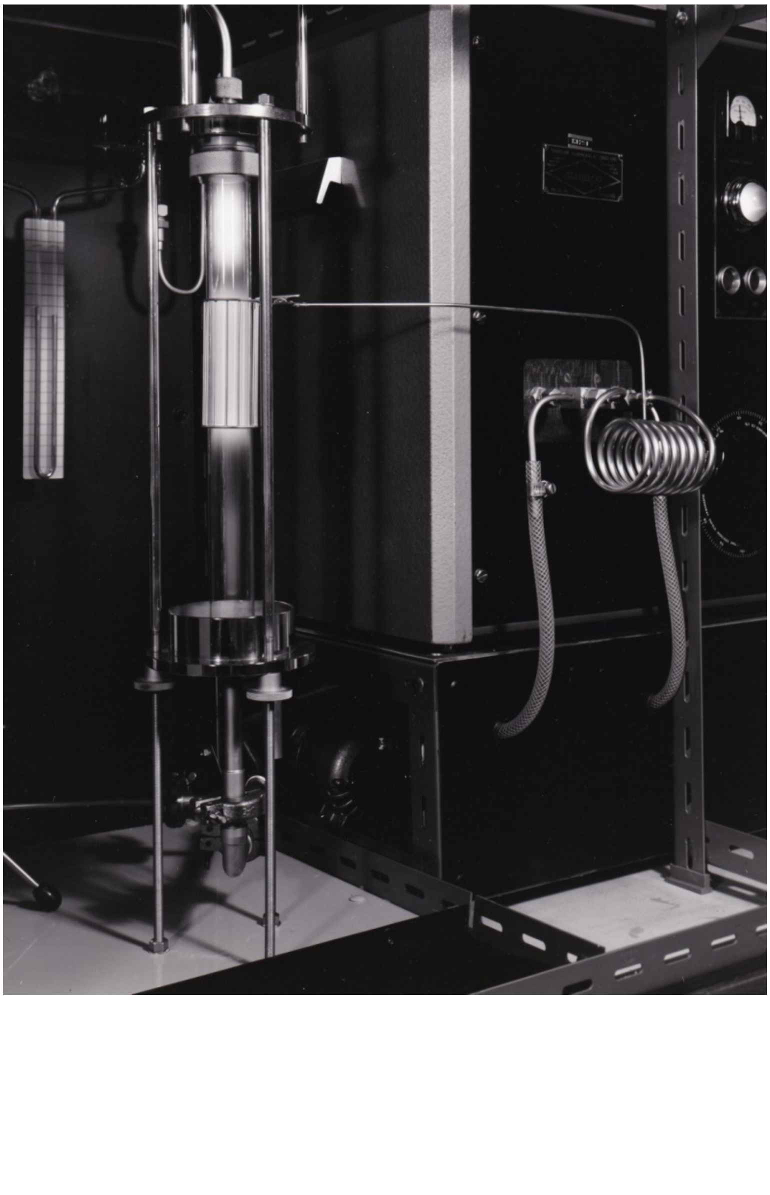
PLASMA PROCESSING DEVELOPMENTS AT STL

A PLASMA IS GENERATED BY APPLYING RADIO FREQUENCY TO A GAS AT LOW PRESSURE, SO FORMING HIGHLY REACTIVE CHEMICAL SPECIES WHICH CAN BE USED TO DEPOSIT OR ETCH MATERIALS

VAPOUR DEPOSITION USING CONTINUOUS PLASMA

- In the 1950s at STL Enfield, **JM Wilson's team** was making high purity silicon by thermally decomposing silane (SiH_4) using RF heating <*see display on Single Crystals*>. In non-heated parts of the apparatus, where there was an unwanted glow discharge, they found deposits of non-crystalline silicon with a very high resistivity.
- In the 1960s, **Henley Sterling, Dick Swann, John Alexander, Bob Joyce, Sadie Hughes** and **Rab Chittick** developed the plasma (glow discharge) process to deposit amorphous silicon, silicon, silicon oxide and silicon nitride.
- By choosing the appropriate gaseous compounds, n- and p-doped silicon, silicon oxide and silicon nitride were deposited epitaxially onto single crystal silicon substrates.
- **The deposition of silicon oxide and nitride on silicon was exploited in the semiconductor industry to deposit insulating layers and to passivate (protect) silicon devices from the environment**.



