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Integrated Silicon Photonics: Visualisation of Patent Datasets for Mapping Technology

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ABSTRACT

Analysing patent information is considered to be one of the most systematic and logical methodology to get an insight into the progress of technologies. Patent statistics can be used to ascertain the maturity of specific technologies or to identify technological trends. Similarly, it is possible to identify whether research activities are clustered or scattered by comparing the number of applications with the number of applicants. Visualization technique is considered to be most eloquent and illustrative way of representing patent information and its analysis results to get insight into various aspects of any particular technology[1]. Statistical analysis of the relevant patent dataset is carried out using patent maps in the visualisation techniques. Different patent maps help in understanding various aspects about the searched system/ technology like top patent assignees, top Inventors. Time based analysis provides the trends of technology on the time scale, while cross-mapping of the patent documents provides further useful information. All the above analysis can be illustrated in patent maps to make it more presentable, structured and customised. In the present paper, the patent maps have been exploited to understand technologies and other aspects related to the Integrated Silicon Photonics.

Keyword: Patent, search, patent map, visualisation, silicon photonics, database

1. INTRODUCTION

Patents are useful sources of knowledge about technical progress and innovative activity[2] and thus have commonly been examined in R&D planning[2,3]. Searching patent documents, either on paid professional databases or freely available databases, results in huge number of documents which may amount to thousands and therefore extracting useful information from such datasets could be quite a challenging job. However, analysis of the unstructured data of patent datasets may be simplified using visual tools like patent maps. There are different types of maps which could be prepared for analysis purposes suiting any particular requirement. In general, statistical analysis maps include rate map, number map, trend map, relation map, radar map, portion map, etc. Broadly, patent maps provide useful information for identifying and planning research work, promoting research/technology and technology management[5] (Fig. 1).

2. LITERATURE REVIEW

The increased quantity of publications, patents, reports, books and other literature has built a huge reservoir of the information base and there are more than 250 million published research papers and approximately 80 million published patent documents[6,7]. These published documents provide researchers an opportunity to search for further research, although managing these documents for search is a challenging task. The rise of computers and advanced analytical software has played an important role in effective utilisation and analysis of this information base. Several analytical techniques and models have been discussed for deducing useful information from such huge database[8]. Citation analysis is one of the most frequently used methods[9]. Network analysis, clustering, network models, neuronal model, keword-vector analysis, co-word analysis,

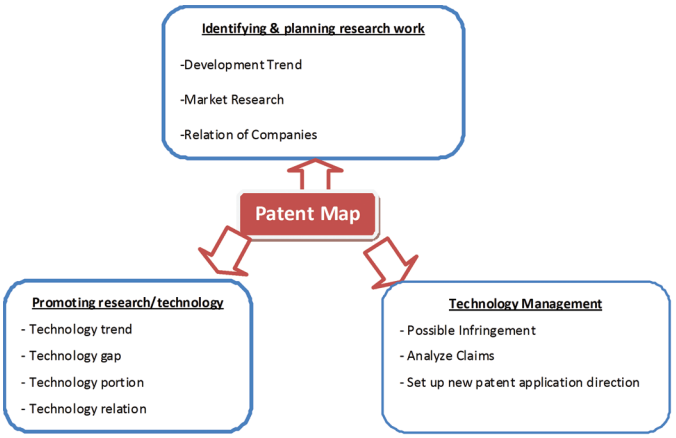

Figure 1. Advantages from patent mapping.

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Bayesian network models, etc., have been also been explored in the literature to extract desired information from the published literatures[10-13]. Scientometrics is a dedicated branch for the study of measuring and analysing science, technology and innovation through databases[14].

As compared to published research papers, the published patent documents are easy to search and extracting information from it is simpler because patent documents are systematically recorded and updated and therefore it plays a key role in analyzing and forecasting future technological trends, conducting strategic technology planning, detecting patent infringement, determining patents quality and the most promising patents, and identifying technological hotspots and patent vacuums[15]. Each patent document contains data under two types of attributes:(1) Structured attributes also referred as bibliometric data and (2) unstructured attributes which include detailed description, summary, claims and drawings of the invention. All these attributes are searchable and systematically presented in a patent document. Deducing information from the structured attributes is easier that the unstructured attributes. However, the structured attributes serve as extremely useful vehicle for R&D management and technoeconomic analysis. The visualization of the huge patent dataset based on the structured data is called patent graph and if it is based on the unstructured data, then is called patent map but the general term patent maps can refer to both cases[16]. Although different forms of patent maps have been developed, most conventional ones use information extracted from the bibliographic fields of patent document to provide simple statistical results[17]. The present paper explores the potential of the visualisation of the huge searched patent dataset through patent maps to provide useful information to the researchers.

