
# Analysis of European Patent Referencing to IEEE Papers, Conferences, and Standards

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## Executive Summary

IEEE engaged 1790 Analytics in this project to assess the impact of IEEE publications on technology developments in several areas of Information Technology (IT). This impact is measured by examining the extent to which patented inventions related to IT build upon papers from IEEE journals, IEEE-sponsored conferences, and IEEE standards. 1790 has conducted a number of similar studies in the past using references from US patents. In this study, we examined the set of references from 2005 published European Patents (EP) to see if the results were similar.

The main findings of this report are:

- The top 25 most active IT companies in the following technologies: Computer Hardware, Computer Software, Information Storage, Medical Equipment, Optics, Semiconductors, and Telecommunications published more than 17,000 patents in 2005 alone. These 17,000+ patents reference more than 4,500 journal articles, conference papers, and standards documents. More than half of these referenced documents are published by IEEE.

- IEEE is not only the most referenced publisher, but its lead over others is huge. Second place Elsevier receives one sixth the references of IEEE, and third place ACM (Association of Computer Machinery) receives only one twelfth as many references as IEEE overall.

- If we only consider conference papers, about 85% of the references go to IEEE sponsored conferences, versus 7% to second place ACM sponsored conferences. (Jointly sponsored IEEE/ACM conferences are ranked third, with 2% of the references).

- These results are consistent with the US results of earlier studies. (See [2] for these results.) This is important because, although approximately 50% of all US patents are non-US invented, it is perceived that there is a US bias which would favor US publications to the detriment of European publishers such as Elsevier. Moreover, it is widely perceived that the European patent systems referencing method is superior to the US system. This study suggests that the earlier US patent studies do not favor IEEE because of any biases within the US patent system.

- To take the above bullet point a bit further, consider Executive Summary Figure 1. The US portion of the Figure is taken from the aforementioned US studies, while the EP figure is from this analysis. In general, the share of IEEE references is higher in the EP patents than in the US patents although the results are somewhat comparable. For the EP study, in all categories except for Optics and Medical Devices the IEEE provides the highest share of the science base. In Optics and Medical Devices the IEEE is ranked second.

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# I. Introduction

In previous studies by 1790 Analytics, it was found that patents from information technology (IT) companies, and patents from several IT related technologies, tend to reference papers from IEEE journals much more often than papers from other journal publishers (see [2]). Because IEEE is a US publisher and Elsevier and others are European publishers, it has been suggested that the positive results for IEEE in past studies may be due to US inventor biases. Moreover, since European Patent Office (EPO) references are widely perceived as being more rigorous, it has been suggested that an EPO patent study might have very different results. The aim of this study was to determine whether referencing patterns from European IT patents are similar to their US counterparts.

# II. Methodology

This study is based on referencing patterns from patents to prior art documents. In the European Patent (EP) system, when an inventor files a patent for a new invention, a search is undertaken by an EP searcher that will reference earlier documents to show how the new invention builds upon or differs from earlier inventions. This is done to delineate exactly what is new about the invention. So for example if someone invents a new mousetrap with an improved spring, the searcher will reference earlier mousetrap patents, and designs to show what has come previously. This way the inventor only gets monopoly rights to the new part of the invention (the improved spring) and does not get to claim rights to any and all mousetraps.

The EP system differs from the US patent system in how references are compiled. In the US system it is primarily the job of the patent inventor and his/her lawyer to list all relevant prior art. The patent examiner will augment the list of prior art if he/she feels that additional references are needed. In the EP system the inventor does not add references. A searcher employed by the EPO and independent of the patent examiner adds all relevant references. This system is viewed as superior to the US system by many patent researchers.

It has been suggested that patents with many non-patent references are likely to contain new leading-edge ideas, whereas patents that only reference earlier patents are likely to be incremental improvements on earlier patented technologies. For a comprehensive study on various hypotheses surrounding the motivations of inventors and searchers in citing non-patent references, see [1].

## A. Patent Set

1790 Analytics has its own broad technology classification that is used for government policy analysis studies. This system categorizes the entire US and EP patent system into 15 broad categories and 75 subcategories of technology. The technologies of interest in the information technology space are listed in Table 1.

For each of these categories we compiled the set of all EP patents published in 2005 and then identified the top 25 patenting organizations for each category. This allowed us to generate a manageable list of 17,000+ patents and 9,000+ non-patent references, which

could be matched to publishers such as IEEE, Elsevier, the American Institute of Physics, and others.

**Table 1 – Seven Categories Used in Study**

| Name | Types of Patents |
|---|---|
| Computer Hardware | Computers and Hardware |
| Computer Software | Software |
| Medical Devices | Diagnosis/Surgery/Medical Instruments |
| Information Storage | Disk Drives |
| Optics | Optics/Photography/Electrophotography |
| Semiconductors and Electronics | Semiconductors/Solid-State Devices/Electronics |
| Telecommunications | Telecom and Other Communications |

## B. Identifying Relevant Non-Patent References

Non-patent references can be to any published document, from comic strips, to brochures, to scientific articles and standards documents. The main difficulty in identifying relevant non-patent references for a study such as this is that the references are not all listed consistently. As an example, below are eight different variants for the IEEE Global Telecom Conference. Some instances use the GLOBECOM shorthand, while others list the entire name. Sometimes IEEE is mentioned and sometimes it is not. When abbreviation variations are included such as Telecom, Tele, Tcom, Proc., Proceed., the number of variants increases further. The same issue exists for variants in journal names and standards documents.

**Table 2 – Variants for IEEE Global Telecom Conference**

| |
|---|
| Proceedings of Globecom '96 |
| IEEE Global Telecommunications Conference |
| GLOBECOM '90:IEEE |
| Proceedings of IEEE Globecom '94 |
| Globecom '97 |
| IEEE Globecom, Global Telecommunications Conference and Exhibiton |
| Proc of the Global Tele Conf, U.S. New York, IEEE |

### 1. Conference Identification

To identify conference proceedings among the non-patent references, we first identified references containing keywords such as meeting, symposia, conference, etc. We then used software to identify 2-word and 3-word phrases that appear frequently in this set of papers. The full string was identified for these string sub-sequences in order to identify frequently cited conferences. In this way, we identified the top 120 conferences referenced in the patent sets, and standardized the names of these conferences (i.e. all of the different variants of a conference were collected under a single name). As an example, all of the variants

shown in Table 2 are assigned to the name '<conf> IEEE Global Telecommunications Conference (GLOBECOM).'

We then looked up each of these conferences on the web to determine who is listed as their primary sponsor. For example, many of the conferences are sponsored by organizations such as IEEE, ACM (Association for Computer Machinery) and ASME (American Society of Mechanical Engineers).

### 2. Standards Identification

There are relatively few standards referenced (although more than in the US studies and particularly in the telecommunications sector), and in general they are easy to identify by looking for strings such as 'standard' or 'std'. Once the records containing the standards were located, it was relatively easy to identify the organization that produced each standard (ETSI, ISOC, IEEE, ISO, JEDEC, ANSI, etc.).

### 3. Journal Identification

Identifying and standardizing journal names is a very difficult process because there are so many different journals, and their names can be abbreviated in many different ways. To make the problem more manageable, we restricted our analysis to the 11,000+ journals covered by the ISI/Thomson Scientific Database. This is not a severe limitation, since these 11,000+ journals include more than 100 IEEE journals, 1200+ Elsevier journals, and 300+ Wiley journals.

Once restricted to these 11,000 journals, we used software that transforms journal names into common abbreviations and then implements string matching. Care must be taken with string matching because, for example, searching for "Urology Journal" will also accidentally identify "Neurology Journal". Similarly, a search for the journal "Science" would accidentally pick up any reference with 'science' in the paper title as well as any of the 800+ journals with science in their titles such as "Game and Wildlife Science". Our proprietary software for journal identification deals with all of these problems in order to get a very good match between the patent references and 11,000+ journals.

After identifying all of the relevant journals, we then used the ISI database to identify the publisher of each journal.

## III. Results

Figure 1 contains the top 25 most active companies within the European Patent system in the telecommunications sector for 2005. We see that the list is dominated by European and Japanese companies (the top US company is Qualcomm which is 9$^{th}$). Since we are using European patents and most of the top assignees are non-US companies there can be no question of a US bias, yet in Figure 2 we see that IEEE is clearly most referenced journal

and conference publisher. In fact Figure 2 shows that IEEE is not only the most referenced publisher, but that it receives 10 times as many telecommunication references as the second place publisher.

To get an idea of what exactly is being reference, we drill down into the top company (Philips) in Figure 3. Here we see that about half of the references to IEEE go to its sponsored conferences such as *The IEEE International Conference on Image Processing*, and about half of the references go to IEEE journals such as the *IEEE Transactions on Circuits and Systems*.

