

## Chapter I: Stan Ovshinsky

The last century has been the century of unrivaled expansion of our understanding and exploitation of Nature. For the first time we learned how and when the Universe was formed, the nature of its most elementary and smallest constituents, and the origin and nature of our species. Our incredibly advanced information technology has made our world accessible and small.

During the past century an ever increasing rate of specialization produced new records of accomplishment and innovation. These developments grew out of the collective efforts of creative minds at our centers of learning, and the inventive and curious spirits that were supported by technologically advanced industries.

Enter Stan Ovshinsky. Born in 1922 in Akron, Ohio, he came from a humble background. He obtained his education by taking an armful of books each week from the Akron Public Library. His endlessly active mind needed no teacher. His academy and his college were, and continue to be throughout his life, books feeding his intellectual hunger. Working as a tool maker and lathe operator in machine shops, he questioned why different materials, such as cast iron or the different steels, vary in ductility or strength; what happens during annealing, and, why do cutting tools lose their edge? Can one stop the shaking and the vibrations of the lathe at high speeds; why is the whole machine out of balance? These simple questions going through Ovshinsky's mind opened for him a deep insight into the functions of the elements, their combinations and the different atomic arrangements in materials, defining their properties. These probing questions did not let go of him until he had invented a well balanced lathe without loose tolerances which ran at ten times higher speed and had cutting tools on both sides. His first important invention was soon followed by automated machine tools. Important lessons he learned were first that problems can be solved by thoroughly analyzing and understanding them and second that one has to build and demonstrate their solutions in order to convince others. Words are not enough. Ovshinsky followed these lessons throughout his life inviting his friends, his doubters as well as his opponents, to come to his company and let the results speak for themselves. No one left unconvinced after such a visit.

It is astonishing that this one remarkable individual, Stanford R. Ovshinsky, self taught and without special training, could compete with the well funded establishments of learning and industry in the second half of this past century and leave us an incredible legacy of brilliant innovations with a lasting impact on our lives. He has navigated the world of science and technology without formal academic training, nor was he funded by high tech industry. He has taken an individual path that places him more in line with Thomas Edison or Charles Darwin, those self taught geniuses of the 19th Century, who laid the ground work for the advances of the 20th Century.

Ovshinsky is the inventor of the nickel-metal hydride battery, which powers a large fraction of our electronic tools and which is indispensable for electric and hybrid automobiles. He invented our rewritable CD and DVD optical disks, as well as new forms of non-volatile computer memories which are being commercialized through Intel, STMicroelectronics and Samsung among others. He holds crucial patents relating to flat panel displays, non-silver photography, hydrogen storage materials, and thin-film solar cells. Moreover, this large range of apparently

disparate inventions did not grow from the solid base of accepted knowledge of materials science. They evolved from a new paradigm of materials discovered and created by Ovshinsky, which at that time contradicted the established teachings of what constitutes useful and scientifically interesting materials. These path-breaking new ideas and inventions were based on his new paradigm of compositional and structural disorder in materials. These ideas broke with the reliance on the crystalline ordered structures, which dominated the conventional thinking of the time and form the contents of this book of selected publications of Ovshinsky and the list of his important patents.

The number of inventions and patents of Ovshinsky rank with those of the master inventor Edison. Yet, this is only a fraction of his accomplishments. He and his wife Iris founded Energy Conversion Devices, Inc. in 1960 and followed a vision "using creative science to solve societal problems": energy conversion devices for freeing our society from our dependence on fossil fuels, using instead the sun as well as hydrogen, the primary element that fuels the universe. According to Ovshinsky, information is encoded energy, therefore, information and energy technologies overlap in his work, they are two sides of the same coin. Working outside the accepted materials technologies, Ovshinsky had to do more than invent devices he needed to realize his vision. He had to create and nurture the scientific foundation for understanding his disordered materials, develop the equipment for making them, invent the machines for their manufacture, and manage his ever growing company: a scientist, inventor, product developer, machine builder, manufacturer, and entrepreneur all in one person.

