Compound Semiconductor Reliability

Recommendations for space use and for further studies:

Since most of the JPL application for GaAs MMIC and mixer diodes are based on the characteristics of rectifying metal/semiconductor contacts, more is learned in any study which can isolate the simplest components of such device without design complications. These are the ohmic contacts and the Schottky junctions.

GaAs devices fabricated at the JPL micro devices lab use the same type of metallization for ohmic and Schottky contacts. Ohmic contacts are made of Au/Ge/Ni/Ag/Au, and Schottky contacts are Ti/Pt/Au. There have been promising results which use Pd/Ge/Au as ohmic contacts. For Schottky junctions, Al has given very high barrier heights in GaAs, and diffusion of Al into GaAs does not cause deep levels, therefore, these two alternate metallization schemes are proposed for a comparative reliability study.

- Fabrication of presently used and alternate test structures for:
  - Ohmic contacts to GaAs (at least two types of test structures, the transmission line method and the Kelvin cross structure)
  - Schottky or rectifying junctions or contacts to GaAs

Having a good sample set for these test structures will enable many project relevant studies, and in addition provide interesting research findings which would be suitable for presentation at microelectronics conferences and applied physics and electrical engineering journals.

Once these test structures are available, activation energies and acceleration factors can be determined for several type of use and stress conditions. A few examples:

1. current stressing
2. thermal stressing
3. combine current and thermal stressing
4. humid environments

This needs to be done after setting up "failure criteria". In ohmic contacts the definition of failure could be for example, an increase of 50% or more in contact resistance. For a Schottky type junction, increase in leakage current is usually observed upon stressing, and sometimes an increase in the diode ideality factor. Therefore, "failure" can be defined as an increase in leakage current one or two orders of magnitude over the unstress values.

Other interesting/useful studies that are NASA relevant:

Determination of contact resistance at low temperatures (are our standard Au/Ge/Ni/Ag/Au ohmic contacts optimized for devices operating at low temperature? Is there a better or more reliable metallization scheme for ohmic contacts to GaAs?

Evaluation of temperature gradients in device during operation using cathodoluminescence spectroscopy and imaging. Determination of the effects of thermal gradients on device reliability is a logical follow-up. This is important in some applications, for example power multipliers operating at cryogenic temperatures – as in the FIRST/PLANCK mission for example.

A very important issue in microwave devices is the extrapolation of DC electrical characteristics in predicting AC performance. This is a very complex issue, and not easy to answer. Device physicists find that among several "good" devices, which exhibit similar DC electrical characteristics (mainly current vs voltage is used) there is always large variations in the AC performance of the device. Since high frequency testing is more difficult, expensive, and requires special set-ups, finding a way to correlate good high-frequency characteristics with some measurable (DC) parameter would be a major breakthrough in the areas of microelectronics reliability and device characterization.
Suggested possibilities:
Performing DLTS analysis and checking for correlation with trap densities
Performing CV analysis