Figure 4 shows the top 25 most active companies with 2005 EP patents related to Optics technology. Again these are non-US companies, so there should be no issue with a US bias in terms of referencing to IEEE. In Figure 5 we see that SPIE receives the most scientific references from the EP optics with IEEE ranked a respectable second. It is not surprising that SPIE is ranked first given that it is an optical engineering society, what is surprising is that in the US studies the IEEE is ranked ahead of SPIE (see Executive Summary Figure). It is also somewhat surprising that IEEE is ranked ahead of the Optical Society of America (OSA) in both studies, since both SPIE and OSA are optical societies while IEEE concentrates more on electronics than optics.

Figures 6 through 15 are similar to Figures 1, 2, 4, and 5 for the remaining categories (Information Storage, Medical Devices, Software, Hardware, and Semiconductors). In order to avoid repetition we will not discuss these figures in detail. For each of the remaining categories other than medical devices, the IEEE has a strong lead in terms of references. Also, this is clearly unrelated to any US bias since the top companies are generally non-US and the patents are European. Within medical devices, Elsevier is top referenced, with IEEE a strong second. In this case Elsevier has many more medical related journals than IEEE so its top ranking is not surprising. IEEE's lead in the other categories is considerable.

## IV. Conclusions

This study examines referencing patterns from European patents in 7 areas of technology. This analysis is a follow-up to earlier studies on US patents (see [2]). In the earlier studies it was clear that the IEEE provided the science base for much of the US patenting in information technology. However since the previous studies involved US patents there were questions of whether IEEE science was referenced frequently due to a US bias. In this study we showed that the results are very similar (and in some cases stronger) when European patents are used.

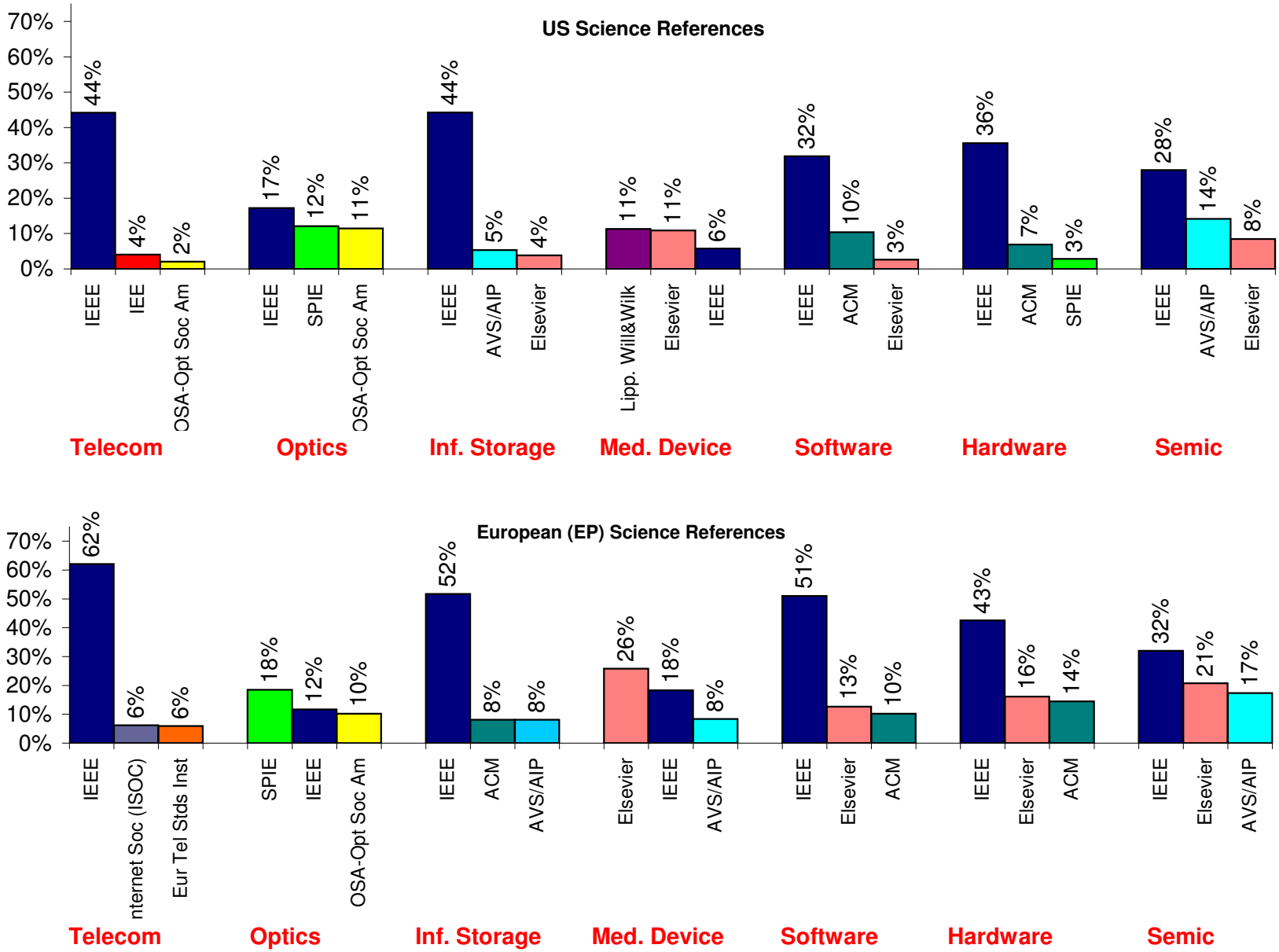
This study when combined with the earlier similar US studies should leave no doubt that IEEE publications and conferences provide much of the science base for advancements in Telecommunications, Optics, Information Storage, Medical Devices, Computer Software and Hardware, and Semiconductors. In other words, much of the advancements in information technology are first available as IEEE journal articles and IEEE sponsored conference papers.

## V. References

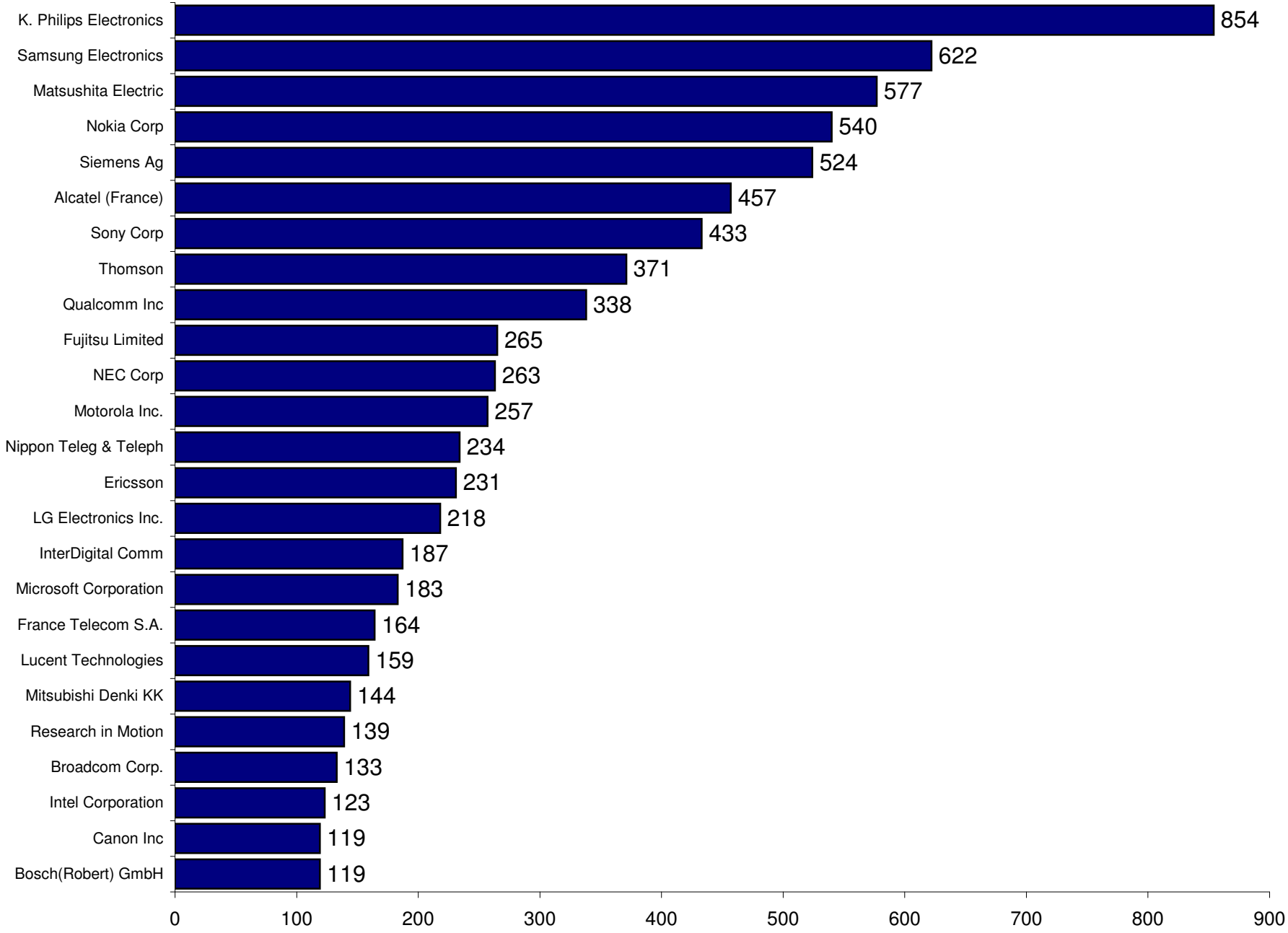
[1] Branstetter, Lee. “Is Academic Science Driving a Surge in Industrial Innovation? Evidence from Patent Citations,” Columbia Business School, Discussion Paper #28.