3. PATENT MAPS FOR INTEGRATED SILICON PHOTONICS

3.1 Integrated Silicon Photonics

Silicon photonics is the study and application of photonic systems which use silicon as an optical medium. Silicon photonic devices can be made using existing semiconductor fabrication techniques, and because silicon is already used as the substrate for most integrated circuits, it is possible to create hybrid devices in which the optical and electronic components are integrated onto a single microchip[18]. These devices have wide applicability as optical interconnects, optical routers and signal processing, long range telecommunications etc. Researchers are actively involved in developing and improving the potentials of silicon photonics to enhance its applicability like harnessing the data explosion where data is growing exponentially at a rate of tenfold every five years. Researchers interested to work in the field of integrated silicon photonics may use patent documents to extract useful information such as actively involved companies, their patent profile, key inventors in this field, highly progressing technological fields in this area, vacancies or unexplored areas, etc.

3.2 Data Collection

For the Integrated silicon photonics, patent search based on keyword and IPC classification was conducted on GPI, an EPO developed database of patents[19]. The relevant classes for the integrated silicon photonics were identified and then search was carried out based on classification alone as well as in combination with the keywords. The patent maps of the broadest patent dataset were prepared and analysed to understand the technology pertinent to integrated silicon photonics. Further as desired the company specific and inventors specific patent search was carried out to extract detailed information about the both using patent documents.

3.3 Technology Trend Map

The trend patent map of the broadest dataset with the year of priority/filing/publication on x scale and inventors/assignee name on y scale provided a key insight of the technology. Figure 2 provides the time scale map of the international patent classification (IPC). As evident from the trend map, the patents in various fields had been filed over the years. However, the key focus area for this particular technology is defined by a set of classifications: H01L, H01S, G02B, G01T, G01F and G01N. These set of IPC codes can be described

H01L - Semiconductor Devices; Electric Solid State Devices Not Otherwise Provided For

H01S- Devices Using Stimulated Emission

G02B- Optical Elements, Systems, or Apparatus

G01T- Measurement of Nuclear or X-Radiation

G01F- Measuring Volume, Volume Flow, Mass Flow, or Liquid Level; Metering By Volume

G01N- Investigating or Analysing Materials by Determining Their Chemical or Physical Properties

G02F- The Optical Operation of Which is modified by Changing the Optical Properties

It is evident that the definitions of all these above mentioned classes are very broad. However, these technology areas are of prime interest for the researches and lot of patents have been generated in these technology areas. The class G02B and Ho1L encompasses patents in the area of optical elements, systems and apparatus & semiconductor

devices respectively. These two are found to be most relevant IPC classification for integrated silicon photonics. Also the IPC classification H01L and H01S relates to patents in the area of devices using simulated emission which is another very relevant class for the present system. The classes H01L and G02B, which were maximally exploited by the researches as seen in the Fig. 2, require further detailing to understand the relevant aspects of the

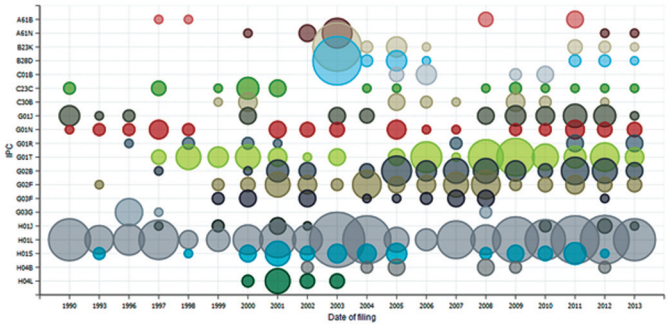


Figure 2. Technology Trend Map: Patent map showing date of filing vs IPC classification.

present Integrated Silicon phtotonics. Apart from these classifications, other IPC classes also show quite a good number of patents over the years. These IPC classes are:

C30B: Unidirectional solidification of eutectic material or unidirectional demixing of eutectoid material; refining by zone-melting of material

C23C: Coating metallic material

B28D: Working stone or stone-like materials (machinery for, or methods of, mining or quarrying)

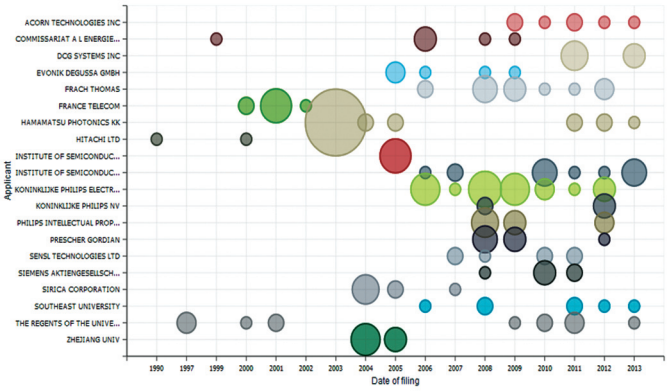
B23K: Soldering or unsoldering; welding; cladding or plating by soldering or welding; cutting by applying heat locally, e.g., flame cutting; working by laser beam