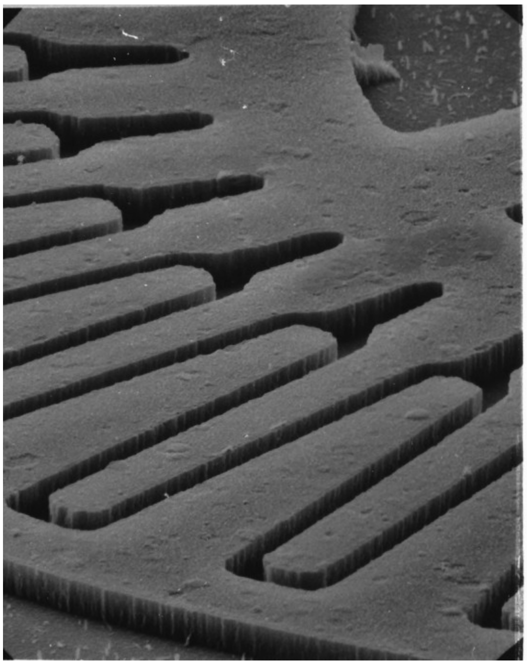
VAPOUR DEPOSITION USING PULSED PLASMA

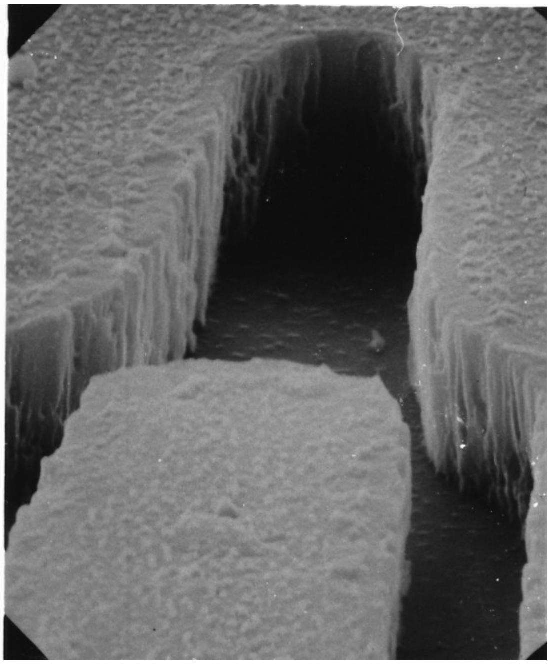
- In the early 1980s, **Rudolf Heinecke** and **Suresh Ojha** developed the pulsed plasma process whereby a 50kW pulse of RF power applied over a microsecond completely dissociates a gas and allows reactions to take place at room temperature.
- The process was subsequently developed by **Ian Llewellyn, Geoff Scarsbrook, Keith Sheach** and **Rab Chittick** to deposit thin films of compounds and layered structures such as:
- aluminium
- silicon nitride
- germanium for infrared missile windows
- germanium phosphide-sulphide,
- silicon oxide-germanium selenide
- silicon oxide-silicon nitride multilayers for rugate filters
- lead zirconate titanate (PZT) and lanthanate form (PLZT)
- diamond.
- The pulsed RF with pulsed gas injection equipment was designed and built by **Ian Llewellyn** and co-workers together with **Peter Swann** of the STL Model Shop.
- The work was funded by RSRE Malvern, USA Office of Naval Research and the USA Star Wars Initiative (SDI) because the uniqueness of the pulsed plasma process enabled novel structures to be deposited using materials normally unstable or difficult to handle, and onto thermally sensitive substrates such as plastics.

PLASMA ETCHING

ETCHING OF SEMICONDUCTOR MATERIALS

In the mid 1970s, **Rudolf Heinecke** developed a process for the precise etching of aluminium using a glow discharge RF plasma. He was able to show that channels **1 micron wide** and **2 microns deep** could be etched in the aluminium metallization of a microwave transistor. The then currently used wet etching of aluminium metallization on a semiconductor was unable to achieve this precision and geometry.



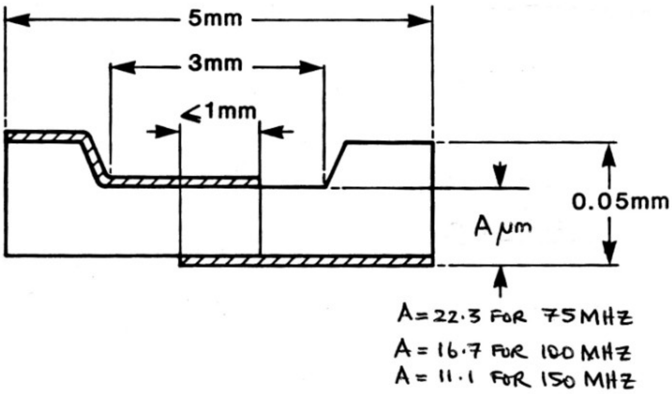


The process was licensed to Electrotech Ltd and is a standard method in the semiconductor industry.

ETCHING OF QUARTZ RESONATORS

In the 1980s the industry standard of making quartz resonators was the mechanical lapping to thickness while monitoring the frequency of the blank. As frequencies rose into the megahertz, the thickness of the blank became very thin and could not be assembled into a device because of its fragility.

David Carter and **Rudolf Heinecke** proposed to plasma etch the central region of a **0.05 mm** thick quartz blank down to **16.7 microns** in order to make a **100MHz resonator**. Trials showed this was feasible and a preproduction equipment was constructed in conjunction with RFA Ltd. A multi-aperture silicon mask to define the area of selective etching was produced by the STL Silicon Microengineering Group. Continuous monitoring of the frequency of the etched region was achieved with circuitry developed by **Roger Williamson** and **Tony Truelove**.



Device structure

Pete Graves, August 2014