Russell Ohl: The “Forgotten” Bell Labser

Discoverer of the p-n junction
Inventor of the Si “solar cell
First to implant ions into Si

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Russell Ohl: Early years at Bell Labs

Discovery of photo-voltage in p-n junctions: 1939-40

Implantation of Si: 1946-51

Shockley's 1954 implantation patent

After Bell

Russel Ohl: Wikpedia

Russell Shoemaker Ohl (January 1898 - March 1987) was an American engineer who is generally recognized for patenting the modern solar cell (US Patent 2402662, "Light sensitive device"). Ohl was a notable semicnductor researcher prior to the invention of the transistor . He is also known as Russell Shoemaker Ohl or R.S. Ohl.Russell Ohlís specialized area of research was into the behavior of certain types of crystals. He worked on materials research in the 1930ís at Bell Labs Holmdel facility, investigating diode detectors suitable for high-frequency wireless, broadcasting , and radar. His work was only understood by a handful of scientists in the organization, one of whom was Dr. Walter Brattain (one of the trio who invented the germanium bipolar transistor in 1947, and who would be awarded the Nobel Prize for Physics in 1956). Ohl, in 1939, discovered the PN barrier (or as it became known, the p-n junction). At the time hardly anyone knew anything about the impurities within these crystals, but Russell Ohl discovered the mechanism by which it worked. It was the impurities which made some sections more resistant to electrical flow than others, and thus it was the "barrier" between these areas of different purity that made the crystal work. Ohl later found that super-purifying germanium was the key to making repeatable and usable semiconductor material for diodes. All diodes (incl. LEDs, laser diodes etc) are descendants of Ohl's work. His work with diodes led him later to develop the first silicon solar cells.

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Russel Ohl: Early Years

Jan 1989: Born, near Allentown PA

1915: Keystone Normal School
(Penn State)

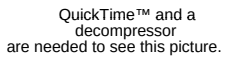
1917: US Army Signal Corps (batteries)

1919: Westinghouse (Vacuum tubes)

1920: U. Colorado (instructor)

1922: ATT:Western Electric (radio)

1927: Bell Labs Clifford, then Homdel



??? **R.S. Ohl**

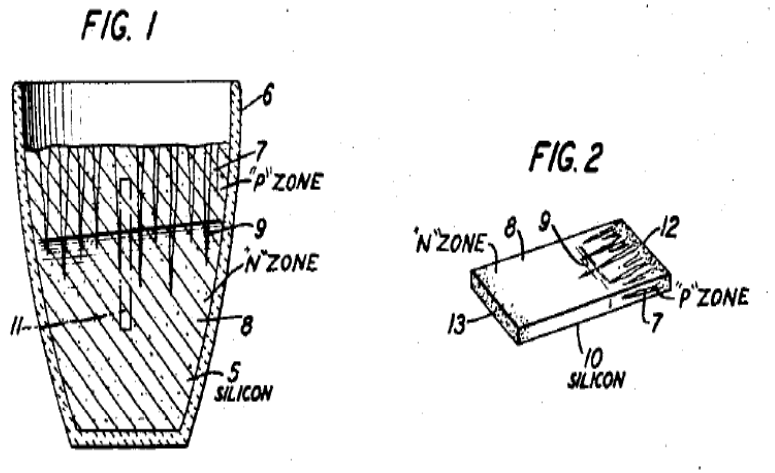
1930's

P-N Junctions and Photovoltage:1940

Light-sensitive Device including Silicon
#2,443,542

Filed: May 27, 1941
Issued: June 15, 1948

QuickTime™ and a
decompressor
are needed to see this picture.



"There was an odor of Phosporous in the air when cutting into n-Si"

Henry Theuerer

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Photovoltage Patent: 1941-48

