

## Selected landmarks in

# The History of Electronics

A contribution to the Institution's 150th anniversary celebrations in 2021  
from the IET History of Technology Network

This is one of a series of timelines which focus on a selection of engineering and technology landmarks which have occurred during the lifetime of the Institution since its foundation in 1871.

Comments regarding any errors in, or significant additions to, this timeline should be sent to the History of Technology Network Manager Anne Locker by Email to [alocker@theiet.org](mailto:alocker@theiet.org)

Date	Event
	<b>1870 - 1879</b>
<b>1871</b>	<b>IET FOUNDED AS SOCIETY OF TELEGRAPH ENGINEERS</b>
<b>1874</b>	Irish physicist George Stoney suggests the existence of a particle, which he initially called an 'electrine' - later the name changed to 'electron' see 1897
	In Germany Karl Braun identifies asymmetric conduction across the contact between a crystal and a metallic wire – basis of the radio Cats Whisker detector
<b>1875</b>	In USA Edison observes dark deposit on inside surfaces of incandescent lamps – the Edison Effect. Later identified as thermionic electron emission.
	<b>1880 – 1889</b>
	The Piezo-electric effect where mechanical stress in certain crystals creates electric potential is discovered by French brothers Pierre and Jacques Curie
<b>1888</b>	Austrian Freiderich Reinitzer identifies liquid crystals. Years later these crystals form the basis of use as TV screens, computer monitors and other display devices
	<b>1890-1899</b>
<b>1891</b>	George Stoney's term 'electrine' replaced by 'electron'

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Date	Event
1894	Jagadash Chandra Bose in India identifies semi-conductors
1895	Wilhelm Rontgen at Wurzburg University discovers X-Rays using a Crookes tube
1897	J.J.Thompson at Cambridge measures the charge-mass ratio of cathode rays finding they were groups of negatively charged particles –originally called ‘corpuscles’ later renamed ‘electrons’ see 1874
	German engineer Karl Braun builds the first cathode ray tube by adding a fluorescent screen to one end of a Crooke’s tube.
1898	Valdemar Poulsen in Denmark achieves the first magnetic recording, later forming the basis of video and audio recording and data storage in computing.
	<b>1900-1909</b>
1901	Jagadash Chandra Bose files for a US patent for a lead sulphide crystal and a metal wire point contact diode (cats whisker) for detecting electromagnetic waves
1904	John Ambrose Fleming at UCL, working as consultant for Marconi, investigates the Edison Effect and creates the thermionic diode –he named it a ‘valve’ as it acted like a water valve with current flow only in one direction making it suitable as a radio signal detector. In USA the term tube was used instead of valve. Some regard this as the the birth of the electronics era ?
1905	Lee de Forest in USA introduces a grid between cathode and anode in the diode to control electron flow. He names it the ‘Audion’ - later renamed the triode.
	Einstein publishes a paper explaining the photo electric effect for which he would be awarded a Nobel Prize in Physics in 1921
1907	H.J.Round at Marconi observes electroluminescence effect – the basis of Light Emitting Diodes (LED) developed later - see 1927
1909	Braun and Marconi awarded Nobel Prize in physics
	<b>1910-1919</b>
1911	Ernest Rutherford, assisted by Hans Geiger and Ernest Marsden at Cavendish Laboratory, Cambridge University identifies structure of the atom
1912	
1913	The ‘Tetrode’ a 4 element thermionic valve developed

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Date	Event
1917	Einstein introduces concept of stimulated emission – this provides the theoretical basis for the creation of MASERS and LASERS in the 1950/60s
1921	Einstein awarded physics Nobel Prize for explaining photo electric effect
	<b>1920-1929</b>
1923	Zworykin patents the iconoscope for use as electronic video camera
1926	Holst & Telegen develop the 5 element pentode valve
1927	Russian Oleg Losev creates the first Light Emitting Diode (LED)
1928	German Engineer Fritz Pfleumer patents magnetic tape for recording – later used for audio and video cassettes and early data storage methods
1929	Tihanyl proposes the charge storage technology concept
	In Japan K. Okabe creates the slotted anode magnetron for generating microwave frequencies
	<b>1930-1939</b>
1931	First practical iconoscope developed by Essie
1932	Tedham and McGee at EMI develop the Emitron TV camera
	Austrian engineer Gustav Tauschek creates the magnetic drum. Concept eventually leads to data storage by Hard Disc Drives (HDD)
1934	Super (i.e. more sensitive) Emitron developed and used by BBC TV
	Hans Hollmann at Telefunken creates a 4 cavity magnetron
1936	Andy Haeff at RCA patents the Travelling Wave Tube (TWT)
	In USSR Alekseev and Malairov develop a multi cavity magnetron
1937	Rusel & Variab invent the Klystron microwave valve
	<b>1940-1949</b>
1940	Russel Ohl patents the p-n semiconductor junction
	Randell and Boot at Birmingham University develop a high power multi cavity magnetron to improve radar sensitivity. Radar defence was critical for the UK during WW2. USA assist UK in the production of these devices

