Then and Now
GaAs Devices and Integrated Circuits
Time Division Duplex

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Early semiconductor research at STL

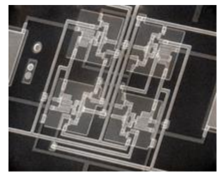
- GaAs (Gallium Arsenide) research begins in the 60s
- New compound semiconductor able to generate and amplify power at microwave frequencies
- Driven by military applications
- Gunn devices or diodes, also known as Transferred Electron Devices (TEDs).
- BUT diodes with inherent limitations of two terminal devices.
- By mid-70s, GaAs transistors are being developed – *MESFETs**
- Transistors, being three terminal planar devices, opened up the prospect of monolithic integrated circuits at microwave frequencies.
- Very exciting times in the semiconductor industry

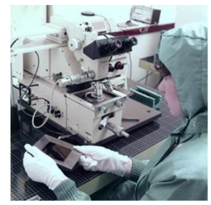
*MEtal Semiconductor Field Effect Transistors

STL started GaAs (Gallium Arsenide) research in the 60s, it was a promising new compound semiconductor able to generate and amplify power at microwave frequencies due to its higher electron mobility than Silicon. Much of the work was sponsored by MoD driven by military applications. The devices were known as Gunn devices or diodes, also known as Transferred Electron Devices (TEDs).
Attractive as these devices were, they were diodes with inherent limitations of two terminal devices. By mid-70s STL moved its work to GaAs MESFETs (MEtal Semiconductor Field Effect Transistors). Transistors, being three terminal planar devices, opened up the prospect of monolithic integrated circuits at microwave frequencies. It was very exciting times in the semiconductor industry

GaAs technologies developed

- Many new technologies and techniques needed:
  - Non-conducting GaAs substrates
  - Ion implantation replacing epitaxial growth for better layer uniformity
  - Fine line lithography and precision mask alignment
  - Dry processing, a very novel technology at the time
  - Moving from handcrafted devices to batch-like wafer processing
- Technology transferred to ITT Roanoke in the early-80s
- Work stopped in Harlow in the late-80s after STC Paignton dropped their GaAs business

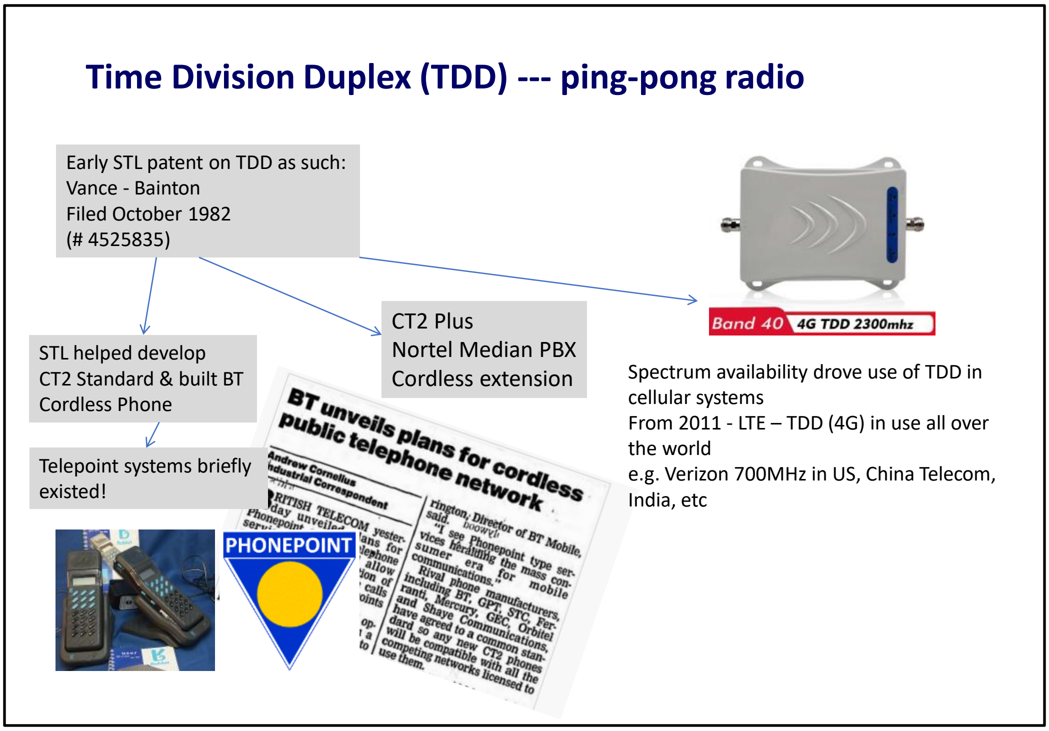




Changing to MESFETs research was challenging, as we had to bring in many new technologies. For example: moving from using conducting GaAs substrates to non-conducting ones; replacing epitaxial growth with ion implantation to achieve the required layer uniformity; introducing fine line lithography and precision mask alignment; dry processing, a very novel technology at the time. Most importantly, moving from handcrafted devices to semiconductor batch-like wafer processing.

We transferred the technology to ITT Roanoke (Gallium Arsenide Technology Center) in the early-80s who went on to become a successful US manufacturer. We then transferred to STC Paignton in the mid-80s. We stopped GaAs work in Harlow in the late-80s after Paignton dropped their GaAs business.

Fast forward some 30 years, GaAs become ubiquitous in military and communication systems, and in the consumer areas which we use daily, such as TVs, smartphones, WiFi, satellite broadcasting. They became so common that they are just chip sets with part numbers, rarely or never identified as GaAs. GaAs and its derivatives are also one of enabling technologies for the new 5G operating in the millimetre waves bands.



Time Division Duplex – invented at STL!

Traditionally duplex radio systems used FDD (Frequency Division Duplex) to allow 2-way simultaneous traffic with a separate spectrum band for each direction. However that requires matched blocks of spectrum with the right spacing and as demand grew in the 1980's we wanted to find a way to use other blocks of frequencies that did not have matching spectrum

The STL Radio Lab had been working on several ideas to allow transmit and receive in the same channel but the analogue versions of this only performed in very special settings. Silicon technology was advancing enough to allow us to think about digitising speech and this opened up the possibility of compressing the data and sending it in half the time with the return speech coming back in between in a ping-pong system.

We patented this (Vance, Bainton) in 1980 and went on to develop the CT2 Cordless Telephone Standard. STC subsequently received a contract from BT to develop a Cordless Telephone based on this principle with the project being done at STL

CT2 was also used in the Telepoint systems which were like a cordless phone box – you could make a call but only in relatively close proximity to a base station. Commercial licences were awarded in the UK – "Rabbit" and "Phonepoint etc – the latter won by a consortium including BT and STC. This eventually proved un-commercial and was overtaken by cellular systems.

When Nortel took over STC we discovered that BNR in Ottawa had further developed the CT2 system to make a mini-cellular version with hand-off between base stations and were selling this in volume as cordless extensions with the very successful Meridian PBX range. We had one installed at STL and it worked well

The desire to use all available spectrum intensified as cellular systems demanded more and more capacity and TDD was incorporated into the 4G LTE Standards. This is widely in use today e.g. in the US with Verizon's 700MHz spectrum and in India and China in the 2.3GHz band

As a footnote – the patent here was used effectively when Motorola took STC to court in the US over sale there of the STC pager. Although unrelated to that product our threat to counter-sue for their use of TDD in other products allowed the case to be settled in our favour