Gunn Diode Oscillator Minutes

David Headland

2003-10-09 14:00

Attendance

- Fourth year students
  - MP Gaskill
  - DP Headland
  - JM Higginbotham
  - RE Irwin [Arrived 14:20]
  - AJ Nelms
  - R Wan
- UMIST staff
  - R Sloan
  - WS Truscott

Swipe cards

The meeting will be temporarily adjourned when Ian Hawkins arrives in order to obtain swipe card access to the lab.

Approval of minutes

The minutes from the last meeting were approved.

Power combining

- A paper on power combining for oscillation circuits was discussed.
- WS Truscott claims the experiment should not have worked, but did not say why.

Risk assessment

- The risk assessment form was approved.
- The form must be signed by all group members.
- The form must be countersigned by a representative of the university.

Non-GaAs materials

- A paper on using InP Gunn diodes was discussed.
- Power combining at 90 GHz was documented.
- InP is considered to be a superior than GaAs material for high power, high frequency applications.
- GaAs is suitable for frequencies up to approximately 60 GHz.
- Second harmonic mode is required for running GaAs Gunn diodes above 60 GHz.
- A paper on GaN Gunn diodes was discussed.
- They would be useful for very high power, high frequency applications.
- So far, only theoretical experiments have been performed.
- Heat production is likely to be far too high for current heat sinking technology.
- Serious research into using InP diodes was suggested.

Injection locking

- An introduction to injection locking was discussed.
- The paper in question referred to IMPATT diodes, but the injection locking technique should apply to any type of diode.

Group identity

- WS Truscott suggested defining a group identity:
  - Team name.
  - Logo.
  - Mascot.
  - WS Truscott suggested adopting a wallaby, after which we'd be able to "make great leaps".

Inspec

- Inspec was mentioned as a good database of papers.
- The following path should be taken to access Inspec:
  1. Go to the library web site
  2. List of databases.
  3. I
  4. Inspec
- An Athens login is required.
- Boolean searches can be performed.
- Full references are provided, but you must find the material yourself from the reference.
- This is the recommended way of searching academic papers.

Holzman book

- R Sloan does not suggest this book at an in-depth reference.
- It has been suggested as a good introduction.
- It is suggested as a good reference for injection locking.
- J Carroll was suggested by WS Truscott as a good book on oscillators.

Web site

- R Wan was created web site graphics and HTML.
- The HTML is not standards compliant, but looks good.
- The HTML can be sanitised and used as a template for content on the web site.

Planar power combining

- A paper on planar power combining was discussed.
- The idea was praised, but the radiation pattern was considered very bad.
- The preferable method is for manufacture in a coplanar circuit to drive schottkySchottky diodes.
- Quasi-optical methods were mentioned.

Swipe card access

The meeting was temporarily adjourned to get gain swipe card access to the lab.

Heat sinking

- A paper on second harmonic mode IMPATT diode operation was discussed.
- These operate in pulsed rather than continuous wave mode.
- Pulsed operation at target power levels would fry Schottky diodes.
- Heat is again the main problem, and must be sunk quickly.
- e2v may be able to provide custom packaging of Gunn diodes if appropriate documentary reasoning can be provided.
- Ceramic discs can be used with multiple devices mounted on top.
- Discs can be made down to approximately 125 μm thick.
- Sever good heat sink materials were discussed:
  - Copper.
  - Single crystal diamond.
  - Ceramics.
- It was suggested that we could enquire of e2v Technologies what substrates are available for their devices and what the heat dissipation properties of them are.
- Device dimensions are small, down to approximately $10\times10\,\mu$m.
- This is a very small area for lots of power to be dissipated in.
- The metal on the substrate is important in how well the heat will be spread sideways.

Diode similarity

- The issue of whether all Gunn diodes would be the same was considered.
- Vertical structure will probably be the same for all devices from the same wafer.
- Etching may produce diodes with slightly differing areas.

- As the area increases, the current and capacitance increases and the inductance decreases.
- The actual reproducibility is unknown.
- This point could be raised with e2v technologies.
- Differences in the devices must be account for in the theory and simulations.

Simulations

- Simulations will be required at some point.
- Everyone should know how to use the simulation packages.
- ADS or microwave office were suggested.
- Gunn diodes can be treated as AC point sources.
- We must try to combine four whilst maintaining in-phase operation.
- They can be placed in a planar circuit and simulated.
- R Sloan will give a grounding in how to use the simulation software.
- This could be used at an interview as an example of leaning to use an engineering software package.

Circuit simplification

- Most components in the circuit will be linear.
- Gunn diodes and non-linear.
- The impedance of the circuit apart from the Gunn diode can be calculated.
- If the diode is then placed in the equivalent circuit, it should operate in the same manner.
- Power will be radiated in all directions.

- Mirrors at the end of the wave guides must reflect the waves in phase.
- Devices are spaced at a distance of approximately $\frac{1}{2}\lambda$.
- The diodes will have a capacitance, so tuning of the positions may be required.
- They will find their own oscillation frequency if placed at a distance of approximately $\frac{1}{2}\lambda$ from each other.

Device limitations

- It is suggested that the first circuit is designed to output at 20 GHz.
- InP devices should be capable of operation up to 200 GHz.

Time planning

- A timescale must be drawn up.
- Tasks must be defined and split up into components.
- Based on the finishing date, tasks be be placed backwards to find the required start date.
- The critical path can then be found.
- Realistic deadlines must be imposed.
- It is likely that the design must be fixed by the December interim presentation.

Mental manipulation

- On seeing the worried looks of the students, R Sloan and WS Truscott decided that "we should sit here for a further ten minutes and really twist the knife".

Impedance matching

- Sometimes a device will radiate 1 W, but with unusual voltage and current requirements.
- Most impedances realisable will be in the range of 50–100 Ω.
- As an example, to radiate 1 W, 10 A may be required at 10 V.
- Knowledge of the device impedance is therefore required.
- Maximum power is obtained when the impedance of the source and load are equal.

Mounting configuration

- All companies will provide guidelines for mounting
  - From a thermal point of view
  - To provide information when deciding upon combination topologies

Team building exercise

- We should challenge the other teams to something we're good at.
- This will build confidence and trust.

Waveguide power combining

- We may wish to find papers for power combining using waveguides (already completed).
- Waveguides may be used if time is short because of their natural heat sinking advantages.
- A deliverable could be a working waveguide power combining circuit, along with a design that was not meant to be fabricated for a planar version.

Information storage

- Certain items will be kept in our lab space:
  - Financial records book.
  - Borrowing log.
  - Research hard copies.
  - Minutes and agendas.

Proposed actions

All	Any further relevant research.
R Sloan	Copy operation notes on Gunn diodes for distribution.
All	Provide suggestions for a group name, logo and mascot.
All	Provide suggestions for tasks involved and how to split them up, along with times associated with each task. This can be arranged into a draft time plan next meeting.
Sloan, Truscott	Try to find a model of a Gunn diode for ADS.
R Wan	Provide HTML and graphics.
DP Headland	Sanitise the HTML and build into the PHP wrapper to form a new template.
All	Gain Athens access from the Library for Inspec.
All	Provide a hard copy of all useful information found to be filed in the lab.
DP Headland	Package the Win32 version of LyX and dependencies for those who require it.
All	Investigate LyX for Win32 as a typesetting environment.

Next meeting

Time Tuesday, 14 October, 09:00

Place D-floor coffee room

Meeting adjourned, 16:10.