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# Presenting the (economic) value of patents nominated for the European Inventor Award 2012

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## 1. The invention

### 1.1 Historic account

This nomination is about the invention of the NiMH rechargeable battery. Stanford Ovshinsky is the key inventor behind this type of technology. However, apart from the NiMH battery – which is today widely used in hybrid cars and also in consumer-type battery for electronic devices – Stanford Ovshinsky was behind many other inventions, making him somewhat of a Thomas Edison of today.

What is even more remarkable about Stanford Ovshinsky is that he is a fully self-taught inventor with no academic background, but with a strive to solve societal problems:

*“My intention has always been to solve the big societal problems. So I sat down and thought about these problems. I anticipated problems with climate already back in the 1950s. I picked information and energy for what I was going to work on; not the least as information and energy are closely related (information is encoded energy). The other topic was hydrogen, and I worked on hydrogen in many forms, which was hydrogen storage, hydrogen ions in a battery....my intention was to make batteries more usable in the transportation sector, as the transportation sector is responsible for 40% of the pollution and climate change gases....” (Stanford Ovshinsky)*

In 1960, Stanford Ovshinsky and his then wife Iris Miroy Dibner, founded the firm Energy Conversion Laboratory, which would later become Energy Conversion Devices (ECD, in 1964) and in 1982 eventually they formed the Ovonic Battery subsidiary. The company sparked the beginning of a range of groundbreaking inventions, such as with nanostructures, batteries, solar cells, phase change memory or in LCD technologies.

Stanford Ovshinsky elaborates further on his motivation in particular in relation to batteries:

*“One other important aspect of my work was that I wanted to counter de-industrialisation. Civilised countries need an industrial base. The NiMH battery technology was an industry enabler, it created jobs.”*

He further aimed to make societies less dependent on fossile fuels, and create respective enabling technologies. Many of his innovations were advances/inventions in the materials fields.

Asked upon basic barriers he encountered with his inventions, Stanford Ovshinsky points to the following recurring barriers:

*“First, you will always meet scepticism. There are always people who say it cannot be done. This is a psychological problem, and you as inventor have to show that it can be done, and that it would be good for making money. The second most pronounced barrier is when established industries, which your invention may endanger, fight back the innovation. For example, NiCd battery producers were not keen to lose their market position; in the automotive industry, there were also some rather unfriendly people.”*

Eventually, Mr. Ovshinsky’s inventions made Ovonic the market leader in NiMH battery technology. The technology has been licensed to all major manufacturers of NiMH batteries. In the beginning of the 1980s, the technology started to replace the older NiCd-based batteries. In the 1990s, the technology was eventually expanded into the transportation sector for use in electric vehicles (EVs). Despite of a contract with

the United States Advanced Battery Consortium (USABC), a consortium including the leading U.S. car manufacturers, to develop NiMH batteries and the subsequent introduction of some models, and although the technology was proven it did not take off (see section 2 on the discussion of reasons). However, eventually it became a success in hybrid Japanese cars, i.e. Toyota and Honda, who licensed and used Stan's technology.

In 2007, after the death of his wife Iris, Stanford Ovshinsky retired from ECD/Ovonic and established a new company, Ovshinsky Innovation LLC. The firm is working on new innovative energy and information technologies. Aged 86, he eventually set up a second firm, Ovshinsky Solar LLC for photovoltaic technology. Stanford Ovshinsky has obtained a range of prizes - such as the Innovation Award for Energy and the Environment (2005 by the Economist) and the Thomas Midgley Award from the Detroit Section of the American Chemical Society. He also holds numerous honorary doctor titles in science. He was named a "Hero of the Planet" by Time magazine, and along with Iris he was named a "Hero of Chemistry."

## 1.2 Technological features

The nickel-metal hybrid battery is a type of rechargeable battery (also abbreviated NiMH or Ni-MH battery). The NiMH battery uses, like the earlier NiCd batteries, positive electrodes of nickel oxyhydroxide. However, the negative electrode is made of a nine-element hydrogen-absorbing alloy instead of cadmium.