99% SI IN SILICA CRUCIBLE IN ELECTRIC FURNACE IN VACUUM OR HELIUM ATMOSPHERE

HEAT SLOWLY TO SOME POINT(e.g.1600°C) ABOVE THE FUSION POINT WHICH IS APPROXIMATELY 1400°C

COOL TO PERMIT SOLIDIFICATION AT ABOUT 1410°C AND DOWN TO 1100-1200°C AT 60°C PER MIN

COOL TO ROOM TEMPERATURE AT 120-130°C PER MINUTE

CUT FROM INGOT A SLAB CONTAINING COLUMNAR AND NON COLUMNAR ZONES WITH AN INTERVENING BARRIER BISECTING THE SLAB

GRIND TWO SURFACES OF SLAB PARALLEL TO THE BARRIER USING 600 MESH DIAMOND WHEEL & WATER LUBRICANT

ETCH THE SURFACES IN HOT SODIUM HYDROXIDE

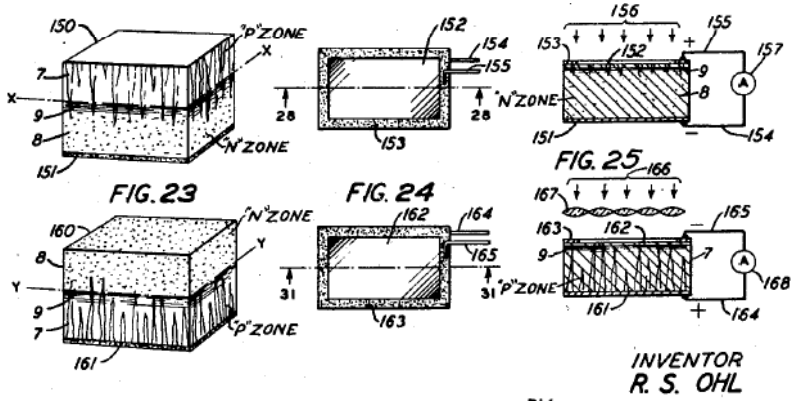
WASH SURFACES WITH DISTILLED WATER

ELECTROPLATE SURFACES PARALLEL TO BARRIER WITH RHODIUM FROM A HOT SOLUTION OF RHODIUM TRIPHOSPHATE SLIGHTLY ACIDIFIED WITH PHOSPHORIC ACID OR SULPHURIC ACID

WASH AND DRY THE RHODIUM PLATING

TIN RHODIUM PLATING (AT LOW TEMPERATURE) WITH ORDINARY LEAD TIN SOLDER USING AN ACIDIFIED ZINC CHLORIDE FLUX

PLACE "TINNED" ELECTRIC TERMINAL ELEMENTS WITH FLAT SURFACES IN CONTACT WITH TINNED RHODIUM SURFACES AND HEAT JOINT UNTIL SOLDER FLOWS



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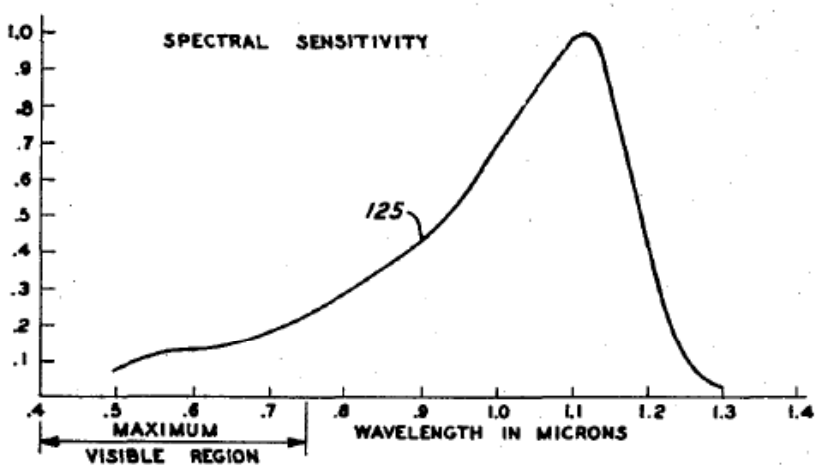
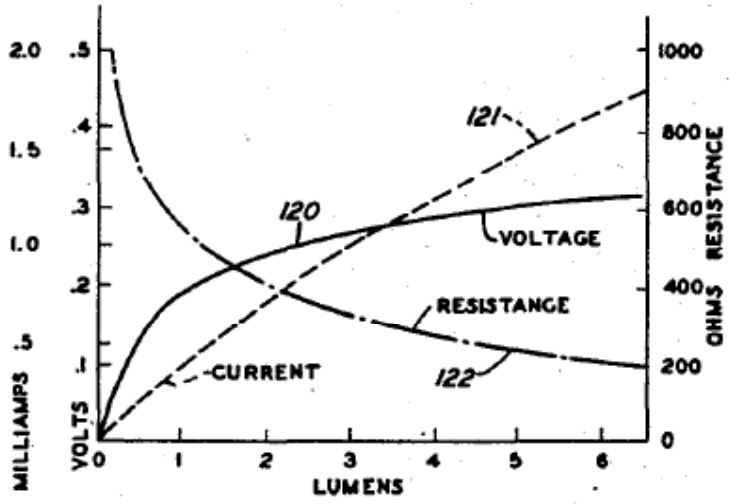
Photovoltage Patent: 1941-46