[2] Breitzman, Anthony. (2005) “IEEE and Patents: An Analysis of Patent Referencing to IEEE Papers, Conferences and Standards,” 1790 Analytics, LLC. Available at www.ieee.org/web/publications/patentcitation .

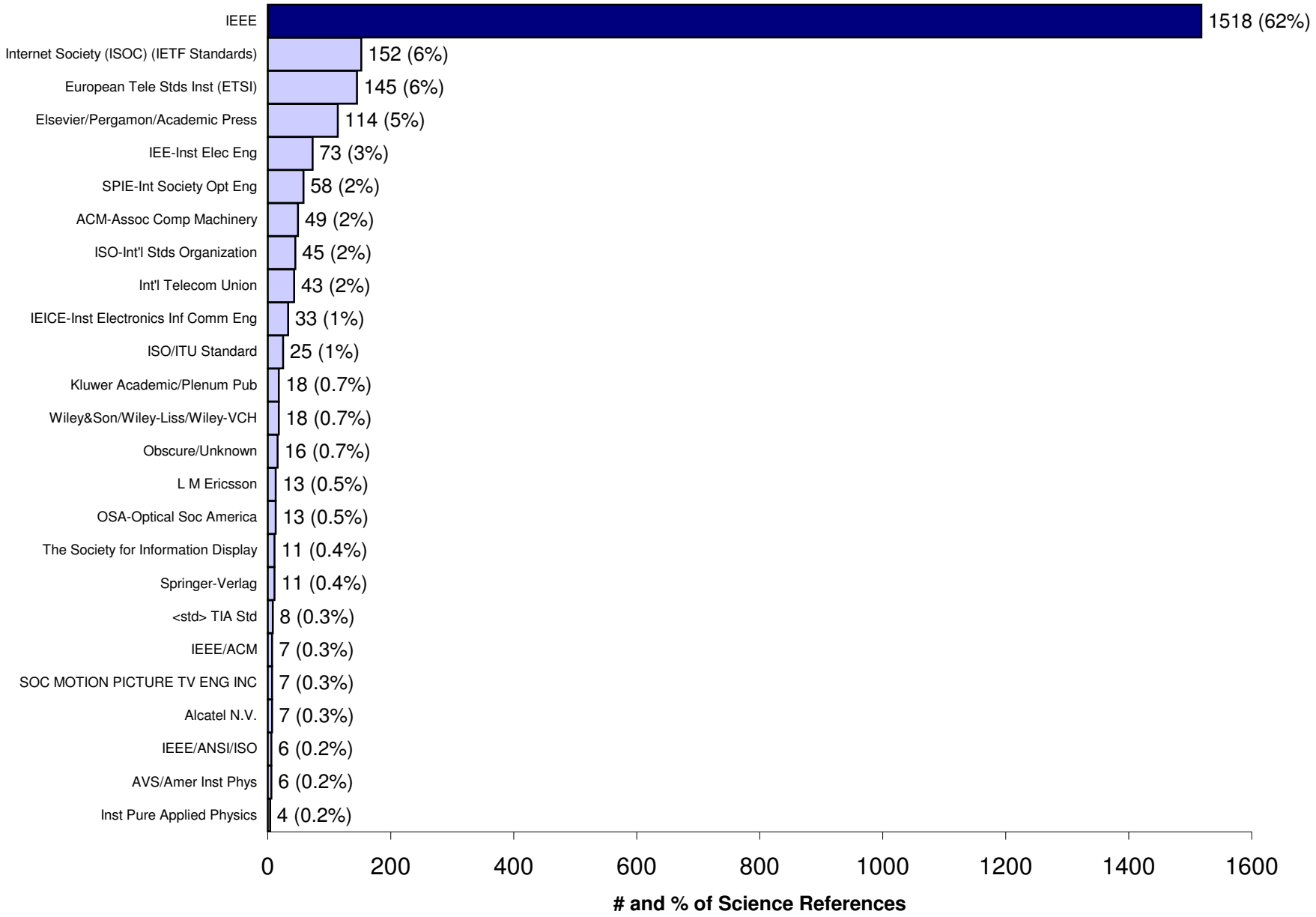
# Executive Summary Figure: Comparison of EP and US Results



# Figure 1: Top 25 Most Active Companies with 2005 EP Telecom Patents



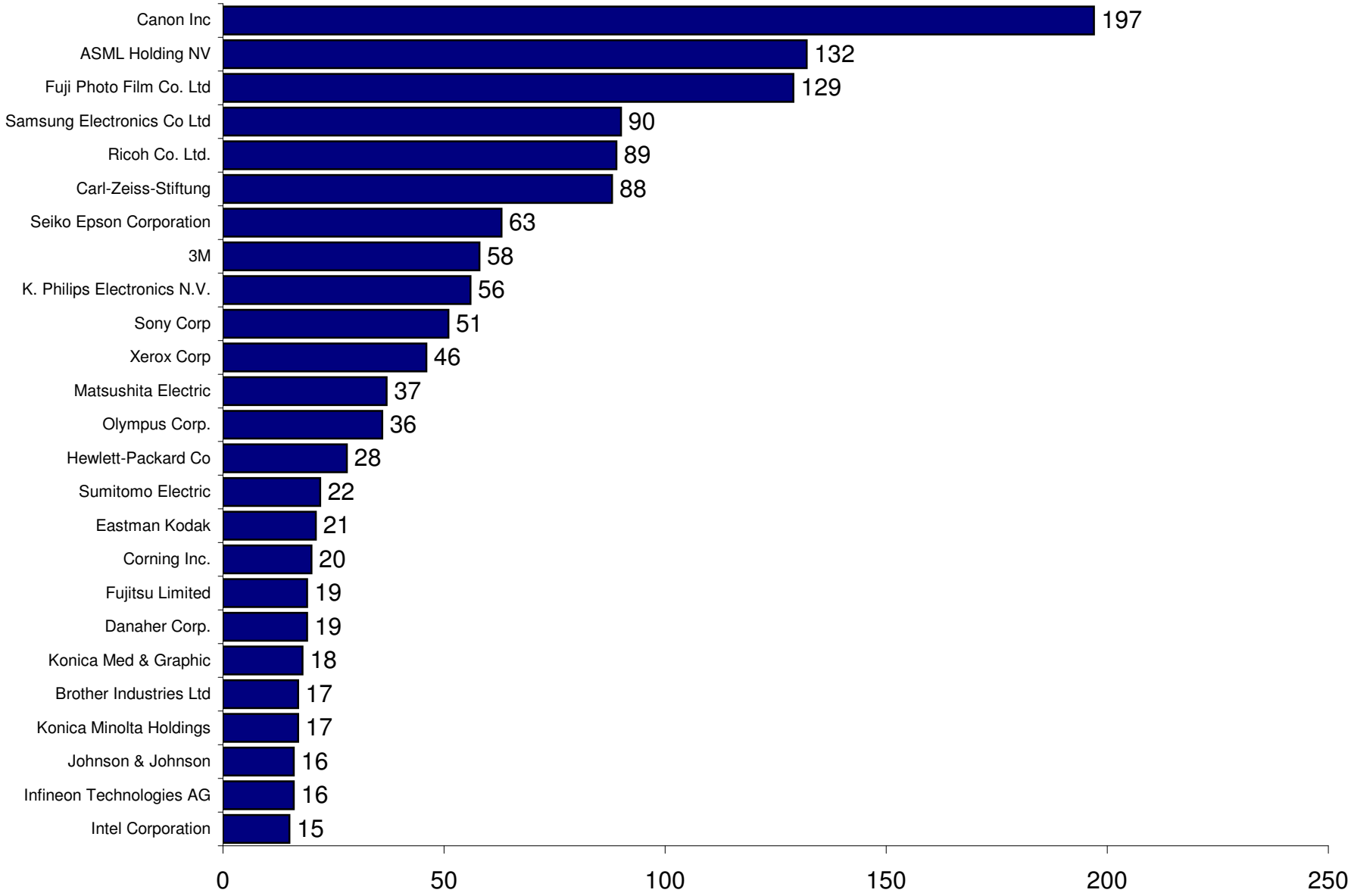
# Figure 2: Number and Percent of References from Most Active Companies' 2005 EP Telecom Patents