The battery university website gauges advantages and disadvantages of the NiMH battery as follows:<sup>1</sup>

*"...new hydride alloys discovered in the 1980s offered better stability and the development of NiMH advanced in earnest. Today, NiMH provides 40 percent higher specific energy than a standard NiCd, but the decisive advantage is the absence of toxic metals.*

*The advancements of NiMH are impressive. Since 1991, the specific energy has doubled and the life span extended. The hype of lithium-ion may have dampened the enthusiasm for NiMH a bit but not to the point to turn HEV<sup>2</sup> makers away from this proven technology. Batteries for the electric powertrain in vehicles must meet some of the most demanding challenges, and NiMH has two major advantages over Li-ion here. These are price and safety. Makers of hybrid vehicles claim that NiMH costs one-third of an equivalent Li-ion system, and the relaxation on safety provisions contribute in part to this price reduction.*

*Nickel-metal-hydride is not without drawbacks. For one, it has a lower specific energy than Li-ion, and this is especially true with NiMH for the electric powertrain. The reader should be reminded that NiMH and Li-ion with high energy densities are reserved for consumer products; they would not be robust enough for the hybrid and electric vehicles. NiMH and Li-ion for the electric powertrain have roughly one-third less capacity than consumer batteries.*

*NiMH also has high self-discharge and loses about 20 percent of its capacity within the first 24 hours, and 10 percent per month thereafter. Modifying the hydride materials lowers the self-discharge and reduces corrosion of the alloy, but this decreases the specific energy. Batteries for the electric powertrain make use of this modification to achieve the needed robustness and life span.*

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<sup>1</sup> [http://batteryuniversity.com/learn/article/Nickel\\_based\\_batteries](http://batteryuniversity.com/learn/article/Nickel_based_batteries)

<sup>2</sup> HEV stands for Hybrid Electric Vehicle

*There are strong opinions and preferences between battery chemistries, and some experts say that NiMH will serve as an interim solution to the more promising lithium systems. There are many hurdles surrounding Li-ion also and these are cost and safety. Li-ion cells are not offered to the public in AA, AAA and other popular sizes in part because of safety. Even if they were made available, Li-ion has a higher voltage compared to nickel-based batteries."*

According to Stanford Ovshinsky, and in addition to the advantages noted above, the NiMH batteries also have greater longevity, and although the combinations of characteristics of both NiMH and Li-ion batteries are optimized differently for each application, the NiMH batteries have a much improved specific energy in electric powertrains since inclusion of information in the referenced article. There are over four million cars on the road with NiMH batteries, and Ovonic's licensees are producing over one billion consumer batteries every year.

## 2. The market

The global patent battery market was estimated to be worth some US\$ 47.5 billion in 2009.<sup>3</sup> The Ni-MH batteries, which are the subject of the invention, account for 3% of the global revenue.

Although the NiMH battery chemistry is considered a mature technology – and some argue that there is only limited scope for improvements –, there is continuous innovation. Its advantage in economic terms is price-efficiency with good performance characteristics.<sup>4</sup> Against this backdrop, NiMH batteries still continue to replace old chemistries – most notably the NiCd chemistry –, while the technology will be in the future in many fields replaced by the – now still expensive – Li-Ion technology.

Against this backdrop, market researchers from Frost & Sullivan see growth potential coming from two segments: First, from the consumer sector. This sector is boosted by growing consumer awareness regarding the savings of cost associated with the use of secondary batteries (if compared to primary batteries). Furthermore, modern NiMH batteries come pre-charged and hence share this ready-to-use feature with primary batteries. Environmental advantages over the NiCd favour the NiMH technology, too. The second segment is industrial applications (emergency lighting, railway applications, etc.), where the NiMH chemistry can excel in terms of robustness, operation in a wide temperature range and high resistance to electrical disturbances at low costs. Electrical and hybrid cars are also a major market segment and source of income for NiMH manufacturers. NiMH batteries power virtually all hybrid cars, though the Li-Ion technology is expected to replace the NiMH chemistry in the long run.

