare parts and products. SEMI has been working with customer groups and is supporting them to develop a standard for authentication of components to address and prevent counterfeiting in the semiconductor device industry. Appropriate use of authentication technologies and standards for spare parts and products with software / hardware coding could help reduce the magnitude of the counterfeiting problem. This effort can leverage the experiences of the automotive and aviation industries and the efforts by chipmakers in authentication technologies as described below.

Chipmakers are taking action to address the challenges they face with counterfeiting of microchips. For example, the May 2007 annual joint statement of the World Semiconductor Council (WSC) urges governments to adopt a policy to deal with coun-

terfeiting, including a fast track procedure for quick review and effective action. It also encouraged all segments of the industry to review ways to address counterfeiting of chips. In addition, in June 2006, the U.S. Semiconductor Industry Association (SIA) formed an Anticounterfeiting Task Force, which has developed a common problem statement and recommendations. It has also held meetings with government, distributors, and brokers and has arranged for a common point of contact at the Customs Service for industry enforcement issues. In October 2007, SIA members met with all US Government enforcement agencies to discuss how to increase efforts to combat counterfeit chips. At SEMICON West 2007, SEMI and SIA announced a joint Anti-Counterfeiting Task Force to evaluate requirements for SEMI standards that would allow semiconductor suppliers to place encrypted codes on containers to enable online authentication by distributors and purchasers.

SEMI needs to form alliances with customer groups with the aim of addressing concerns of the industry regarding the prevalent use of counterfeit spare parts and components. In this connection, SEMI could work with customers and help them recognize the potential quality, reliability, and safety impact of counterfeit spare parts, which could be quite costly. In addition, SEMI member companies should work with customers to address their

concerns regarding the extremely high costs of spare parts and components and develop practical models and solutions for resolving this serious issue.

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## APPENDIX

### Survey Results

On behalf of SEMI, Noblemen Group performed a detailed study of the IP challenges and problems facing the semiconductor equipment and materials industry, including an in-depth customized survey and interview combination, conducted with the executives of a large representative group of SEMI member companies globally. These companies included equipment, materials, subsystems, and component suppliers of various sizes from Asia, Europe, and North America representing a cross section of the supplier industry across the value chain. Noblemen developed this study with special focus on IP challenges and concerns, economic impact of IP infringements, and the role that SEMI could play in this area. The survey portion of this study was deployed via "www.zoomerang.com." Of a total of 85 companies that were targeted 49 responded, corresponding to a response

rate of 57.6% and representing 56.3% of the total annual sales of the entire equipment and materials industry (~ \$78 billion in 2006). Figure A.1 shows the mix of companies that participated in this study. Figure A.2 (page 15) illustrates the revenue distribution of these companies, and Figure A.3 (page 15) shows the locations of their headquarters. Important results of the survey portion of this work are summarized in the following sections.

### Degree of IP Challenges

As shown in Figures A.4 and A.5 (page 15), a huge majority of respondents reported facing some form of IP challenge (88%), with ~ 54% characterizing the nature of their IP violation as "serious" to "extremely serious."

### Forms of IP Violations

Figure A.6 (page 16) illustrates the degree of various forms of IP violations experienced by the industry, characterized as "somewhat serious" to "extremely serious". As shown, between 33% and 71% of the respondents report various forms of patent infringement or counterfeiting of core products or spare parts and components, trade secret theft, or trademark infringement.

Approximately 59% of survey participants report that they have taken legal action against IP violations, with 48% of them reporting satisfactory results from this effort. Only ~ 24% of all respondents report receiving payments for IP-related settlements.