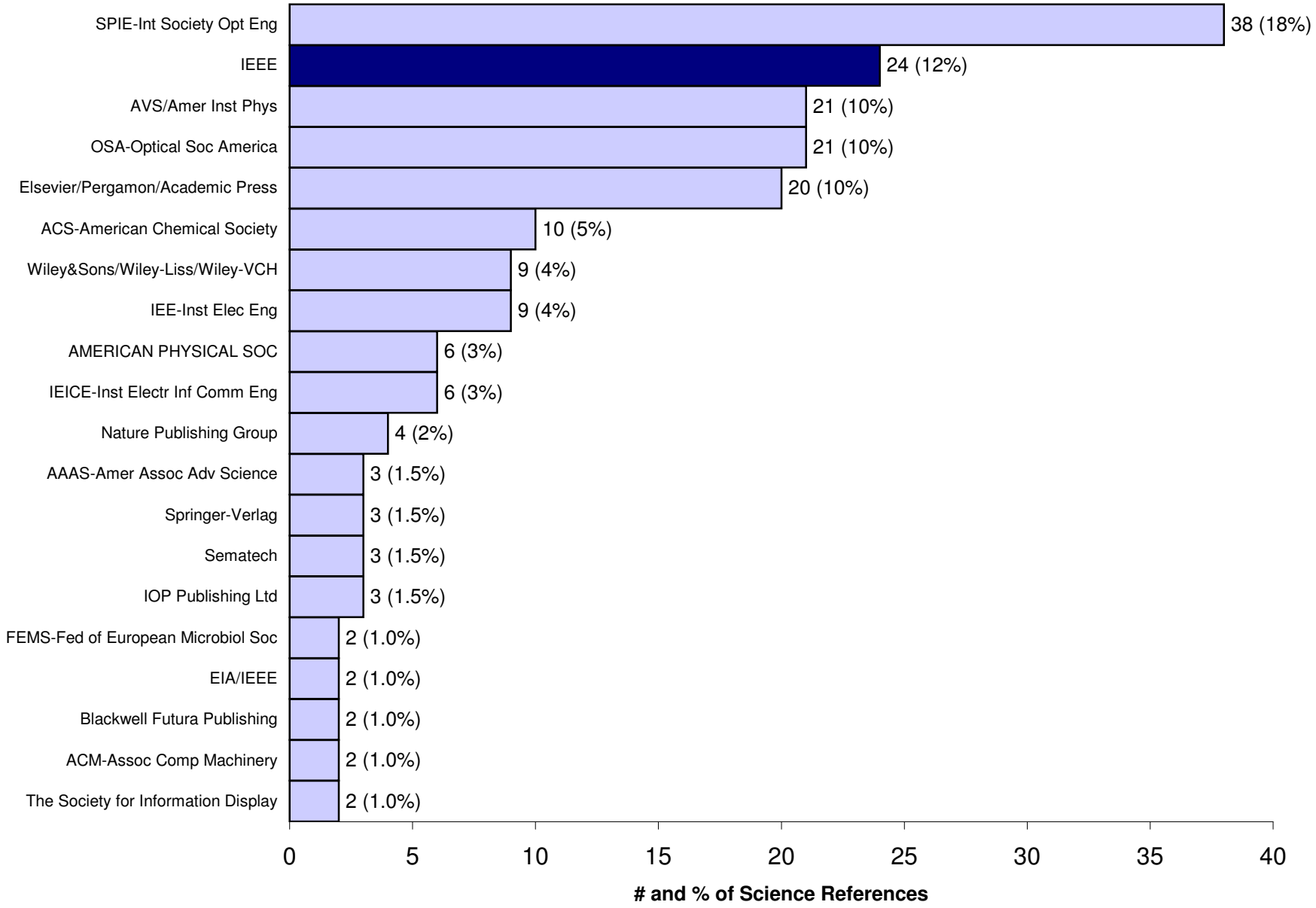
## Figure 3: Example List of Referenced Publications from Philips EP 2005 Telecom Patents

| # Refs | Journal/Conference/Standard | Publisher |
|---|---|---|
| 61 | <conf> IEEE Misc Conf | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 57 | <conf> IEEE Int Conf on Image Proc | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 27 | IEEE Trans Circ Systems | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 19 | <std> ISO Std | ISO-International Standards Organization |
| 17 | <conf> IEEE Vehicular Technology Conference | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 15 | Misc IEEE | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 15 | Proceedings of the SPIE | SPIE-INT SOCIETY OPTICAL ENGINEERING |
| 14 | IEEE TRANSACTIONS ON IMAGE PROCESSING | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 12 | IEEE TRANSACTIONS ON CONSUMER ELECTRONICS | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 12 | SIGNAL PROCESSING-IMAGE COMMUNICATION | Elsevier/Pergamon/Academic Press |
| 11 | <conf> IEEE Global Telecommunications Conference (GLOBE | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 11 | <conf> IEEE Int Conf Acous, Speech, and Sig Proc (ICASSP) | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 9 | IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIO | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 9 | IEEE TRANSACTIONS ON INFORMATION THEORY | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 8 | IEEE JOURNAL OF SOLID-STATE CIRCUITS | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 8 | <conf> IEEE int symp on Circuits and sys (SCAS) | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 8 | <conf> IEEE conf on comp comm (infocomm) | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 8 | IEEE TRANSACTIONS ON COMMUNICATIONS SYSTEMS | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 8 | <std> ETSI - European Telecomm standard | European Telecommunications Standards Institute (ETSI) |
| 5 | IEEE COMMUNICATIONS MAGAZINE | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 5 | COMPUTER COMMUNICATIONS | Elsevier/Pergamon/Academic Press |
| 5 | <conf> SID (Soc Inf Disp) Misc Conf | The Society for Information Display |
| 5 | <std> IETF - INTERNET ENGINEERING TASK FORCE | Internet Society (ISOC) (IETF Standards) |
| 5 | <conf> IEEE int conf on comm (ICC) | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 5 | <conf> ACM Misc Conf | ASSOC COMPUTING MACHINERY |
| 5 | <conf> ACM/IEEE Design Automation conf | IEEE/ACM |
| 5 | <conf> IEEE International Conference on Multimedia & Expo | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 5 | PROCEEDINGS OF THE INSTITUTE OF ELECTRICAL AND | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 4 | SIGNAL PROCESSING | Elsevier/Pergamon/Academic Press |
| 4 | ELECTRONICS LETTERS | IEE-INST ELEC ENG |
| 4 | <conf> IEEE int conf on imag proc | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 4 | <conf> Joint Conf or IEEE Computer and Communications Soc | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 3 | <std> IEEE/ISO/ANSI Std | IEEE/ANSI/ISO |
| 3 | IEEE transacTIONS ON ACOUSTICS | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 3 | Proceedings of the SPIE | SPIE-INT SOCIETY OPTICAL ENGINEERING |
| 3 | Misc. Am Inst Physics | A V S AMER INST PHYSICS |
| 3 | <conf> IEEE Military Comm conf (MILCOM) | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 3 | Unseparated IEEE | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 3 | IEEE COMMUNICATIONS LETTERS | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 3 | OPTICAL ENGINEERING | SPIE-INT SOCIETY OPTICAL ENGINEERING |
| 3 | <conf> IEEE/Navy Asilomar Conference on Signals, Systems, | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |
| 3 | comp Networks | Elsevier/Pergamon/Academic Press |
| 3 | JOURNAL OF ELECTRONIC IMAGING | I S & T - SOC IMAGING SCIENCE TECHNOLOGY |
| 3 | LECTURE NOTES IN COMPUTER SCIENCE | SPRINGER-VERLAG |
| 3 | <std> ATSC Std | ATSC Standard |
| 3 | IEEE PERSONAL COMMUNICATIONS | IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS |