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After WWII: Ion implantation

After the war a new era opened up. I went over to the Roberts House and then I started research again. I was kind of free then. I started doing some work that I had heard Henry Thera had done. He had made a surface of silicon photoactive by heating it to a thousand degrees in a closed container, in a quartz container in the presence of phosphorous. He got photo activity. Well, I tried with only red phosphorous and I didn't get any activity. I said maybe the answer to this was to seek out and find some way of getting that phosphorous into the surface, pushing it with an electric field. So, I started building up an apparatus. I had quite a complicated apparatus and I was able to make phosphorous vapor and put 800 volts on it and drive it into the surface of the silicon. And lo and behold I made a darn good photocell and darn good transistor cells.

R.S. Ohl

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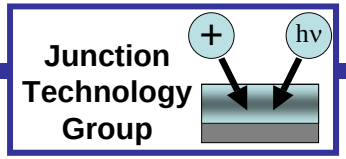


Ion Implantation into Silicon: 1948-52

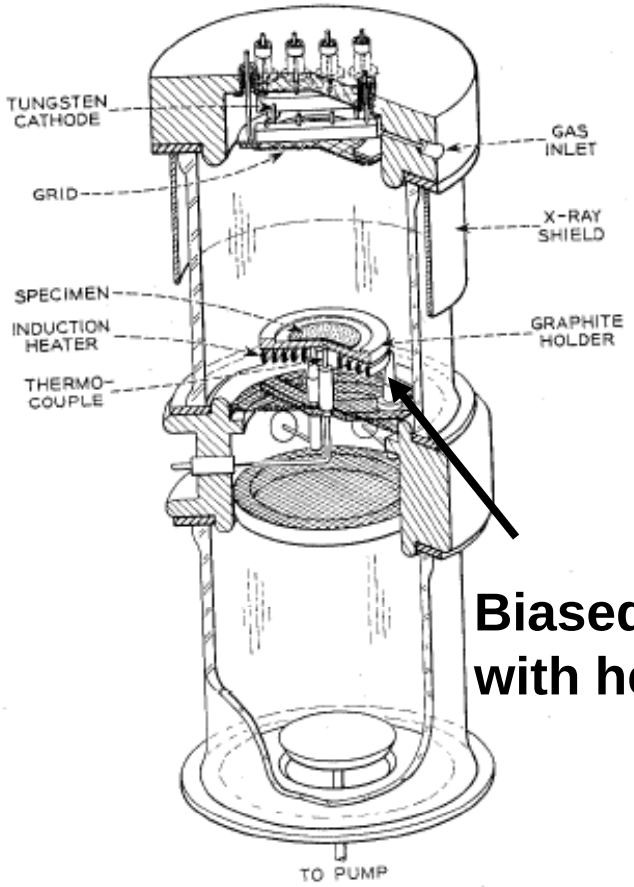


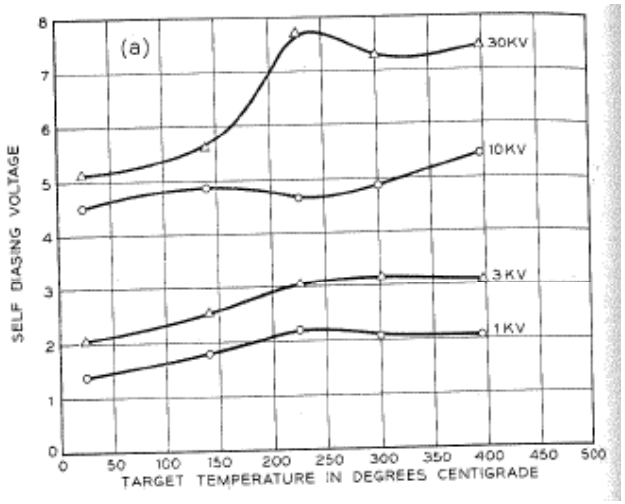
Fig. 1—Bombardment apparatus.

Biased target with heater.

Properties of Ionic Bombarded Silicon

Bell Technical Journal
Vol 31,Jan 1952, 104-121.

Submitted Aug 23, 1951



H, He, N, Ar
20 to 400 C
0.1 to 30 kV

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Implant Suff is Heavy.

