

GOLF A meeting is to be held in the R&I Conference Room, Tuesday 4 April 1978, at 1300 hours, to see if there is enough interest in the Laboratory to form a golfing section within the framework of the Laboratory Recreational Society. All those interested are invited to attend.

CHRISTIAN FELLOWSHIP Friday 17 March - All are welcome to come along to the Lecture Theatre at 1240 to hear the second part of the soundtrack of the film, 'Gospel Road'. This is an easy to listen to recording featuring Johnny Cash who both sings and comments on the life of Christ.

This year, as a follow up to the annual Laboratory Carol Service, a Good Friday/Easter Day interdenominational service will be held in the Lecture Theatre at 1240 on Wednesday 22 March. The service will include well known hymns accompanied by an electronic organ and will be led by the Rev Norman Russell, Vicar of Harwell. The service will last for approximately 35 minutes and all members of staff are very warmly invited to come along.

On Friday 31 March, it is hoped that an ex member of staff, John Matthews, will be leading the meeting and all are welcome to come along at 1230, R2 Conference Room.

RUTHERFORD

Bulletin

5

13 March - 4 April 1978

Microelectronics at Rutherford

Council has approved the expenditure of £1.35M for the establishment of semi-conductor device fabrication facilities at several universities, and a precision mask-making facility at the Rutherford Laboratory.

Masks are essential to define the very fine, complex patterns required in the manufacture of microelectronic circuits. The masks to be produced by the Rutherford Facility and used by the solid-state devices research community in universities and polytechnics in the United Kingdom, will use a computer-controlled electron-beam pattern generating machine to be manufactured by the Cambridge Instrument Company.

In the next issue of the Bulletin we hope to carry an article on electron-beam lithography by Ron Lawes, the project leader for the Rutherford Facility.

In this introductory article an attempt is made to set the scene on the world of microelectronics. Interested readers who wish to delve more deeply into the subject should consult the September edition of Scientific America.

A 19th century beginning

The last decade has produced a revolution in electronics technology and to understand what has happened it is necessary to go back 30 years to the development of the transistor, an electronic amplifying device utilising the properties of single-crystal semiconductors. However, semiconductors had been in use since 1889 when Heinrich Hertz used them in the original detection of radio waves.

During the next 50 years these two 'electrode' devices were to be increasingly used, in the early radio receivers (Woolworths in the 20's sold an excellent crystal detector for 6 (old) pence) and power rectifiers. The development of the transistor has rendered the large, power hungry vacuum tube largely obsolete although still used in high-power situations.

As the transistor improved, becoming smaller, more reliable and cheaper, the rapidly developing computing industry provided a large potential market although it was the various space and missile programmes with their demand for complex electronic systems in which size, weight and power requirements were of paramount importance which produced, largely unsuccessfully, attempts to miniaturise conventional components. Nevertheless the demand was there and the ultimate solution was the integrated circuit, normally referred to as an IC.

In a microelectronic device, all the components of the circuit must be fabricated in a crystal of silicon or on the surface of the crystal. Silicon is used, and although not ideal as only modest values of resistance and capacitance can be achieved and insulators not at all, it is without equal for the fabrication of transistors which are found in large numbers in a modern IC. However, clever circuitry and the fact that a modern chip can contain hundreds of transistors (which incidentally come in a great variety of forms) has, to a large extent, overcome these problems. In addition, the vast majority of IC applications, transistors are used as simple switching devices - on or off - and in this mode they require few auxiliary devices.

Extraordinary growth rate

The concept of building complex circuits in semiconductor material itself began within a few years of the introduction of the transistor being extended and devel-

oped until by 1969-70 the birth of the modern IC was conceived. Progress since that date has been astonishing, the number of components and complexity doubling each year with a decline in cost of over 100 during the past 10 years. A modern IC chip, less than 1" x 1" can carry in excess of 100,000 components and the technology is still far from the fundamental limits imposed by the laws of physics. There are however limits imposed by manufacturing techniques and this is where EBL opens up new avenues.

As an introduction to the pattern definition or lithography problem, the following brief description indicates the steps using present day optical techniques.

Manufacture starts with the growth of a single crystal ingot of 'doped' silicon typically several feet long which after grinding into a cylinder 3-4 inches in diameter, is sliced into wafers, polished on one surface (to a high degree) on which is then formed a thin layer of silicon dioxide - an excellent insulator. The circuit design, stored in a computer memory, contains a complete list of the exact position of every element and connection in the circuit. From this, a set of plates called photomasks are prepared, each mask holding the pattern for a single layer of the circuit. Taking as an example the most basic masking step, the oxidised layer is coated with photoresist and dried. The first mask is positioned on the wafer and exposed to UV light. The exposure renders the resist insoluble in a developer solution hence a pattern of the photoresist is left wherever the mask is opaque. A solution of acid selectively attacks the silicon dioxide transferring the pattern into silicon dioxide form and leaving the resist and silicon substrate unaffected. The silicon substrate can then be doped selectively with suitable impurities of phosphorus, boron, arsenic through the windows left in the silicon dioxide. This is usually done by controlled diffusion of the doping material into the silicon but a new technique called ion implantation enables more accurate doping to be performed. By using this technique and a large number of different masks, a complex integrated circuit can be built up in a three dimensional form.

