RAL
DESIGN & DISCOVERY
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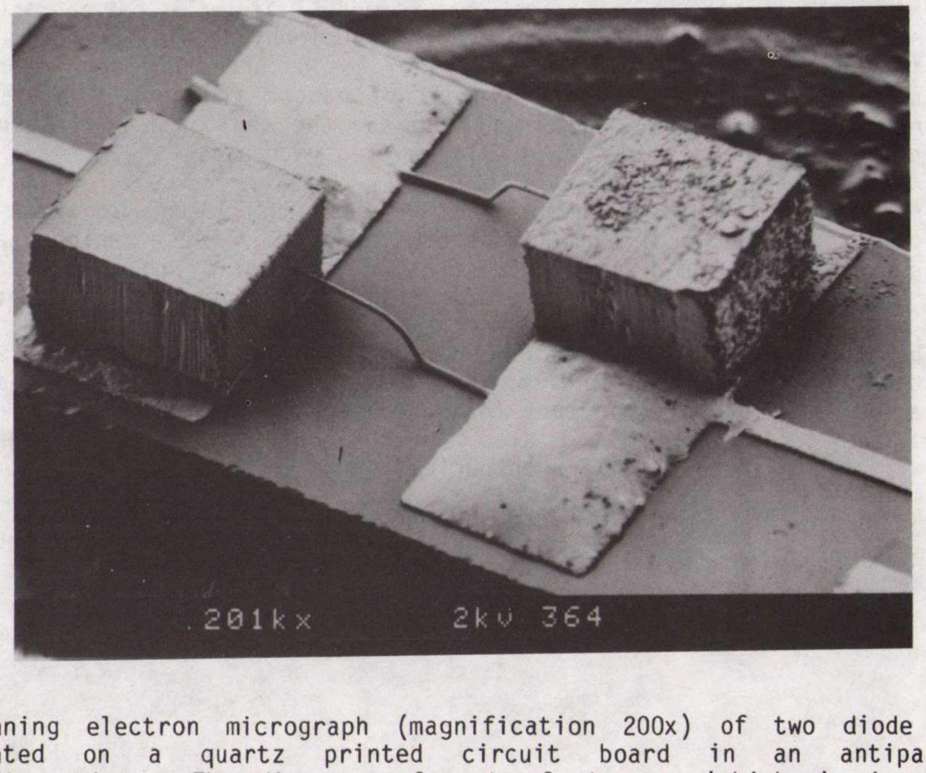
RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

MILLIMETRE TECHNOLOGY

Radio receivers with a better sensitivity than is currently available are now required in the millimetre/submillimetre region of the electromagnetic spectrum, for applications in astronomy and in remote sensing of the atmosphere. The Millimetre Technology Group is concerned with the development of the specialised components which determine the performance of receivers in the frequency range 300-1000 GHz. Because the radiation being detected has a very short wavelength (less than one millimetre), the components need to be correspondingly small and include structures which are often less than a few microns in size. This means that as well as correctly designing and testing novel circuits, it is also necessary to develop suitable manufacturing and assembly techniques for miniature components. RAL is very well equipped to undertake these tasks and has an excellent precision workshop and a comprehensive range of assembly facilities.



Scanning electron micrograph (magnification 200x) of two diode chips mounted on a quartz printed circuit board in an antiparallel configuration. The diameter of each of the two 'whisker' wires is 5 microns. This is six times less than the diameter of a human hair.

THE SCIENCE

The millimetre and submillimetre regions of the spectrum are the last of the wavebands to be opened up for astronomical exploration by ground based telescopes, and some examples of the types of study which are possible with the JCMT are as follows:-

- It is now known that stars form in dense regions of interstellar gas which are opaque to optical radiation. However, at infrared and millimetre wavelengths these regions are transparent and it is possible to investigate the detailed processes going on inside them by observations in these wavebands. Because the dense interstellar clouds are cool and very rich in molecular gases, measurements of the radiation (emitted in the form of molecular lines) allows unique measurements of the temperature, density and motion of star forming regions. In this manner it is hoped that a better understanding can be gained of the processes by which stars form.

- Because of the richness of the molecular line spectra of these regions, it is possible to map out in detail the distribution of different chemical species within molecular clouds. This is one of the most interesting fields for the relatively new discipline of interstellar chemistry. The densities found in interstellar clouds are much lower than those found in terrestrial laboratories and consequently many rare molecular species can survive in the interstellar gas.

- The use of molecular line radiation as a tracer of the abundances of different chemical species in different locations within galaxies is an ideal method of studying the chemical evolution of the material out of which the stars in galaxies are formed. It will be particularly helpful in understanding whether or not nucleosynthesis (the production of heavier elements from lighter ones) has occurred uniformly throughout galaxies, whether or not infall of matter from other galaxies or intergalactic space is important and how the regions around stars are enriched by the products of stellar nucleosynthesis.

- The continuum radiation emitted by the cool dust clouds in which stars form is detectable at submillimetre wavelengths. These regions need to be studied with high angular resolution to identify the regions where the youngest stars and their precursors, the protostars, are forming.

- The nuclei of active galaxies like quasars are strong sources in the submillimetre waveband and the determination of their spectra and time variability is very important for understanding the total energy demand of the active nuclei and also the physical conditions in the most extreme conditions within such nuclei.

For more information, contact: D T Llewellyn Jones
Head of Atmospheric Science Division
(0235) 821900 Ext. 5621