The Transformation of Semiconductors

Market Analysis of thin, flexible semiconductors

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In the late 1990s and early 2000s, semiconductor manufacturers patented thin, flexible printed circuit boards (PCB) and integrated circuits (IC), but did not have the technical means to implement these technologies. Today, the older patents in this space are newly relevant since more recent manufacturing capabilities will enable the wide array of advanced applications that are possible with thin, flexible semiconductors. Despite the fact that most of these patents are on OLEDs and LCDs, these technologies have wide-ranging applications which will transform markets such as 3G and 4G technology, wearable devices, intelligent sensors, and others.

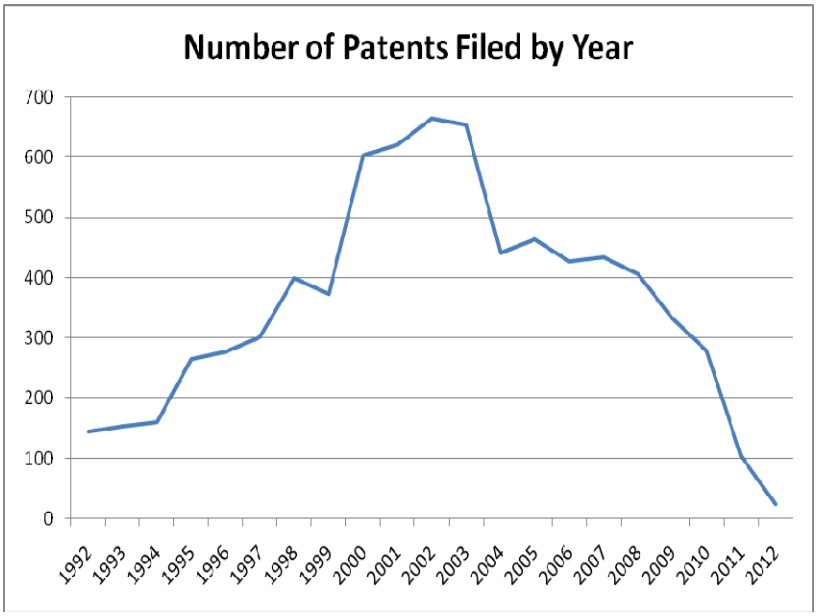


Fig. 1 Graph of quantities of patents filed on thin, flexible semiconductors by year.

The chart to the left demonstrates the increased rate of patenting thin, flexible semiconductors from approximately 1995 to 2003. After 2003, the rate fell sharply and has since continued to decrease. These patents had ambition beyond their means. In their eagerness to stake claims to a new market, consumer product companies like Samsung, Sharp, Sony, and LG filed patents based on a mistaken belief in their capacity to integrate thin, flexible circuits into displays. Unfortunately, technical insufficiencies prevented them from executing this forward-looking strategy.

Now that these patents have already started to expire, companies will quickly need to reintegrate them into their approaches. With the help of new manufacturing processes, what was formerly a pipe dream can become a fully-enabled product pipeline. There are at least ten thousand patents in this space. If you don't have a patent on thin film semiconductors by now, there are plenty available for purchase.

The mass production of flexible, thin semiconductors has the power to change how humans interact with the world in all aspects of life beyond OLEDs and LCDs. In 2013, the Institute of Electrical and Electronics Engineers (IEEE) published an article in the *IEEE Spectrum* about the seamless integration of computing into everyday objects.[1] This becomes possible with flexible circuitry that can be added to our clothes, our bodies, or our houses.

Such circuitry enables 'brilliant' sensor design. *MIT Technology Review* acknowledged this in a key article on bendable microchips. "A key advantage is that these strategies enable commercial, off-the-shelf components to be configured into flexible, stretchable formats."[1] The IEEE also acknowledges that thin, flexible chips create much more efficient sensors, saying that