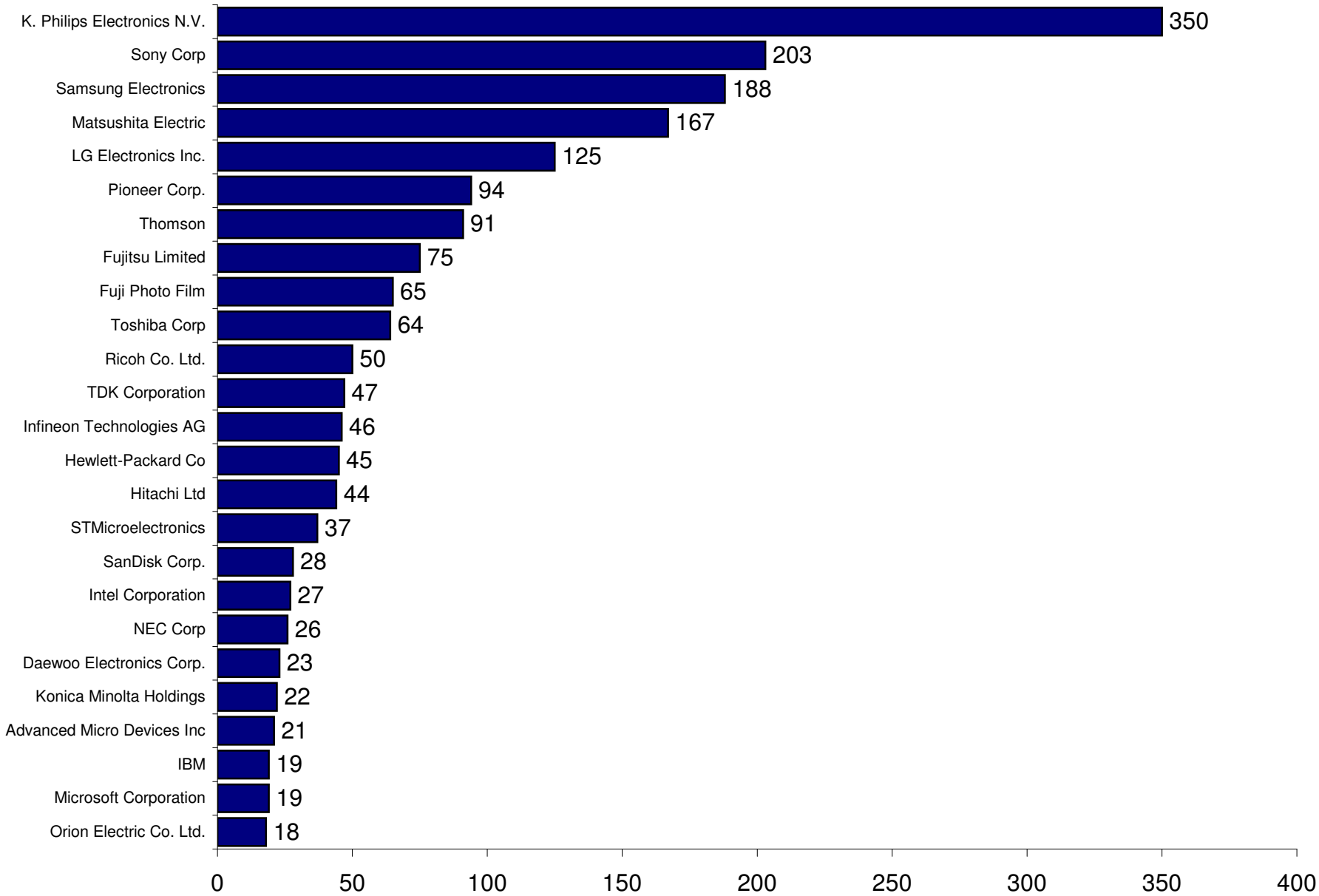
# Figure 4: Top 25 Most Active Companies with 2005 EP Optics Patents



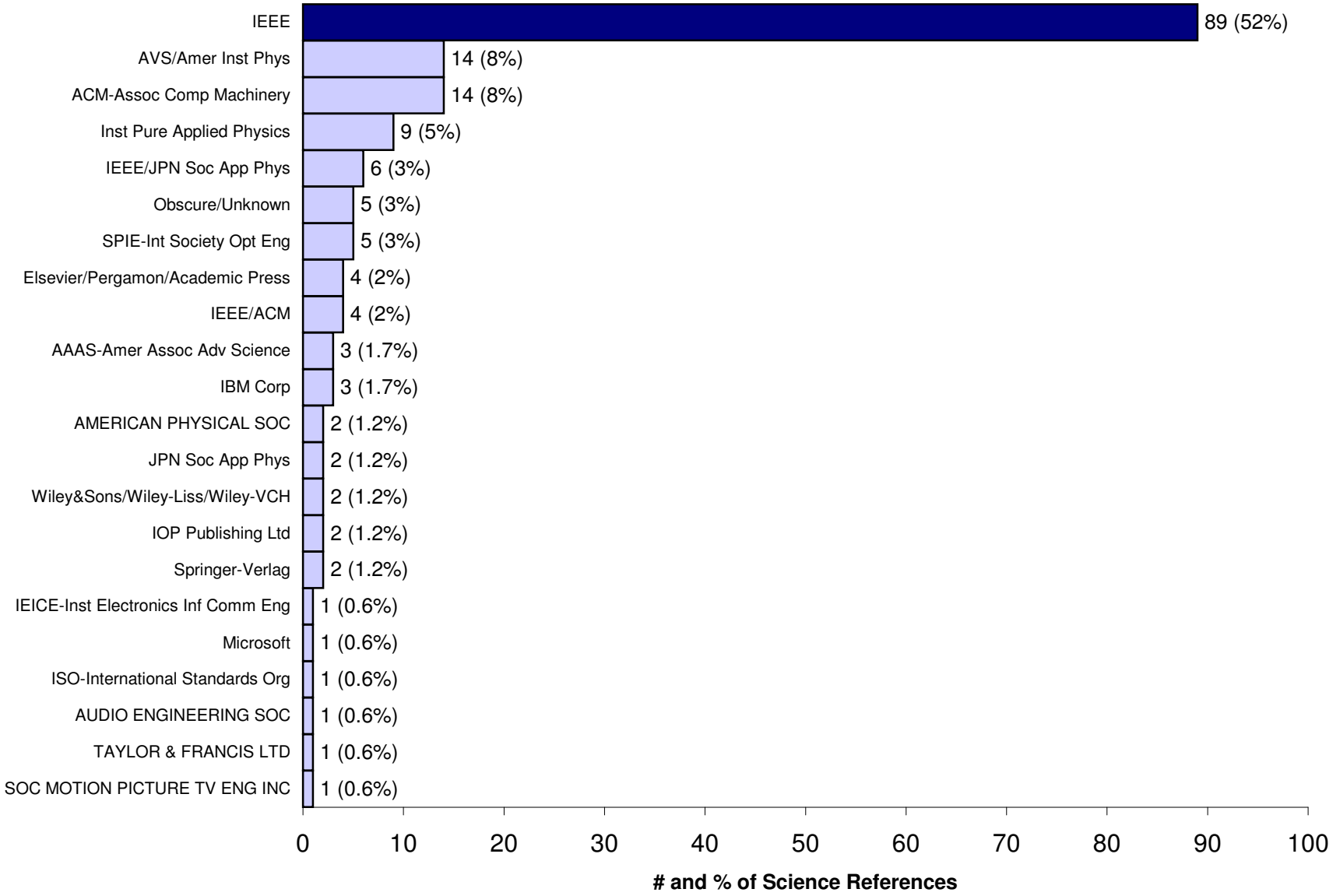
# Figure 5: Number and Percent of References from Most Active Companies' 2005 EP Optics Patents