A61N: Electrotherapy; magnetotherapy; radiation therapy; ultrasound therapy

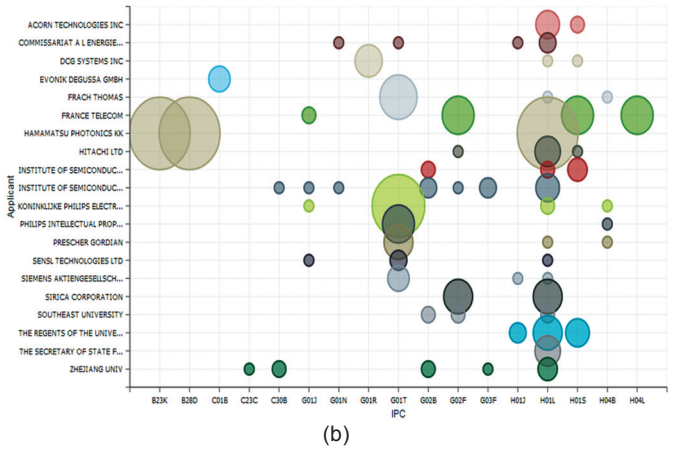
Although, patents have been filed in these areas of technologies, the focus of the researchers has not been much in these areas.

4. MARKET RESEARCH MAP

Study of patent maps over one another, is useful technique to understand the applicants' technology focus, their research work, strategy, planning in a particular area of technology. Overlapping the information, deduced from one patent map over the another, yields useful results and provide interesting facts not only about the technology but also about the assignees/inventors. In the present study, patent map overlapping was carried out to understand the inventors' research area with passage of time. Patents maps of the top 20 applicants/inventors over the time scale, i.e., date of filing and IPC classification were prepared using statistical tools of GPI database (Fig. 3 (a&b)). These patent maps were useful in analysing the growth of technology with respect to each applicant/inventor over the years. The time scale map of the applicants depicted that Hamamatsu Photonics KK, Koninklijke Philips Electronics, Institute of Semiconductor, Hitachi Ltd, Acron Technologies, DCG systems, France telecom, Philips IPR, etc., are among top applicants in this area of technology. The IPC classification-based patent map showed that the technology area of the patents filed by these applicants may be understood by the IPC classes B23K, B28D, G01T, H01L, G02F.



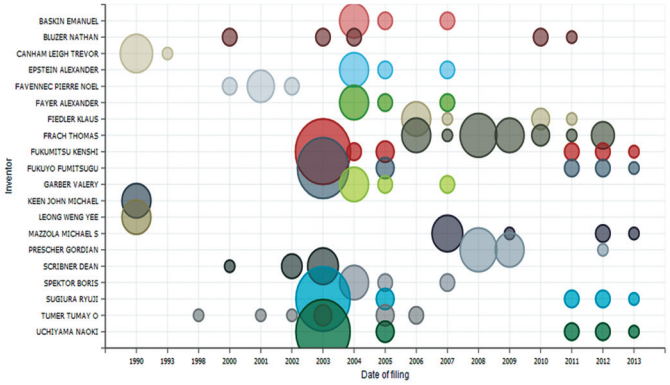
(a)



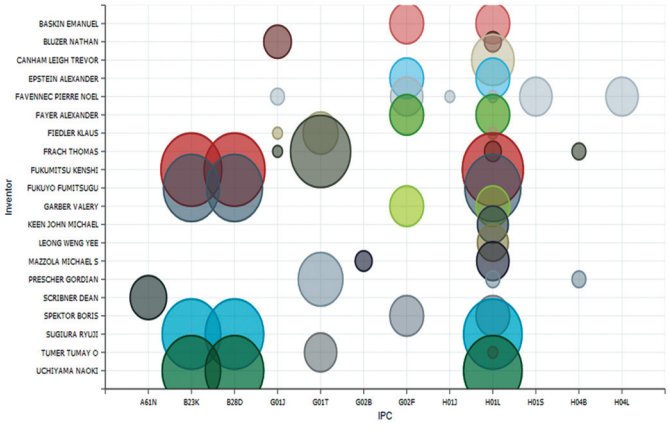
(b)

Figure 3. Patent map showing top 20 applicant vs (a) date of filing and (b) IPC classification.

