

Key inventions / events and people in the history and evolution of Photovoltaics

A personal encounter and choice – no academic ambition what-so-ever!

Some observations:

- *Developments best documented since the 17th Century.*
- *Multidisciplinary: alchemy; natural science; physics; chemistry; optics; engineering, mathematics; quantum physics*
- *Geographical weight: West-Europe (England, Scotland, France, Germany, Italy) and US (since 21st Century).*
- *Gender: knowledge of light and electrical power is a male thing*

From 1900BC	Alchemy, Cosmologies & creation myths by Early / Ancient Cultures like f.i.: Andean Cosmovision; Maya cosmology;	Andes region; Yucatan (East Mex/ Belize/N.E. Guatemala)	- 'Living astronomy': synchronize social and productive life with the rhythms of the cosmos - - According to an ancient Mayan Calendar we are living in the last days of a great cosmic cycle known as the "Long Count." Traditionally, this is labeled as the Death of the Fourth period of the Sun and the Birth of the new Fifth Sun. Overview by NASA here: http://sunearthday.nasa.gov/2005/images/ao_poster.pdf
214-212 BC	Archimedes	Syracuse, Greece (c.287-212BC)	- 'Death ray': using mirrors as a parabolic reflector to concentrate sun rays and burn ships of the Romans attacking Syracuse
1250	Roger Bacon	Somersetshire, England (1214- c. 1294)	- Magnifying glass ; Physical analysis of convex glasses and lenses, the invention of spectacles and achromatic lenses; Anticipates later inventions such as microscopes, telescopes, spectacles, flying machines, hydraulics and steam ships.
Late 1400's	Aztecs	Central Mexico (14th-16 th Century)	- Creation of the ' Piedra del Sol ' (Sunstone); the Aztecs' idea of the cosmos...
+/- 1600	Galileo Galilei	Pisa, Italy (1564-1642)	- Attempted to measure the speed of light . He used lamps and men on mountain tops, made several measurements and decided that light traveled so rapidly that he could not measure its speed.

1676	Ole Christensen Rømer	Kopenhagen, Denmark (1644-1710)	- First definition of the speed of light : 225.000 km/s.
1690	Christian Huygens	(1629-1695)	- Light is a wave . Huygens developed this idea by Descartes and published it in 1690. Wave theory predicted that light would refract because the waves would travel more slowly in glass. Robert Hooke, Newton's rival, supported the wave theory.
1670-1672 ; 1704	Isaac Newton	Lincolnshire, Scotland (1642-1727)	- White light consists of different colors (Prisma experiment) - Light is a particle (1704)
1765	James Watt	Firth of Clyde, Scotland (1736, 1819)	- Enhanced Steam Engine (of 1712 model of Thomas Newcomen) adding a rotation engine ('solar system' model; based on movement of Earth around the Sun – also see Rutherford)
1787	Antoine Lavoisier	Paris, France (1743-1794)	- Identification of Silicon - Combustion, generated by focusing sunlight over flammable materials using lenses ('Father of modern chemistry')
1799	Alessandro Volta	Como, Duchy of Milan (1745-1827)	- Invention of the battery
1801	Thomas Young	Somerset, England (1773-1829)	- Light is a wave (<i>suggested by Christiaan Huygens early 18thC</i>) - Interference – by passing light through two slits. With one slit, a pattern of light was created, when a second slit was opened by itself the same pattern of light was created. When both slits were opened at the same time, darkness appeared where there had been light with either alone! Light plus light equals dark
1818	François Jean Dominique Arago	Estagel (Perpignan) France (1786-1853)	- Arago (Poisson's) spot is a bright point which appears at the center of the shadow of a circular object in light from a point source. Since the spot occurs within the geometrical shadow, no particle theory of light could account for it. Its discovery provided weighty evidence for the wave nature of light. - Light is polarized - Rotatory Magnetism
1820	Georg Ohm	Erlangen, Germany (1789-1854)	- Current - Potential difference
1822	Augustin-Jean Fresnel	Broglie, France (1788-1827)	- Fresnel Lens