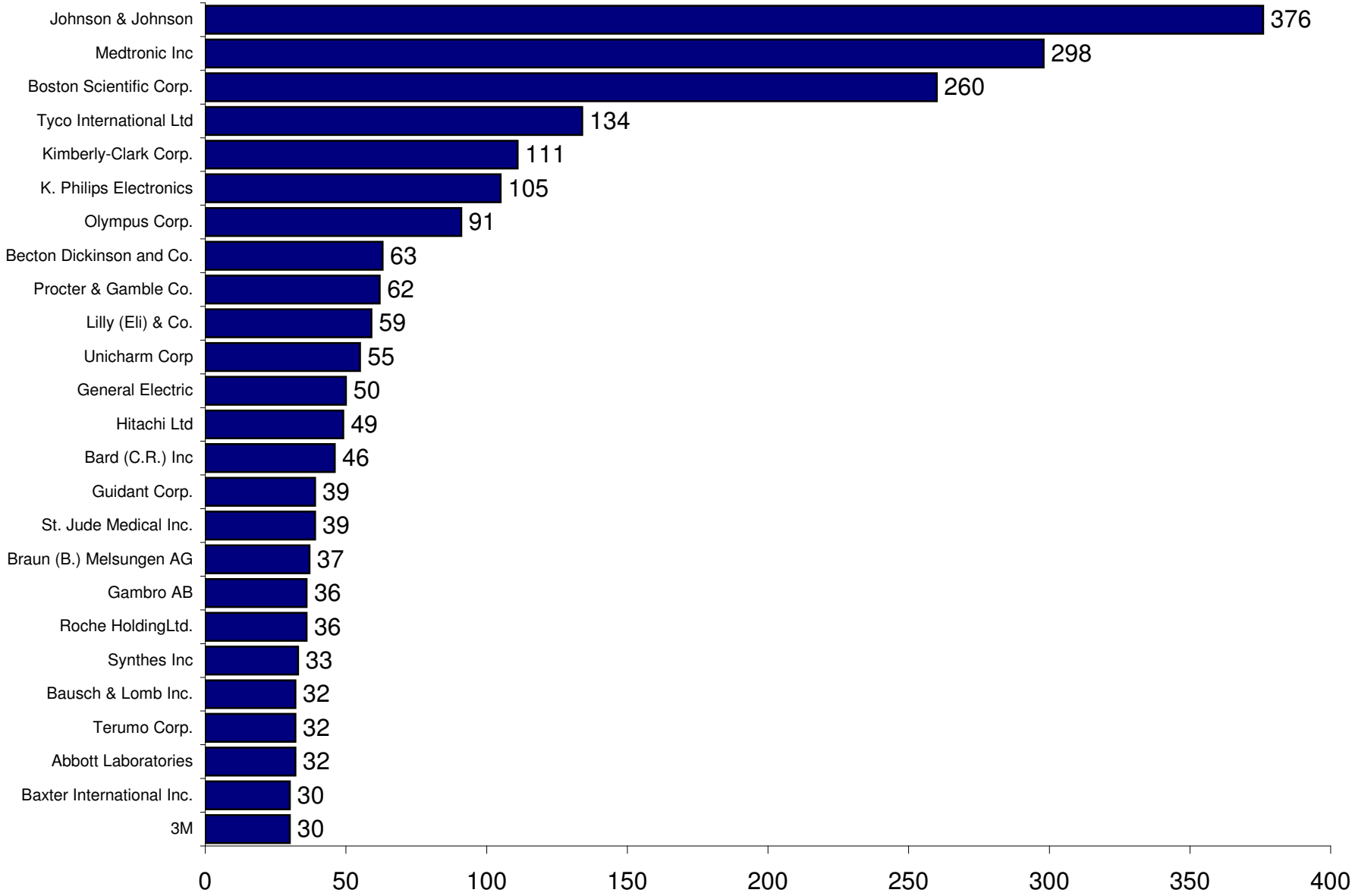
# Figure 6: Top 25 Most Active Companies with 2005 EP Information Storage Patents



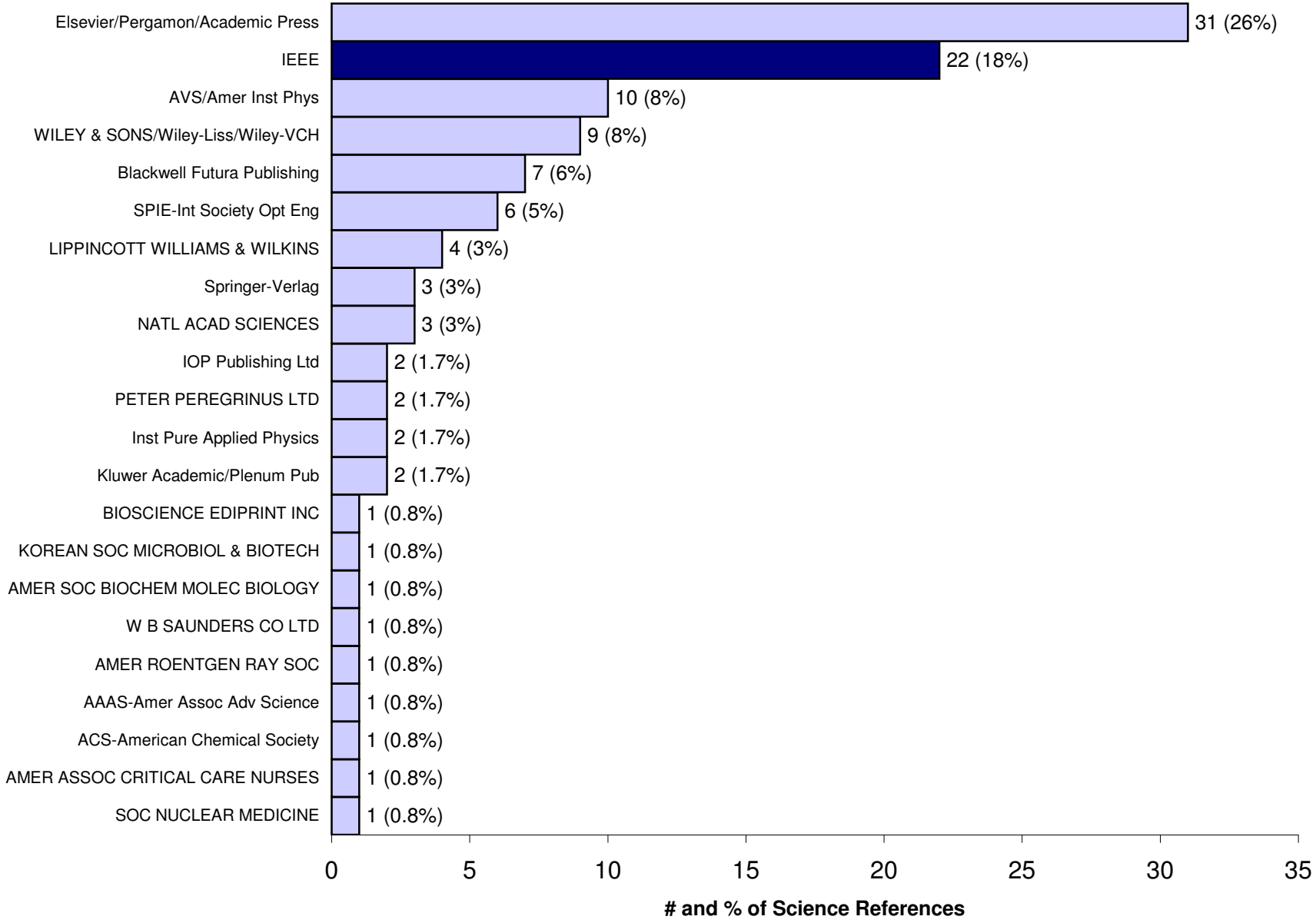
# Figure 7: Number and Percent of References from Most Active Companies' 2005 EP Information Storage Patents



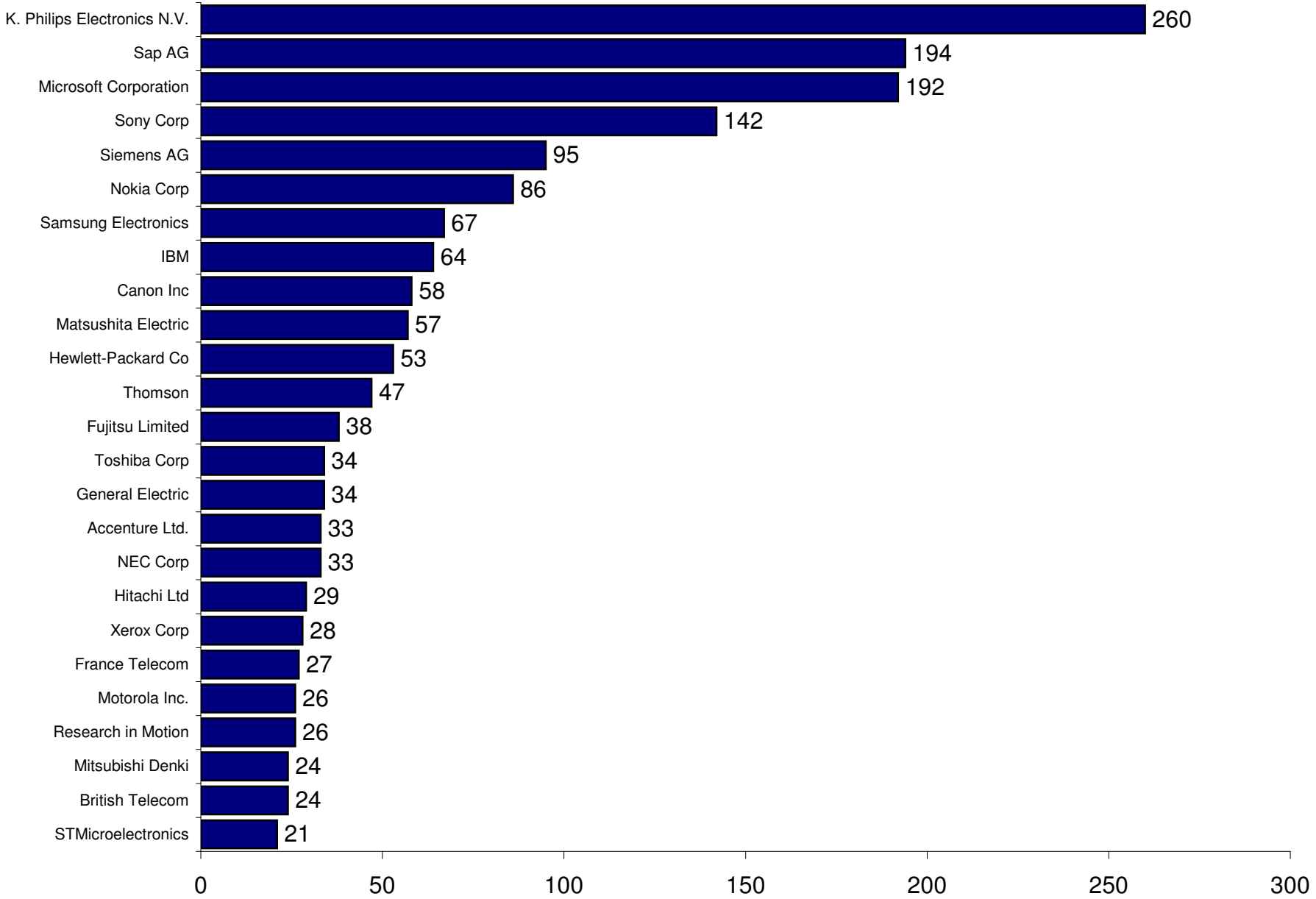
# Figure 8: Top 25 Most Active Companies with 2005 EP Medical Device Patents