Ovshinsky's strong and unwavering belief in himself and his awareness of his superior intelligence as well as his unusually dogged mind guided him through times when the establishment just could not accept that he was right. Ovshinsky knew that pure reason and clear logic as well as the laws of nature were on his side, he had thought through and understood each problem and saw the results of his ideas in his laboratory. He concluded that his opponents just needed more time to understand, to be able to overcome the boundaries of their academic thinking. The scientific and industrial communities are often astonishingly conservative and adverse to new concepts and ideas. They are also averse to listening seriously to people outside their league who are not part of their world, like the self taught Ovshinsky. Academic education not only conditions and confines thinking in specialized disciplines, it also narrows the choice of problems that are considered worth solving and sets up blinders to other areas. Lacking this formal education and prejudice, Ovshinsky was able to see all fields of science and engineering broadly as one intellectual unity. His ship of imagination did not stay close to the safe shores of known territory.

Materials science has become ever more important for opening new areas of technology. It is therefore astonishing that a large new family of materials lay dormant, waiting to be discovered and used. The sparks of Ovshinsky's ideas caught fire in Japan, China, and Europe. The Japanese were particularly inspired by the fact that one individual could be so creative and yet outside the establishment. The founders of Sony, Sharp and Cannon asked Ovshinsky to show them how to change their traditional ways and how to encourage individual thought and imagination in their country. Some seeds must have germinated because the PBS science program, Nova, called Ovshinsky "Japan's American Genius". Ovshinsky's new field became known as "Ovonics" for Ovshinsky+electronics. Soon, international scientific conferences and journals started to focus on

this new materials science. Some adopted names like Ovonic science and Ovonic materials. The Ovshinsky Award honors major contributors to the field.

There is a mysterious quality in Ovshinsky's persona that attracts people into his sphere, builds life long friendships and awakens deep respect and devotion. Meeting him leaves each person with a deep impression of his superior intellect, his self confidence, his compassion to improve society combined with his certainty that his vision can be realized. His enthusiasm is contagious. In his presence you feel how exciting it would be to join him in his endeavors. As a result he and his wife Iris attracted many great minds with diverse expertise and broad talents as friends, supporters and collaborators.

Energy Conversion Devices, the company Stan and Iris founded in 1960, always had a different working atmosphere from that of other companies. People felt less as employees than as collaborators participating in Ovshinsky's thought process and sharing the excitement of success and the process of inventing. Most discussions and brainstorming happened at a big round table where its head was anyone who offered an interesting idea. There was no hierarchy and advancement just meant larger responsibilities. This book does not name the large number of collaborators who contributed to the success of Ovshinsky's work. They are found as coauthors of his publications and patents and are acknowledged at the end of his published papers.

The publications selected for this book, though overwhelming in their breadth and scope, portray only the scientific and technical accomplishments. It is impossible to fully describe or bring to life for the reader the richness of Ovshinsky's mind and the greatness of his personality. The very soul of who we are at our very best is expressed in our curiosity. Ovshinsky's curious and inquiring mind is boundless. He explores and admires excellence in any field, be it music, art, painting, poetry, theatre, history ... his over 20,000 volume library, are all beautiful expressions of the best in humans.

Ovshinsky never stopped being fascinated by the functions of the brain, beginning with his first publications on neurophysiology. His original work and life long fascination spawned his, as yet, unrealized idea of a new generation of computers, a cognitive computer based on his lifetime inventions of devices. But these ideas will reach far into the future. This book deals with the past and the present. It tries to bring to life the multifaceted ideas and accomplishments of Ovshinsky during the past 20 years. His earlier publications have been presented and discussed in a prior volume. [1]

[1] *Disordered Materials, Science and Technology*, Ed. D. Adler, B.B. Schwartz and M. Silver (Plenum Press, New York and London. 1991)