Like-wise for the inventors, the time scale showed that all the top twenty inventors of this technology area are very active as shown in the patent map Fig. 4 (a). The scattered bubble diagram shows not peculiar trend, however, it shows the fairly good amount of work done by each inventor as measured by the number of patents filed by them. Further, on analysis of the technology focus area in map (Fig. 4 (b)), it is observed that similar to applicants key interest area and the technology trend as shown in trend map (Fig. 2), the technology are of inventors' interest are B23K, B28D, G01T, H01L, G02F.



(a)



(b)

Figure 4. Patent map showing top twenty inventors vs (a) date of filing and (b) IPC.

5. RELATION MAP

Another patent map to understand the relation between the inventors and the applicants was prepared. The relation map as shown in Fig. 5 provided an interesting piece of information. Thirteen among the top twenty inventors (Fig. 5) had affiliations to the top applicants like Hamamatsu Photonic, Kniniklijke Philips, Philips IPR, Sirica Corp., France telecom and Frach Thomas. This is a very useful piece of information in case any collaboration of joint development/venture has to be worked out.

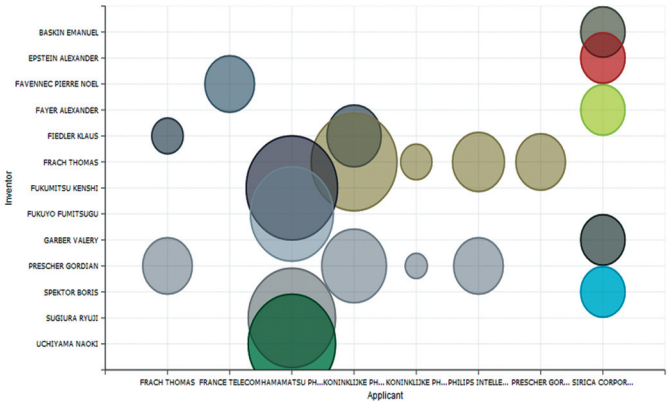


Figure 5. Patent map showing top twenty inventors vs applicants.

6. HIGHEST PATENT FILER: APPLICANT AND INVENTORS

After studying these patent maps, it may be concluded that Hamamatsu Photonics Ltd is one the most active company in the area of integrated silicon photonics. Therefore a detailed study of this company was done using the IPR search tools of GPI and an attempt was made to corroborate the patent information with the company's profile. Hamamatsu Photonics Ltd. is approximately 50 years old Japanese company working the area of advance photonic technologies. It has more than 1500 products in the area of optical sensors including microPMT, Photomultiplier tubes, PMT modules, PMT Assemblies, color sensor, IR detectors etc. This company has also been very active at protecting its innovations by filing patents. A patent search at GPI for the applicant 'Hamamatsu Photonics' showed more than 19,000 patents. The technology focus of this company could be identified by the IPC classes in which it had filed maximum number of patent applications and it primarily included A61B, B23K, G01J, G01N, G01T, G01B, H01J, H01L, H04N and H01S. Out of these, B23K, H01L, H01S, G01B are the common technology areas between the searched results of applicant name Hamamatsu Photonics and keyword search results for "silicon photonics". This shows that, the company Hamamatsu Photonics Ltd is one of the major players in this area in terms of products as well as patents. Another useful piece of information was drawn using GPI search tools wherein the active researchers of the Hamamatsu Photonics Ltd were identified. Fukuyo Fumitsugu, Uchiyama Naoki, Muramatsu Masaharu, Fujita Kazuki are among the top researchers/inventors of the Hamamatsu Photonics Ltd.

6. CONCLUSIONS

Patent documents used as an information source for research can't be analyzed directly because they consist of natural language. In extracting valuable information from these searched huge patent document datasets, advanced analytical techniques need to be applied, therefore making useful patterns and visualization of the resulting patent data has been used in treating the intellectual property from the information retrieval point of view[21-23]. Patent maps represent an excellent tool to present complex patent datasets in simplest and eloquent graphs which may be customised as per the information requirement. In the present study, patent maps of patent dataset, selected from GPI developed by European Patent Office, were prepared and analysed to understand the entire gamut of technology pertinent to integrated silicon photonics. Patents maps of the top 20 applicants/inventors over the time scale, i.e., date of filing and IPC classification, prepared

using statistical tools of GPI database have helped in identifying the major players in this technology segment in a very illustrative, eloquent and structured manner. Similarly, patent relation map, prepared to capture the relationship between the inventors and the applicants of patents related to Integrated Silicon Photonics, has successfully demonstrated the linkages between the inventors and applicants. Further, the highest patent filer was identified using patent maps. Hamamatsu Photonics Ltd. was one of the most active company in developing products and filing patents in the area of Integrated silicon photonics. Like this, patent search tools represent an advanced tool in analysing and forecasting future technological trends, conducting strategic technology planning, detecting patent infringement, determining patents quality and the most promising patents, and identifying technological hotspots and patent vacuums.

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