Fig. 2 SEL showcases 3-fold touch-sensitive OLED Display

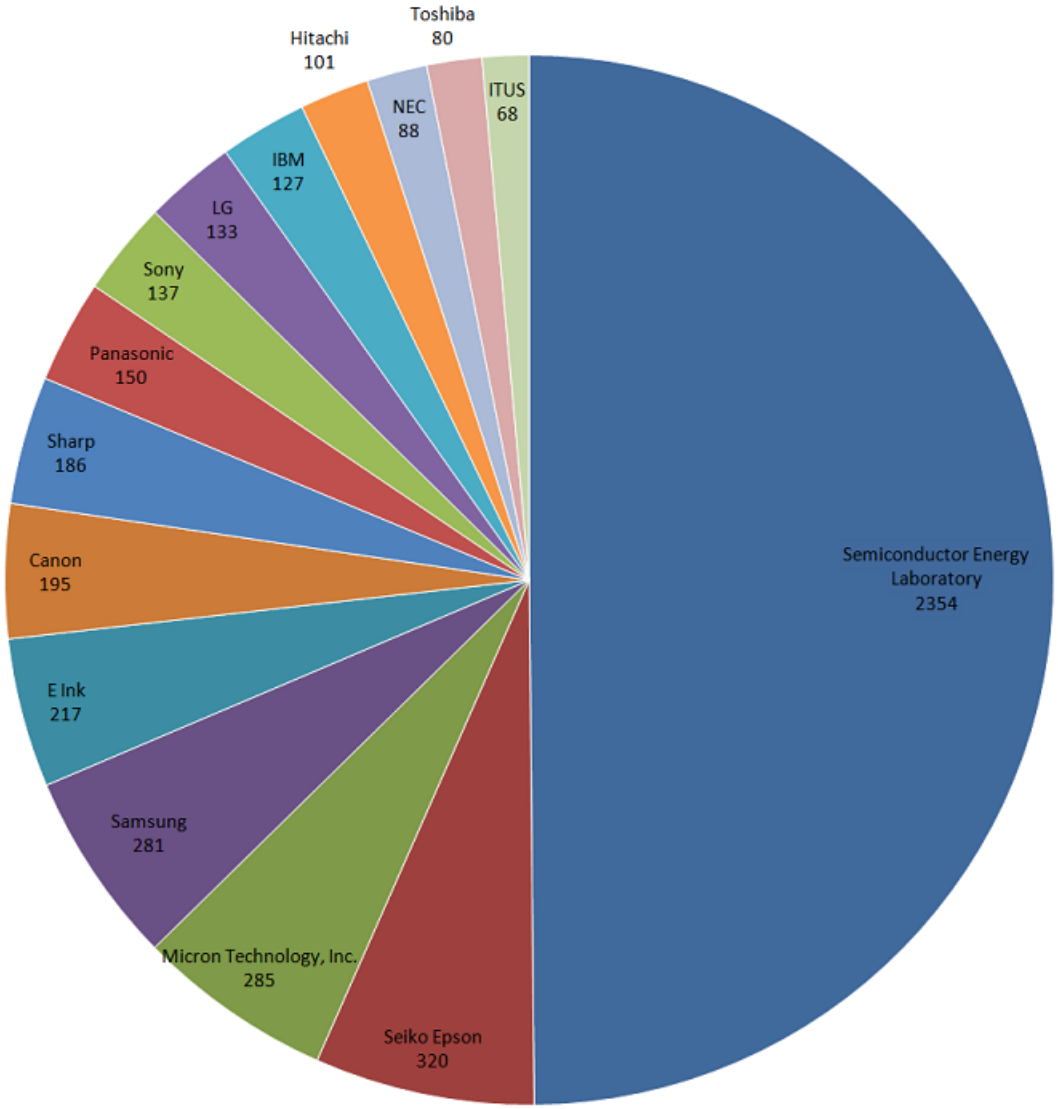
[1] http://spectrum.ieee.org/semiconductors/materials/make-way-for-flexible-silicon-chips
[1] http://www.technologyreview.com/news/429344/bendable-microchips-could-make-smarter-sensors/

"…ultra-thin chips of less than 20µm become flexible, allowing integration of silicon IC technology with highly flexible electronics. This combination allows for highly intelligent products of unprecedented thinness, flexibility and cost. Examples include sensor systems integrated into food packaging or healthcare and sport monitoring tags as wearable patches or even directly in clothing textile."[2]

Now that these radical semiconductor technologies can be reliably integrated into consumer products, they have opened new market entry pathways for the tech companies who began patenting flexible PCBs more than a decade ago. These companies are already on the way to establishing inroads into wearable electronics, control systems, medical devices, energy production and transportation, and an array of other sectors which the market has begun to express significant interest in over the past several years.

Analysis

The following chart displays the top 15 names in the thin, flexible semiconductors market. Overall, Semiconductor Energy Laboratory (SEL) owns 25% of the patents and 50% of the patents owned by the top 15 names. In November 2014, SEL exhibited an OLED display which can be folded three times.[3]



[2]http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6698673&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel7%2F6684410%2F6698588%2F06698673.pdf%3Farnumber%3D6698673

[3] http://techon.nikkeibp.co.jp/english/NEWS_EN/20141031/386141/?SS=imgview_e&FD=48575398

Sony, E Ink, Sharp, Samsung, Toshiba and Seiko Epson have all worked to develop flexible OLEDs or LCD displays. IBM has been focusing on flexible semiconductors for over two years.[4] Many of the patents in this space focus on displays; however, wide-ranging applications will be at the forefront of an immense wave of new technology deployed into the world economy.