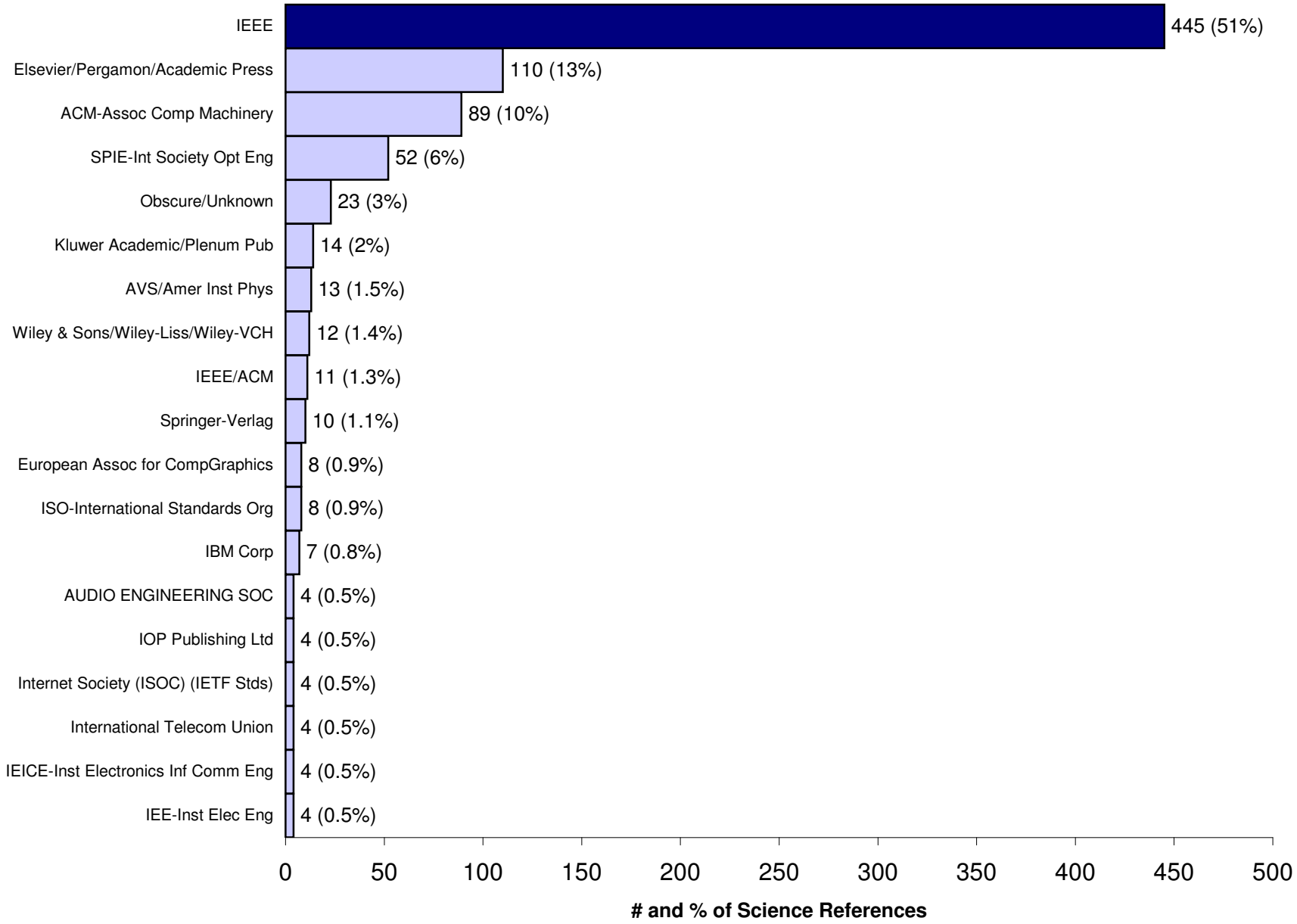
# Figure 9: Number and Percent of References from Most Active Companies' 2005 EP Medical Device Patents



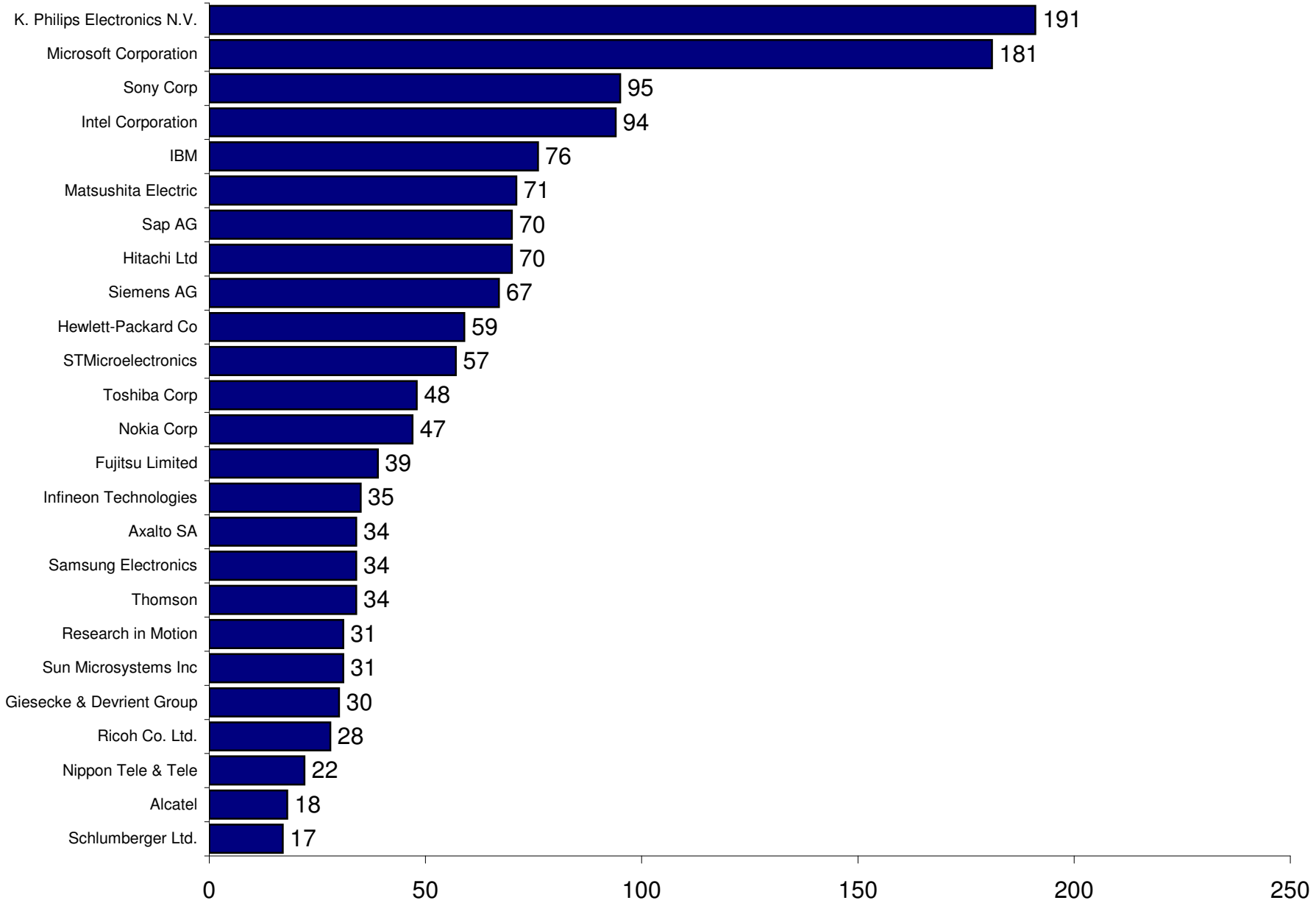
# Figure 10: Top 25 Most Active Companies with 2005 EP  Software Patents