It was 1946-1947, somewhere in there. One day Kelly was there, and he liked this work. He liked to see that work. I said, "You know the thing that bothers me is that this stuff is heavy; this weighs a lot." I said, "This building is old. Right below me is an old friend, and if this thing falls down, it is going to kill him. Kelly didn't say anything. The next thing was, I had orders to move down in the basement.

They tore all the machinery out of the basement and rigged it up in real fine shape. Nice floor and everything; I had a good laboratory down there. Then we began by doing the bombarding work. I built heavy apparatus. Then I found all this stuff. I bombarded with helium, nitrogen, phosphorous, and all kinds of things. I finally discovered it wasn't the material that was really inducing the effect. It was the fact that you were hitting the surface with something and doing something to the boron that was in there. It would knock it out of the crystal structure. Once it was out of the crystal structure, it would not contribute to the conductivity. Once you could do that, then you made a thin layer there, you see. You had a thin layer of high purity silicon.

Then you get the current going through this high resistance layer and it flows through that easily. When you change the polarity it soon takes electrons out of that layer and you get a high resistance. Then you don't get any more current from the base until your field gets up high enough to draw the whole emission right out of the base.

R.S. Ohl

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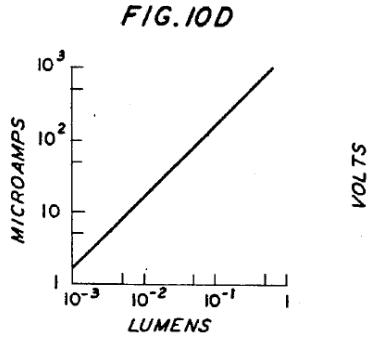
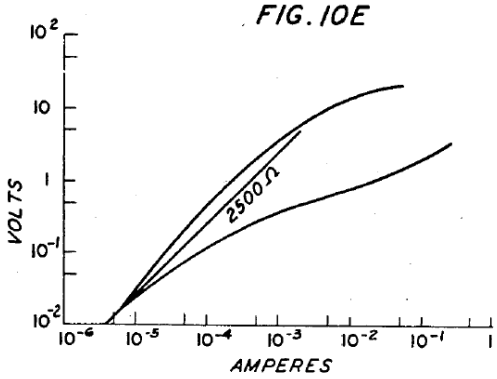
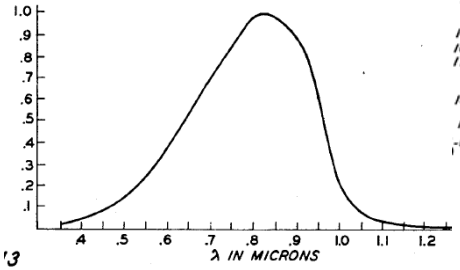
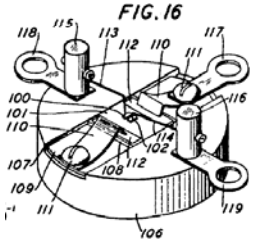
Ohl's Patent: 1950-56

Semiconducting Translating Device
#2,750,541
Filed Jan 31, 1950
Issued: June 12, 1956