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Date	Event
<b>1947</b>	John Bardeen and Walter Bratten members of team led by William Shockley at Bell labs USA create the first point contact transistor
	<b>1950-1959</b>
<b>1950</b>	William Shockley published "Electrons and Holes in Semiconductors", based on his ground-breaking work at Bell Labs on semiconductors.
<b>1951</b>	William Shockley at Bell Labs patents bipolar p-n junction transistor, superior to the point contact version
	Charles Hard Townes outlines concept of the MASER (microwave amplification by stimulated emission of radiation)
<b>1952</b>	UK engineer and IEE member Geoffrey Dummer presents paper in Washington suggesting that transistors, and other components could be fashioned in one solid block to improve circuit reliability - the first proposal of Integrated Circuits
	William Shockley at Bell Labs proposes Field Effect Transistor (FET)
<b>1955</b>	Silicon dioxide identified by Fosch and Derick at Bell labs as a suitable substance for creating a mask during diffusion in silicon chip production
<b>1956</b>	Shockley, Bardeen and Bratten awarded Nobel Prize in Physics
	A solid state MASER for low noise amplification reception at satellite Earth stations is created by Nicolaas Bloembergen at Harvard University
	Shockley moves from New jersey to California and establishes Shockley Semiconductor Labs –regarded as the start of Silicon Valley
<b>1957</b>	Gordon Gould a PhD student at Columbia University conceives idea of the LASER (light amplification by stimulated emission of radiation). At about the same time at Bell Labs Charles Hard Townes and Arthur Schawlow develop the concept of an optical MASER working in the infra-red and visible light region, for which Bell Labs file for a patent in 1958 (granted in 1960). Gould is denied a patent. This leads to a long legal dispute until Gould is eventually granted a patent in 1973, The question of who first conceived the LASER is still debated by historians
	Silicon Control Rectifier (SCR) or THYRISTOR created for power applications
	Robert Noyce and Gordon Moore, members of Shockley's team leave to establish Fairchild Semiconductors in Silicon Valley as a subsidiary of Fairchild cameras.
<b>1958</b>	Diffused junction MESA transistors are manufactured by Fairchild. MESA transistors are so named due to their shape

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Date	Event
	Jack Kirby at Texas Instruments builds first integrated circuit using surface mounted MESA transistors, resistors and capacitors on one solid block
	Leo Esaki of Sony demonstrates the tunnel diode
<b>1959</b>	Jean Hoerni develops the planar process which revolutionises semiconductor and integrated circuit manufacturing processes.
	Robert Noyce at Fairchild Semiconductors uses Jean Hoerni's planar process to manufacture world's first monolithic integrated circuits
	<b>1960-1969</b>
<b>1960</b>	First working LASER created by Theodore Maiman at Hughes Aircraft Company
	PLASMA TV screen created by placing a matrix of small cells of ionised gas which respond to electric signals, between two glass plates.
	First FET is constructed by Kahng & Attala (Bell) using Metal Oxide Silicon (MOS)
<b>1962</b>	Nick Holonyak creates 1 <sup>st</sup> visible light LED using gallium arsenide phosphate
	MOSFET (metal oxide silicon field effect transistor) created by Hofstein Heiad
<b>1964</b>	A practical Liquid Crystal Display (LCD) is created by the RCA Company (Radio Corporation of America)
	Charles Townes received Nobel Prize for his fundamental work on quantum electronics and the MASER and LASER concepts
<b>1965</b>	Gordon Moore predicts doubling of components per chip every 2 years (later adjusted to doubling transistors per chip every 2years : Moore's Law)
	Robert Noyce and Gordon Moore establish a second company INTEL (Integrated Electronics) also located in Silicon Valley
<b>1969</b>	Willard Boyle and George Smith at Bell Labs create the Charge Coupled Device (CCD) using MOS capacitors allowing transformation of light into a series of stored charges : used in video and still cameras, medical devices, telescopes etc
	<b>1970-1979</b>
<b>1970</b>	The PROM (Programmable Read Only Memory) chip created