Ovonic Battery Company is considered a pioneer, key player and strong IP holder holding basic patents in the field of NiMH technology. The business model employed makes use of licensing and/or joint ventures with other manufacturers for commercialising the technology. In fact, there is not only one but also a set of around 120 (U.S.-) patents related to the NiMH technology and owned by the firm. The

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<sup>3</sup> Frost & Sullivan figures quoted by the Battery University, [http://batteryuniversity.com/learn/article/global\\_battery\\_markets](http://batteryuniversity.com/learn/article/global_battery_markets)

<sup>4</sup> Seminiaro, V. (2011): Growth Opportunities for the Nickel Metal Hydride (NiMH) Batteries Market, Frost & Sullivan Market Insight, <http://www.frost.com/prod/servlet/market-insight-top.pag?docid=227505850>, April 2011

company claims that that it has all manufacturers of NiMH batteries worldwide as licensees.<sup>5</sup> However, it is expected that 14 crucial NiMH patents will expire by 2014.

In 2010, the firm earned nearly US\$ 8 million from royalties for NiMH technologies, the majority of which is related to royalties from hybrid vehicles.<sup>6</sup> Interestingly, though, because of Ovonic's manufacturing partners control representing special interests, the firm has been accused of deliberately blocking access to the NiMH technology for use in the automotive market (and hereby halting the development of a market for electrical cars). Ovonic Battery had been initially set-up as a joint venture between ECD Ovonics and American Natural Resources Company (ANR) in 1982 as separate legal entity. Over the course of time, ownership of this joint venture changed frequently and has seen firms such as oil-company Chevron or General Motors (GM) as significant stakeholders. Against this backdrop – and in the light of certain licensing terms<sup>7</sup> – a larger group of people believe that oil/automotive industry interests and these industry's control over the firm are responsible for limited market success of NiMH powered vehicles. Opponents to that view point to economic necessities behind the licensing terms and deny an 'oil industry conspiracy'. A full and detailed account of this story is available at Wikipedia for further research.<sup>8</sup>

Ovonic battery company was re-integrated into ECD Ovonics as a unit within the 'ECD Ovonics Materials' division. ECD Ovonics is active in a large range of technologies – most notably solar technology – and has employed some 1,500 staff in 2010.<sup>9</sup> In 2012, Ovonic battery company was acquired from ECD by BASF.

### 3. The role of the patent(s) and Intellectual Property Rights (IPR)

#### 3.1 Motives for and benefits of patenting and employed IPR strategy

Stanford Ovshinsky gauges the relevance of patents as follows:

*"Patents should be seen as an opportunity, not a danger. An inventor would not exist without patents. Patents create a chance for the invention, they are the source of change. Without some protection, successful innovation would hardly be possible."*

However, Stanford Ovshinsky asserts that patenting should be done professionally, "...because only then can you have a position where even a small firm can be able to negotiate with a big firm."

Enforcement of patents is nonetheless for Stanford Ovshinsky a big problem. For him, most fundamental patents are often by people at the periphery of an industry:

*"A critical success factor for enforcement and also for business success is understanding policies. There are a lot of policies in large firms. Many such firms have access to their local governments. An inventor should not use policies, but he/she should have a good understanding of the way these organisations think, of their needs. The same holds true also of governments and countries, where inventors should have the same type of understanding"*

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<sup>5</sup> "Advanced Ovonic Battery Technology - NiMH, Li-Ion Cathodes, Proton-Ion", presented at the Avicenne Batteries 2011 Congress, September 29, 2011, <http://energyconversiondevices.com/pdf/OvonicFetcenkoAvicenne2011.pdf>

<sup>6</sup> ECD Annual Report 2010, [http://energyconversiondevices.com/pdf/2010\\_Annual\\_Report.pdf](http://energyconversiondevices.com/pdf/2010_Annual_Report.pdf)

<sup>7</sup> Such terms have included prohibitively large minimum sales requirements for the licensee or outright denial for usage in the automotive markets.