New fabrication technologies, recently put into practice by California-based eSurface Technologies and others, create highly flexible PCBs which are only microns thick. eSurface's additive circuit manufacturing process allows conductive materials to be added to an expanded variety of substrates.[5] The company's proprietary chemical deposition achieves improved adhesion via covalent bonding, as well as greater circuit density and better signal integrity compared to earlier etching methods. By reducing the current limitations on substrate choice, circuit size, and flexibility, these technologies will allow for partnerships with electronics manufacturers to create new markets for semiconductors.

Chipset makers like Ibiden, Intel, Texas Instruments, and STMicroelectronics will be able to manufacture mobile devices which can take any shape, such as paper-thin, foldable tablets. In 2014, Intel announced its interest in creating fashionable wearable electronics by partnering with Fossil and acquiring smartwatch maker Basis Science.[6] Intel could use flexible circuit technologies to create intelligent apparel. Last fall, Apple introduced the Apple Watch.[7] The company could integrate its product lines including wearables into entirely new forms. In the WiFi innovation space, Qualcomm and Nvidia will be able to change the LTE market by enabling 4G access on any type of personal item.

Since 2006, the US government has been researching the technological implications of thin, flexible microchips in space applications. "The Missile Defense Agency is currently supporting an effort to update this technology for use by the military and NASA in space's hostile and radiation-heavy environment."[8] The US Air Force owns a patent entitled "Latching zip-mode actuated mono wafer MEMS switch method" with a priority date of 2004, which details the fabrication of a thin MEMS switch for use in RF devices. Qualcomm and Broadcom could utilize these technologies in satellite chipsets to reduce the large cost of satellites.

Conclusion

Clearly, these older patents have the possibility to bring new life to the PCB and IC markets. However, the entities that hold them could be left behind in the new wave of intelligent sensor design if they make the mistake of believing that thin, flexible semiconductors only affect the OLED, LCD or E Ink display markets. Although these applications have been the primary focus of patenting activity in the thin, flexible semiconductor space, this technology represents nearly limitless possibilities to integrate semiconductors into everyday life.

Entities wishing to manufacture these new technologies will either patent their own iterations or, more wisely, they will license these technologies from those with the patents and technical knowledge to bring these new possibilities to consumers.

For more details on this report, please contact patentlyobvious@m-cam.com.

[4] http://www.extremetech.com/computing/145800-ibm-develops-flexible-nanocircuitry-10000-times-thinner-than-paper
[5] http://esurface.com/the-esurface-process/
[6] http://techcrunch.com/2015/01/06/intel-wearables-chip/
[7] http://www.m-cam.com/patently-obvious/ticking-tim-bomb-or-bonanza
[8] http://www.defenseindustrydaily.com/us-looking-to-put-more-powerful-flexible-microchips-in-space-02345/

A Brief Primer on the Patent System

In recent years, the importance of patents and intellectual property rights as an important variable in the marketplace has come to the forefront of the public consciousness as world leaders declare their country's lead in the innovation race. Damaging intellectual property litigation is becoming increasingly common across all industries. This is exacerbated when patent rights are granted for non-novel ideas. A vast amount of precedent innovation is unconsidered by patent-granting authorities in the creation of new IP rights. Patent granting authorities including the United States Patent and Trademark Office (USPTO), European Patent Office (EPO), Japanese Patent Office (JPO), Chinese State Intellectual Property Office (SIPO), Korean Intellectual Property Office (KIPO) and many others are constrained by the use of patent classification systems which are routinely circumvented by patent applicants.

There is a two-way social contract underlying the patent system. In the United States, patent terms are generally limited to 20 years from the date of application. By statutory intention, once a patent has expired, the patent holder loses the right to exclude others from fully utilizing any innovation described in the patent. A large number of patents enter the public domain when they are "abandoned" – when owners discontinue paying patent maintenance fees. Patents also only provide an exclusionary right in the country for which the patent is filed. As demonstrated by the Global Innovation Commons[9] (G.I.C.), using intellectual property available in the public domain eliminates the need to pay licensing fees on those innovations in countries where the patent was never registered, or worldwide, if abandoned.

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[9] http://www.globalinnovationcommons.org/