The limit to this optical lithography process is the wavelength of light, just as it is in the optical microscope. The answer to many of these problems is to use an electron beam whose wavelength is less than 1μ as is done in electron microscopy. Lines up to 20 times narrower than the optical limit can be generated, although in practice scattering of electrons in the resist coating imposes some limitations.

Through the looking glass

What then does the future hold and how will it affect our lives? Nowadays anyone can purchase a small calculator every bit as powerful as the old and very large MERCURY computer installed at Harwell in the 50's which incidentally consumed approximately 25kw of power; not surprising as MERCURY used 2160 valves! But the enormous reduction in size and cost, microprocessors are increasingly being used in a great variety of fields. Gadgets in the home, factory, in industry, in medicine, the medical field, the list is immense.

Just as the personal book was made possible by the industrial revolution, so it is prophesied, will the personal computer of the 80's provide access to vast amounts of information. This leaves unanswered the question as to whether this revolution will fulfil the predictions now being made.

How many people make use of our existing libraries?

RUTHERFORD LABORATORY BULLETIN

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Deadline for
insertions

1000 hours Tuesday, 28 March

INTERNAL EVENTS

NIMROD LECTURE SERIES
Monday 13 March
1130
Lecture

What is (Un-)Known About the τ ?

Dr G Enkes/DSEY

COMPUTING SEMINAR
Tuesday 14 March
1400
R&I Conference Room

Data Acquisition for the Spallation Neutron Source
Dr J B Forsyth/Neutron Beam Research Unit

HEP SEMINAR
Wednesday 15 March
1100
R&I Conference Room

An Amplitude Analysis of the Reaction $\pi^+ d \rightarrow \pi^+ \pi^+ \pi^- p$
G Wapstra/Durham

SAFETY FILM SHOW
Wednesday 15 March
1230 and 1315
Lecture Theatre

'On The Safe Side' - a 20 minute colour film, sponsored by the UKAEA, dealing with hazards encountered in high voltage research laboratories. After an introduction covering the nature of electric shock, standard safety precautions used in fixed installations are shown. The film then deals with the additional hazards met in high voltage research areas where experiments require frequent change of equipment. Of interest to high voltage research workers at all levels.

NIMROD LECTURE SERIES
Monday 20 March
1530 (NOTE TIME)
Lecture Theatre

μSR Spectroscopy: the Muon as a Probe of Condensed Matter

D Fleming/SIN & TRIUMF

The use of muons for studies in solid state physics and chemistry is a field which has grown very rapidly over the last few years and there are now over 1000 published papers on various aspects. The topic is of considerable interest to UK scientists since the Spallation Neutron Source (SNS) could in principle be used to provide suitable muon beams. In his lecture Dr Fleming (who has worked on these experiments at both SIN and TRIUMF) will give an introduction to this topic of μSR spectroscopy and will give examples from experiments carried out at SIN and TRIUMF showing its relevance to atomic and solid state physics and to the study of isotope effects in chemical kinetics.

COMPUTING SEMINAR
Tuesday 21 March
1400
R27 Colloquium

Development of the GEC 4080 as a Data Editing Facility

Dr C S Cooper/C & A Division

HEP SEMINAR
Wednesday 22 March
1100
R&I Conference Room

Title and speaker to be notified

HEP SEMINAR
Wednesday 29 March
1100
R&I Conference Room

Spontaneous Breakdown of Supersymmetries

P Nigam/Edinburgh

EXTERNAL EVENTS

ELEMT PART PHYSICS SEMINAR/NP DEPT, OXF - 1400 hrs
14 Mar: Prof J D Bjorken/SLAC - Neutral currents without gauge theories.

THEORY GROUP SEMINARS/DARESBURY LABORATORY - 1400 hrs
13 Mar: Dr J C Inkson/Cavendish - Bonds, bands and excitations in semiconductors.

20 Mar: Dr B Kramer/Essen - Compton profiles and the electronic ground state of profiles.

THEORY PHYS SEMINAR/CONF RM, BLDG 8.9, AERE - 1400 hrs
21 Mar: Dr M Tucker/CGB - The grain boundary porosity in UO_2 during gas release.

THEOR PHYS SEMINAR/HANBURG - 1430 hrs
15 Mar: Prof G Kramer/Hamburg - Problems with an orthodox model of the new particles.

THEOR & HEP SEMINAR/SOUTHAMPTON - 1430 hrs
17 Mar: Dr J Leveille/IC - Charm production in QCD.

OBITUARY NOTICE

We regret to announce the death of Mrs M E Turner on Sunday, 12 March, after a long illness. She was aged 44. Mary Turner joined the Rutherford Laboratory in March 1968 as a part-time scanner and continued to work in the field of data-processing until she became ill. Mary will be sadly missed by her friends and colleagues. Our deepest sympathy is extended to her husband and two daughters.