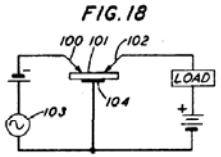


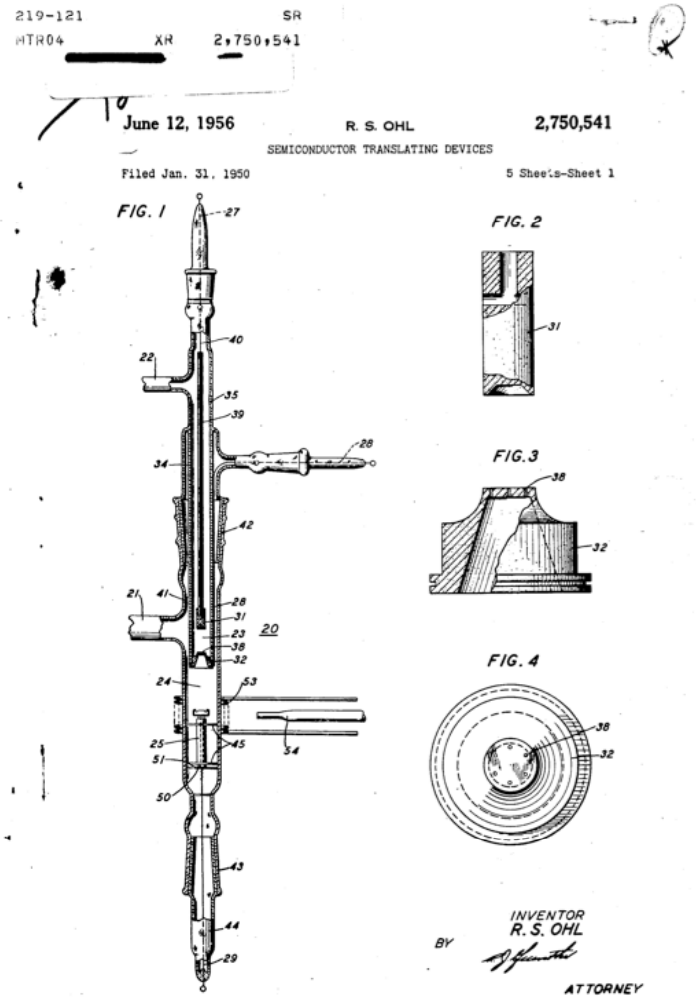






INVENTOR
R. S. OHL





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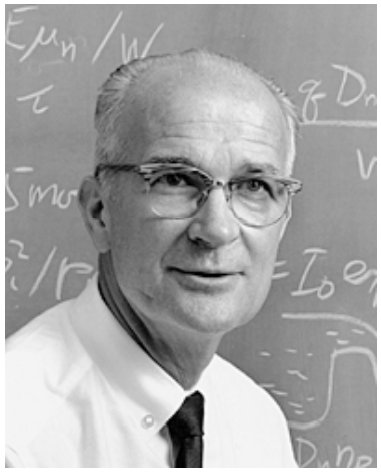
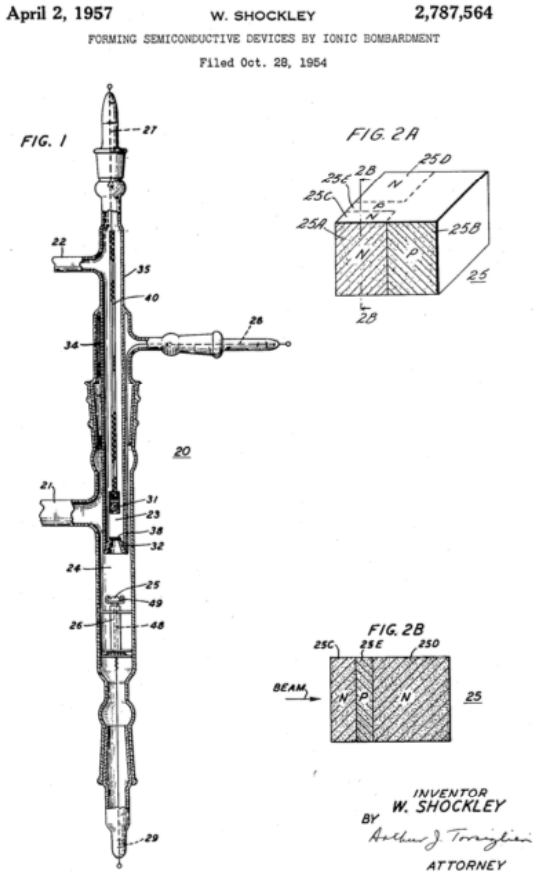
Shockley's Patent: 1954-57

Forming Semiconductive Devices
by Ionic Bombardment
2,787,564

Filed: Oct 28, 1954
Issued: April 2, 1957



Doping with BF_3, etc
Energy effects
Damage
Annealing
Ion-beam masking



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Russell Ohl: Later Years

1955: Elected a Fellow of Instit. of Radio Engineers (IEEE)

1958: Retired from Bell Labs at 60 and move to CA

1970-80s: Research into resistivity response of plants, crystal growth, etc.

March, 1987: Died in Cambria, CA

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Russell S. Ohl: 1898-1987

The one who discovered p-n junctions and photo-voltage effects and pioneered implantation of ions into Silicon.

QuickTime™ and a
decompressor
are needed to see this picture.

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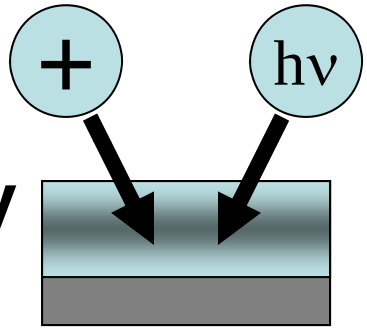

Our kind of guy.