**Figure A.1** Mix of the Respondents by Industry Segment

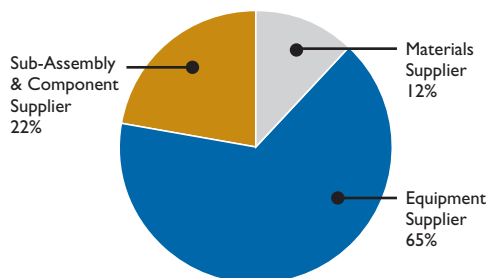


Figure A.2

Revenue Distribution of the Respondents

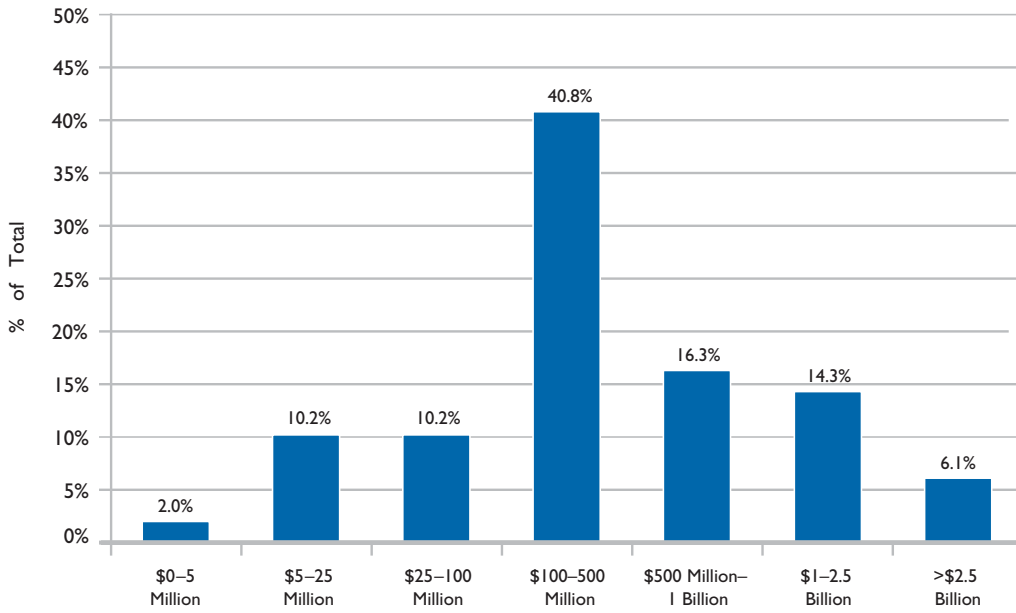


Fig.A.3 Location of Main Headquarters

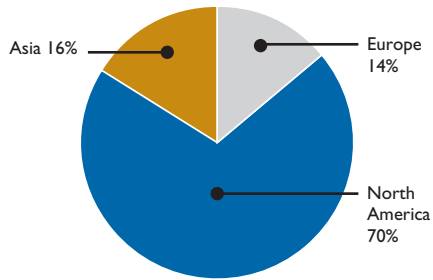


Fig.A.4

Degree of IP Challenge

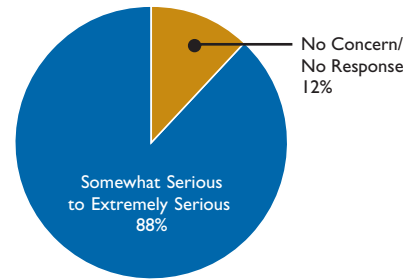
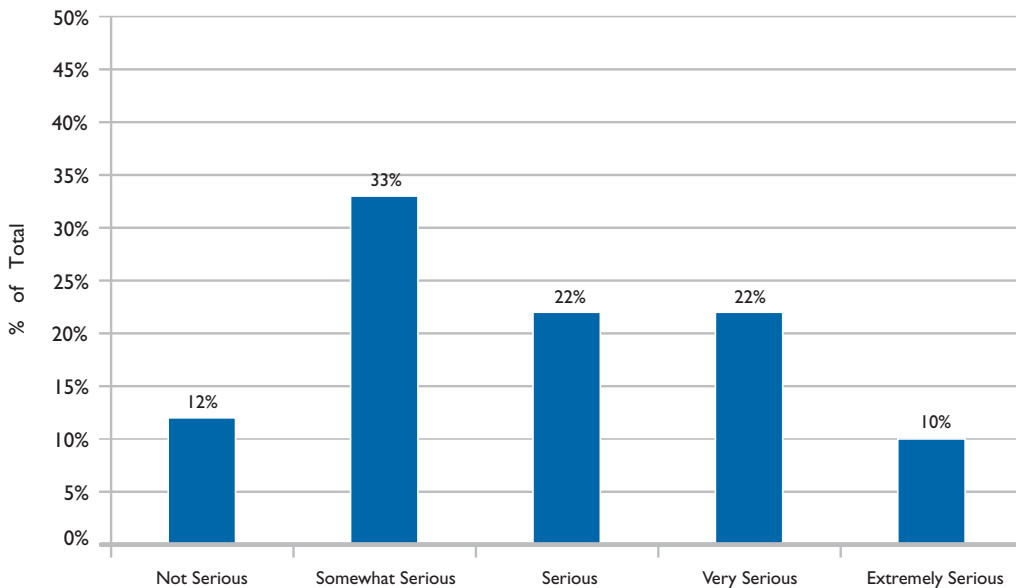
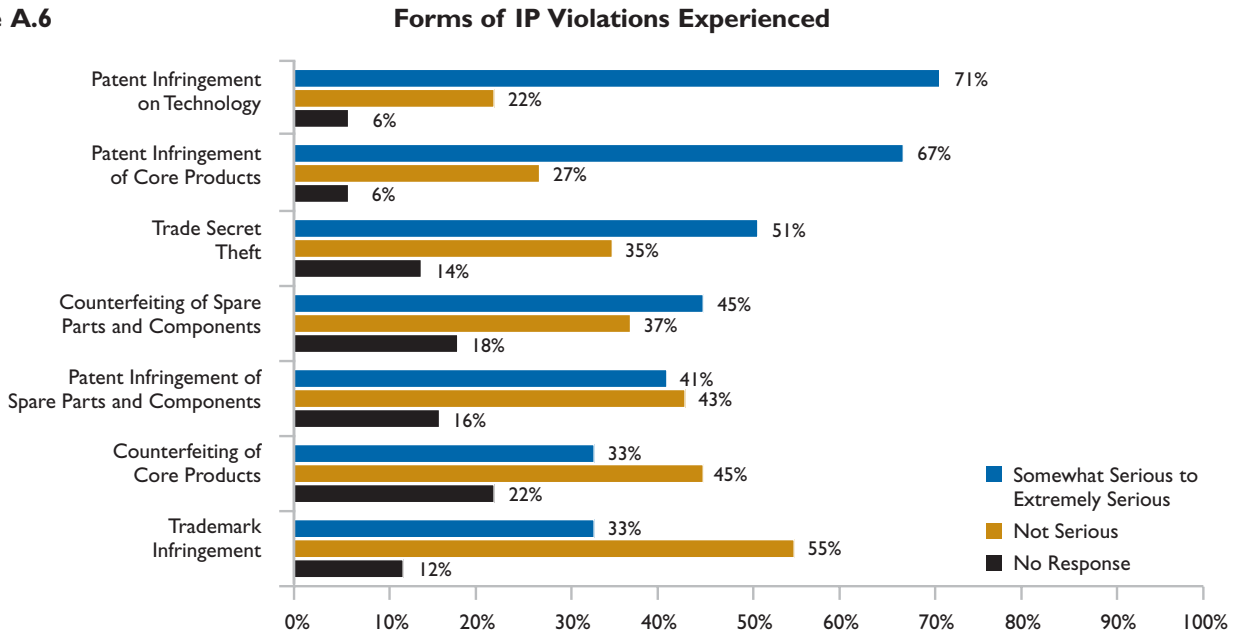


Figure A.5

Seriousness of IP Challenge



**Figure A.6**



**Regional IP Concerns**

The survey results revealed that IP problems exist in all regions. Many companies have “serious” to “very serious” concerns on IP violations in Taiwan, China, Korea, and North America (Figure A.7).

Figure A.8 (page 17) shows that companies believe that IP violations are getting worse in Korea (~ 37%), Taiwan (~ 25%), and China (~ 22%).

**IP Violations by Customers**

This survey also showed that over 53% of respondents have experienced some form of IP violation by customers (see Figure A.9 (page 17)).