CHANGE OF ADDRESS

The Department of Theoretical Physics, Oxford University, has moved from 12 Parks Road. Correspondence should be addressed to: Department of Theoretical Physics, Oxford University, 1 Keble Road, OXFORD, OX1 3NP. Would all who correspond with the Department please amend their records.

FSSU

This is to give notice to members of staff who have, or have had previous FSSU policies, that the chance of full back service credit into the PWMS, expires on 31 March 1978. Anyone who thinks they might be eligible should contact Miss A Curran, Ext 495, before that date.

FILM BADGE NOTICE

It is Period 3. Colour strip - RED for β films and neutron packs. Please check that you are wearing the correct dosimeter and that all old ones are returned. Next film issue - Monday 27 March 1978.

MISSING EQUIPMENT

The following note has been received: "Will the person who borrowed my Technicell 20" x 15" draughting machine board kindly return it forthwith, to E G Sandels, Room 306, R2."

OVERSEAS VISITS

Dr R W Newport, to CERN, 15-15 March, to attend European Spectrometer meeting.
Dr J C Thompson, to CERN, 15-17 March, for EMC Group meeting and discussions.
Dr J Carr, to CERN, 15-23 March, to work on EMC experiment.
Mr A R Thorne and Mr G C Adams, to CERN, 13-17 March, to attend Orbital Test Satellite meeting and for discussions on microprocessor systems.
Dr D H Reading, to the USA and Canada, 14-23 March, to attend and give talks at the AAPM Charged Particle Beam Task Group Workshop at Los Alamos and to visit TRIUMF at UBC for discussions.
Dr K Palzer and Dr C Omer, to CERN, 15-17 March, to attend collaboration meeting on K p 70 GeV experiment.
Dr L C W Hobbs, to Grenoble, 15-18 March, to attend ILL Scientific Council meeting.
Dr R C Brown, to the USA, 17 March-29 April; set up and data taking for exotic meson search at SLAC.
Prof F R Hogwood, to Grenoble, 19-20 March, to attend IFIP Satellite Organising Committee meeting.
Dr W Venn, to CERN, 29 March-4 May; experiment W424 run.
Dr A C Ricketts, to CERN, 30 March-8 April; experiment W424 run.
Dr G K Kalous, to CERN, 30 March-17 April and 20 April - 2 May and Dr W Camerer to CERN, 30 March - 2 May; W430 setting up and running experiment.

BULLETIN NOTICE

Owing to the Easter break, this issue covers a period of three weeks. Copy for the next issue should be sent to the Editor as soon as possible and before Easter where-ever possible.

LIBRARY MATERIAL MISSING

A short time ago the library asked people (nicely) not to steal books and periodicals. Over the past fortnight the following missing items have been brought to our attention. This happens when someone needs them and is inconvenient as we have to borrow or buy another copy. Disregarding the cost of replacing expensive books, there is the problem that many journals cannot be replaced. Because most scientific journals are supplied on subscription the publishers do not print many extra copies. WILL STAFF PLEASE SEARCH CONSCIENTIOUSLY AND BOOKSHelves. If we have to take action to stop thefts it will inconvenience the vast majority of blameless readers.

BOOKS

RYDER, L R - Elementary particles and symmetries, 1975 £12.90

SPIEGEL, M - Outline of theory and problems of advanced calculus, 1963 30/- (loan copy)

STUMP, D and WEINGARTON, D - Quark confinement and field theory, 1977 £18.70

PERIODICALS

Nuclear Instruments and Methods vol 140 (1)

Physics Today vol 30 nos 11 and 12, 1977

Physical Review Letters vol 35 (16) 1975. 2 copies

LOST

A small black purse containing about £1 lost between the Restaurant and the East end of R1. It belongs to one of the North Berke College students and anyone finding it should contact the Library.

THE NUMBERS GAME

Mr Paul Burkinshaw and Mr Peter Smith have a problem. Their telephone extension is 307 and people keep ringing them for transport. The TRANSPORT extension is 317 as shown correctly in the current Rutherford directory. It is not so much a finger problem as people with long memories: 307 was a Transport extension - it no longer is, or has been for quite a few years. People with slightly shorter memories will no doubt recall that 307 used to be the extension for the local IPCS Section. Secretary when that office was held by one of the multi-talented Smiths at the Lab, in that case - Mr P F Smith (the 327 one - not 325!). The next time you require transport, remember - 317. Both Paul Burkinshaw and Peter Smith will be most grateful - you see they both work in R27 - on computers!

MESSAGE OF THANKS

Sandra Lawson joined the Lab Staff last September. After spending six months in the typing centre, moved to R1 where for the past sixteen months she has worked as an assistant to the Director's Secretary. Sandra wishes to thank her friends for all the lovely presents she received and is sorry she was not able to see everyone before leaving. We wish her good luck in her new job.