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[http://en.wikipedia.org/wiki/Patent\\_encumbrance\\_of\\_large\\_automotive\\_NiMH\\_batteries](http://en.wikipedia.org/wiki/Patent_encumbrance_of_large_automotive_NiMH_batteries)

<sup>9</sup> ECD Annual Report 2010, [http://energyconversiondevices.com/pdf/2010\\_Annual\\_Report.pdf](http://energyconversiondevices.com/pdf/2010_Annual_Report.pdf)

A particular example of how policies can come to help is the willingness of catching-up economies (and catching-up firms) to become technological leaders, "...which makes them very much interested in new technologies. This was true in the past of the Japanese, - which picked up the NiMH battery - and it repeats now with China. For inventors, exploring such opportunities could be one interesting option." (Stanford Ovshinsky).

Larry Norris, at that time patent attorney working for Stanford Ovshinsky, explained in that context that Ovonic had licensed the NiMH technology for consumer device use to Japanese manufacturers, but was not allowed to out-license the technology for automotive use. However, the Japanese car manufacturers eventually produced their batteries for hybrid vehicles from consumer batteries and argued that the licensing terms were not jeopardised. The case was eventually settled, with the result being that the way to success was paved for cars such as the Toyota Prius.

### 3.2 Patent statistics and patenting trends

The nominated patent EP0639295 was applied for in 1991/1993 and granted by the EPO in 2001. After a maximum running time of 20 years, patent life is going to expire in 2012/2013. At the moment, the patent is still in force in DK, KR, PH, CN and in Europe.

The company Ovonic Battery has applied, since it has been established in 1982, for 170 patents. 85 were PCT applications with EP designations. 38 patents have been so far granted by the EPO, and 28 are still in force. Most applications occurred in 1998 and 2001, with 15 applications (patent families), respectively. The patents are concerned with the internal structure of secondary batteries (rechargeable batteries), the composition of electrodes used in batteries and with fuel cells. Other applicants have so far cited these patents more than 1,000 times, which is a clear sign of patent value. The applicants which cite the patents most are Panasonic, Sanyo, and, since the mid 1990s, Toyota. Ovonic Battery is continually applying for new patents.

To date, there have been 2,307 patents file on NiMH batteries. Besides first applications of Energy Conversion Devices (later Ovonic) on the technology, there have been also early applications by Toshiba (in 1993). The ranking of the most important patent applicants in this field shows Panasonic in the lead (105 patents), followed by Ovonic (72 patents), Sanyo (62 patents) and Toyota (45 patent applications.)

In the mid-1990s, NiMH battery patents were classified in patent class B60L (electrical equipment or propulsion of electrically propelled vehicles) and H04M (telephonic communication). A comparison of patents referring to Li-batteries and to batteries with NiMH chemistry shows that in class B60L 593 are concerned with Li technology and only 74 with NiMH. Li-related patent applications have also increased over time, while NiMH patents have stayed constant. This reflects the change of technology to Li batteries as described above also in the patent databases.

As for Stanford Ovshinsky himself, since the 1940's he has applied for 509 patents including fundamental patents. The most recent one dates from February, 2012. Geographic coverage is wide: 35 countries plus 168 times EPO applications and 156 as PCT applications. More than 30% of applied for patents have been granted – e.g., in the U.S. 104 and 70 by the EPO.

## 4. Conclusion

The patented technology of NiMH batteries has proven in a large number of consumer batteries and also in hybrid cars. It can be therefore considered a valuable invention, also with positive societal and environmental impacts.

According to Stanford Ovshinsky, success factors for the inventions have been:

- Perseverance
- Independence (to have one's own company)
- Flat hierarchies and an innovation culture within the firm
- Interest by catching-up economies and/or catching-up firms who want to become technological leaders

Stan feels a great sense of accomplishment in that his battery patents enabled electric and hybrid-electric vehicles to become an increasingly important factor for reducing climate change gases and building new industries.