**Figure A.7**

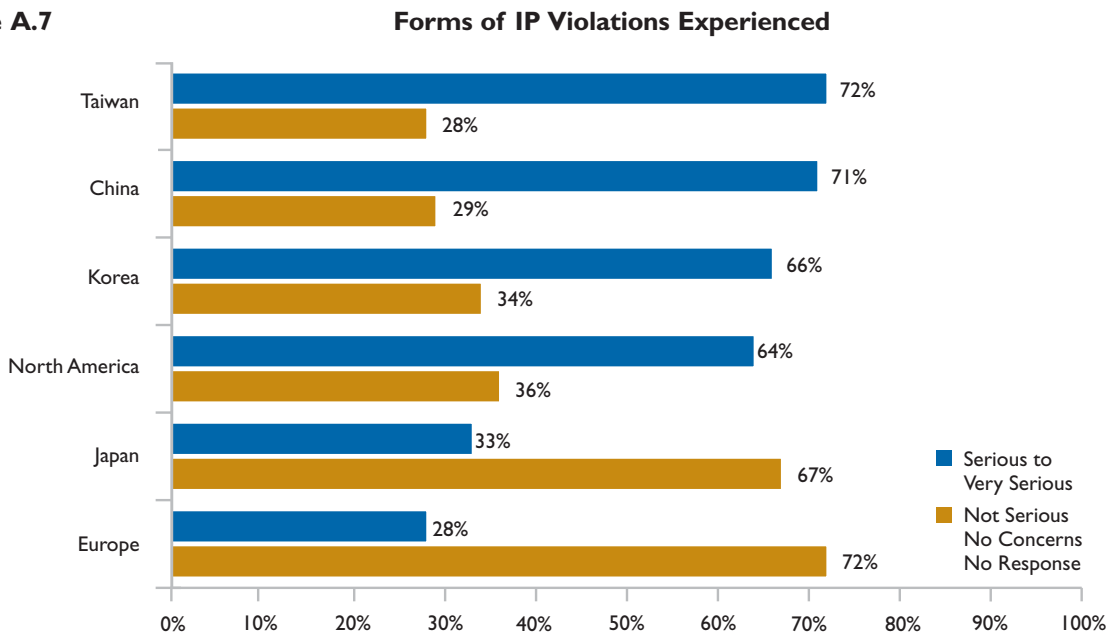


Figure A.8

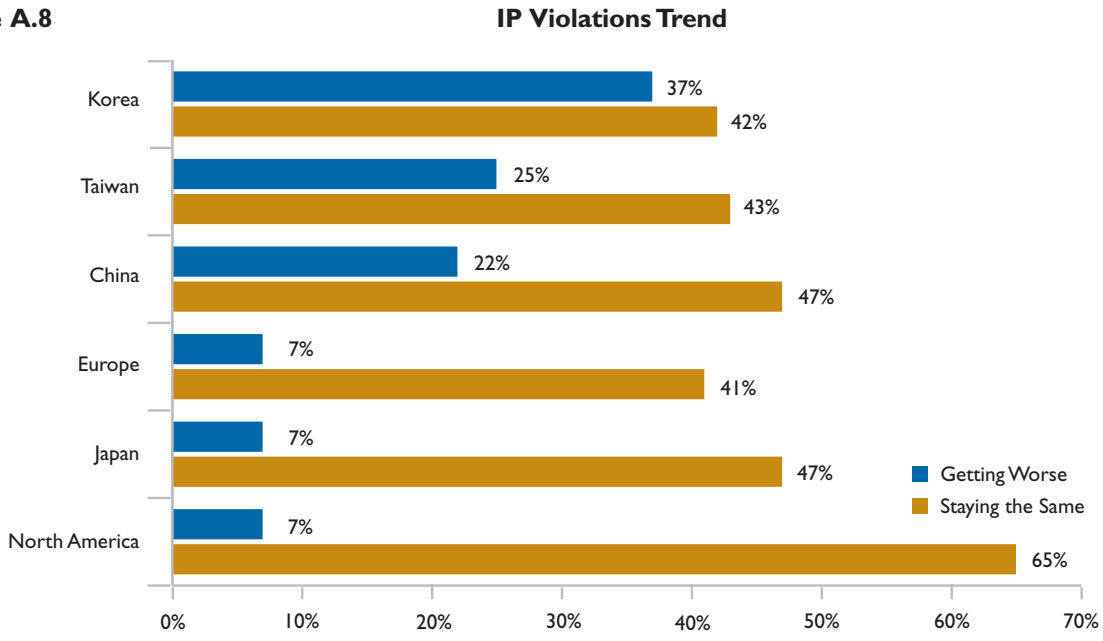
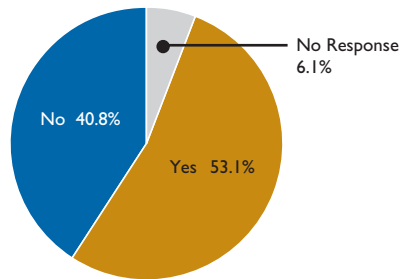


Fig.A.9 Extent of IP Violations by Customers



Has your company experienced IP violations by customers?