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Date	Event
<b>1971</b>	At Intel the first MICROPROCESSOR is created – the 4004 – a 4 bit device it has an arithmetic and logic unit (ALU), a control unit, registers, a bus system and a clock effectively being a computer on a chip
	The EPROM (Erasable Programmable Read Only Memory) is created, This has a window through which ultra violet light can be shone on the chip to erase the existing then allowing the writing of new programmes
	In Switzerland the Twisted-Nematic (TN) LCD mode of operation created. These give a black-on-grey or black-on-silver display suitable for small alphanumeric displays such as wrist watches,
<b>1972</b>	At Hull University a stable crystal material biphenyl is identified for LCDs
	At Intel a 2 <sup>nd</sup> generation 8 bit MICROPROCESSOR – the 8008 – is created
	Motorola introduce their first MICROPROCESSOR – the 6800
	An EEPROM (Electrically Erasable Programmable Read Only Memory) is created at the Electrotechnical Laboratory in Japan by Tarui, Hayashi and Nagai. An EEPROM avoids need for use of ultraviolet light as for the EPROM
<b>1973</b>	After protracted court cases in the USA Gordon Gould is granted patent rights to the LASER as his notebooks prove he conceived the concept before Townes and Schawlow – <i>see 1957.</i>
<b>1975</b>	Kodak creates arguably the first digital camera using CCD technology
<b>1978</b>	Walter Spear and Peter LeComber at Dundee University invent the amorphous silicon thin-film field transistor switch used in LCDs in TVs and other devices
	The Laserdisc an optical disc data recording format is created in the USA, a predecessor of the Digital Versatile Disc (DVD)
	Intel introduce the first 16 bit MICROPROCESSOR
	<b>1980-1989</b>
<b>1980</b>	Sony and Phillips engineers develop the audio compact disc (CD) . Later developments include a CD-ROM created for computer memory storage
<b>1981</b>	Arthur Schawlow receives share of Nobel Prize for his work on LASER spectroscopy
<b>1982</b>	First pre-recorded audio CDs come on the market
<b>1983</b>	First commercial video cameras using CCD produced by Sony

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Date	Event
	The PENTIUM family of MICROPROCESSORS is released by Intel
	<b>1990-1999</b>
<b>1990</b>	British chip design company ARM (Advanced RISC Machines) founded as a joint venture between Apple Computers, Acorn Computers and VLSI (very large scale integration) Technology
<b>1996</b>	Blank DVDs (digital video or versatile discs) for video or data recording available
<b>1998</b>	Sony develop the Flash Drive memory stick for digital cameras and mobile phones based on the MOSFET with floating gate
<b>1999</b>	SanDisc, Panasonic and Toshiba develop the secure digital (SD) memory card, to compete with Sony's Flash Drive
	<b>2000-2009</b>
<b>2000</b>	Jack Kirby awarded Nobel Prize in physics for invention of the integrated circuit. Speculation that Robert Noyce would have shared award if he had survived.
	The 32 bit Pentium MICROPROCESSOR available from Intel.
<b>2007</b>	Sony introduce an OLED Tv (Organic LED television)
<b>2009</b>	Willard Boyle and Charles Smith jointly awarded half the Nobel Prize for Physics for developing the Charge Coupled Device (CCD). Charles Kao shares the prize for his pioneering work in the 1960s on optical fibres for transmission systems.
	<b>2010-2019</b>
<b>2010</b>	Apple introduce the iPad tablet computer
	Siri – a voice activated virtual personal assistant introduced by Apple
	The AMOLED (active matrix organic LED) is created
<b>2014</b>	Isamu Akasaki, Hiroshi Amano and Shuji Nakamura awarded Nobel Prize in Physics for the invention of the 'blue' LED. Blue LEDs allows production of energy saving white light bulbs in place of inefficient incandescent
	Voice activated personal assistant ALEXA introduced by Amazon
<b>2019</b>	Foldable screen displays for use in mobile phones become available

**For further information see: -**

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