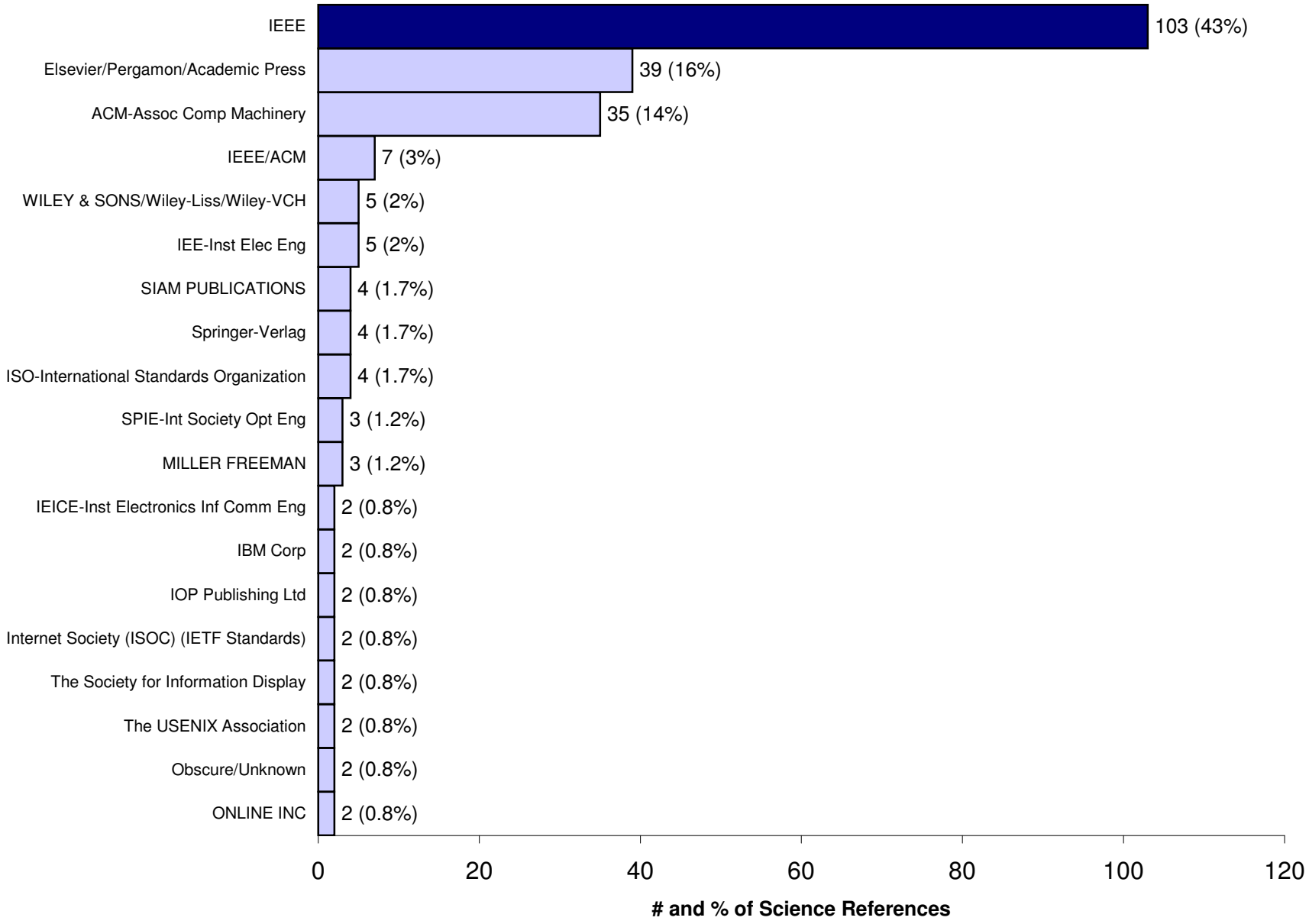
# Figure 11: Number and Percent of References from Most Active Companies' 2005 EP Software Patents



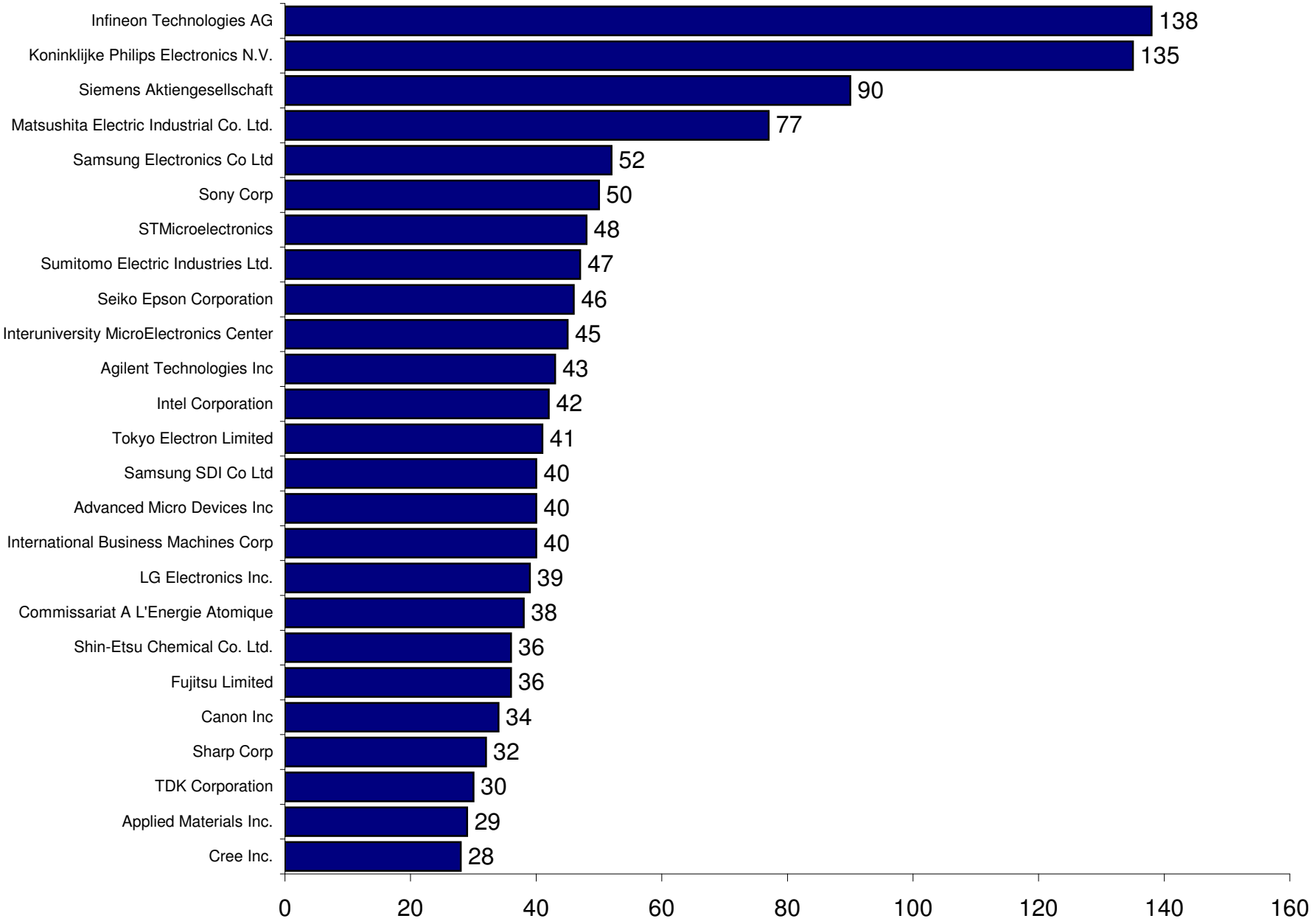
# Figure 12: Top 25 Most Active Companies with 2005 EP  Hardware Patents



# Figure 13: Number and Percent of References from Most Active Companies' 2005 EP Computer Hardware Patents



# Figure 14: Top 25 Most Active Companies with 2005 EP Semiconductor Patents



# Figure 15: Number and Percent of References from Most Active Companies' 2005 EP Semiconductor Patents