1831-1832	Michael Faraday	South-London, England (1791-1867)	- 3 Laws of electromagnetic induction
1839	Alexandre Edmond Becquerel	Paris, France (1820-1891)	- The photovoltaic effect recognised for the 1 st time with a 'wet cell' battery
1843	Samuel Heinrich Schwabe	Dessau, Germany (1798-1875)	- The solar cycle (accidentally).
1848	Johann Rudolph Wolf	Zürich, Switzerland (1816-1893)	- Discovered independently the coincidence of the sunspot cycle (11,1 years) with disturbances in the earth's magnetic field.
1850	Rudolph Clausius	Germany (1822-1888)	1st and 2nd Law of Thermodynamics 1865: introduced the concept of entropy
1854	William Rankine	Edinburgh, Scotland (1830-1872)	- Thermodynamics: the study of energy in all its forms (<i>with Joule and Carnot one of the founding fathers</i>)
1862	Léon Foucault	Paris, France (1819-1891)	- Speed of light = 298000 km/s (0.6% off the currently accepted value.) - intensity of the light of the sun , as compared with that of carbon in the arc lamp, and of lime in the flame of the oxyhydrogen blowpipe - the interference of infrared radiation , - light rays differing greatly in lengths of path ; - the chromatic polarization of light .
1873	James Clark Maxwell	Edinburgh, Scotland (1831-1879)	- The speed of light (in vacuum) appears as a universal constant ('c') . One of the consequences of Maxwell's: Treatise on Electricity and Electromagnetism (<i>based on findings of H.C. Oersted and Michael Faraday</i>).
1874	George Johnstone Stoney	County Offaly, Irish Midlands (1826-1911)	- Discovery of the Electron
1875	Werner von Siemens	Lenthe, Germany (1816-1892)	Describes the principle of a Selenium PV cell and presents at the Academy of Sciences of Berlin the photovoltaic effect in semi-conductors.
1876	William Grylls Adams & his student R.E. Day	London, Cambridge, England professor of Natural Philosophy , London, (1836-1915)	1st report of the PV effect in a solid material . Variations observed in the electrical properties of selenium when exposed to light.

1882	Augustin Mouchot	Semur-en-Auxois, France (1823-1912)	- A solar reflector is directed at a steam engine that prints 500 copies/hour of a newspaper ('Le Soleil').
1883	Charles Fritts	New York, US	- First Solar Cell built. A thin wafer of Selenium coated with a grid of very thin gold wires and a protective sheet of glass. <1% efficiency
1900	Lord Rayleigh	Maldon, Essex, England (1842-1919)	- The ultraviolet catastrophe: how energy is distributed among the different frequencies in the case of black body radiation (<i>black body</i> : is one that absorbs all the radiation falling on it and then re-emitting all of that radiation)
1900	Max Planck	Kiel, Germany (1858-1947)	- Radiation is punctuated behaviour (particle) as it is absorbed or emitted from time to time in packets (Quanta) of energy of a definite size. The energy content of 1 quanta is proportional to the frequency of the radiation. - <i>h</i> : The constant of proportionality; a universal constant of nature
1905	Albert Einstein	Ulm, Württemberg, Germany (1879-1955)	- Photoelectric Effect: a beam of light ejects electrons from within a metal. - Theory of Relativity
1911	Ernest Rutherford	Manchester, UK (1871, 1937)	- The nuclear Atom ('solar system' model of the atom)
1912	Giacomo Luigi Ciamician	(1857-1922) Trieste, Austro-Hungarian empire	Prophet of Solar Energy - presented a unified view of all the aspects in which solar energy and radiation may satisfy humankind's needs for energy and commodities.
1913	Niels Bohr	Manchester, UK (1885-1962)	- The Bohr Atom
1923	Arthur Compton	Wooster, Ohio, US (1892-1962)	- Electromagnetic Radiation has a particle like character (<-> wavelike) most persuasive evidence to date, by investigating the scattering of X-rays (high-freq. Radiation)
1925	Werner Karl Heisenberg	Würzburg, Germany (1901-1976)	- Matrix Mechanics – 'Mini dictionary' for translating from particles to waves and vice versa (<i>based on work of Prince Louis de Broglie (Fr): if undulating light also showed particlelike properties, then maybe particles as electrons could manifest wavelike properties...</i>)
1926	Erwin Schrödinger	Vienna, Austria-Hungary (1887, 1961)	- Wave Mechanics
1930	Paul Adrien Maurice Dirac	Cambridge, UK (1902-1984)	- Principles of Quantum Mechanics (also Max Born in Göttingen)

1940ies	Richard Feynman a.o.	New York, US (1918-1988)	- Quantum ElectroDynamics (QED); quantum theory of the electromagnetic force (building on the work of Dirac)
1946	Russell Ohl (Bell Telephone Laboratories)	New Jersey, US (1898, 1987)	- Patent on modern Solar Cell "Light Sensitive Device"
1948	Bell Telephone Laboratories (Bardeen & Brattain)	New Jersey, US	First transistors (using doped silicon)
1953	Bell Telephone Laboratories (Daryll Chapin, Calvin Fuller, Gerald Pearson)	New Jersey, US	- Sensitivity of Semiconductors to light. Silicon slices doped with certain impurities are much more efficient in producing electricity from light. - 1 st practical solar cells with a sunlight energy conversion efficiency of around 6 percent
1958	Sputnik 3	Russia, US	Sputnik 3 is 1 st satellite using solar arrays (followed by US space satellite Vanguard I for empowering a small radio transistor.
1970	Zhores Alferov (Dr.)	Vitebsk, Bellorussia, Russia (1930)	1 st highly effective GaAs heterostructure solar cells
1991	Michael Grätzel & Brian O'Regan	Lausanne, Switzerland	Organic Dye (Sensitized) Solar Cell

Based on:

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Wikipedia - http://en.wikipedia.org/wiki/Solar_cell#Four_generations_of_development

More Timelines & history, see:

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<http://inventors.about.com/od/timelines/a/Photovoltaics.htm>

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