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GaAs in Space

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Satellites are regularly launched into Earth orbit to provide TV signals, communications services, geographic location services or to scan the planet for geological data. Some are sent to investigate neighboring planets, which just like those on timeless missions into remote corners of our solar system send data about their discoveries back to Earth. Modern satellites include microwave communications equipment for mission control and to communicate data. The use of Microwave frequencies enables high gain antennas to beam the signal back to base where even more powerful ground based antennas reject cosmic noise and background noise generated by the Earth itself.

Gallium Arsenide (GaAs), a III-V compound semiconductor with high electron mobility and saturated electron velocity, is well recognized for its performance advantages at microwave frequencies both in space and in Earth bound applications. In fact, GaAs can be found in many applications including your cellular phone, the base station which connects your phone call, your WiFI link and even fiber optic links.

There is a lot of GaAs in space but why is this spooky stuff loved so much by the space electronics community? What makes it so special? GaAs is a technology exploited by the space industry for its microwave performance, reliability, radiation hardness, cost-effectiveness, integration, longevity and stability.

Performance

GaAs provides low noise figures, high gains and high powers at very high frequencies from processes which are generally quite simple in their structure. Particularly important at higher microwave power levels, Gallium Arsenide's larger band-gap effectively enables the high frequency performance at higher break down voltages than Silicon based technologies operating at the same high frequencies.

Reliability

We all know how important it is that expensive space projects run failure-free through their intended lifetime. Repairs are usually impossible after launch so reliability is paramount in space electronics! Fortunately, features inherent in GaAs technologies enhance its reliability. I will just touch on the technicalities in broad terms here, starting with the wafer material. TriQuint has a vast library of GaAs reliability papers based on many years of testing and gathering data. Visit TriQuint's technical library to learn more.

GaAs is about 1000 times more resistive than silicon which means higher isolation and reduced sensitivity to latch-up modes, surface effects and ionic contamination, which can plague silicon.

According to Arrhenius equation, higher activation energies predict longer median lifetimes. Because the activation energy is much higher in GaAs than it is in Silicon, it is possible to predict 1 billion hours (114,000 years) median lifetime for a GaAs MESFET. Additionally GaAs can operate reliably at 150°C channel temperature, a conservative derating point used for GaAs, which is way above the 110°C maximum specified for space equipment.

Most GaAs MMIC processes use gold metal layers which remove the intermetalic compound problem associated with gold bond wires and aluminium metal layers. Gold metal layers are also less susceptible to corrosion and electromigration.

Radiation hardness
Objects in space are bombarded by high energy radiation from the Solar Wind, the Van Allen belt and other sources. Such radiation can alter the atomic structure of a semiconductor lattice, effectively depleting minority carriers and is especially detrimental to bipolar structures. Producing silicon on a high isolating substrate (SOI - Silicon On Insulator) helps it survive radiation better, but because GaAs is in itself highly insulating and works through majority carrier transfer (majority carriers significantly outnumber minority carriers), it offers inherent radiation hard properties.

Integration
Because the GaAs substrate is such a good insulator, high performing passive microwave components can be integrated monolithically without detrimental substrate coupling effects usually associated with Silicon technologies. This property removes the need for critical off-chip passives and makes RF and microwave circuits very repeatable. Couplers, baluns and transformers are integrated on many GaAs MMICs and sometimes even used as stand alone GaAs based components in mixed technology modules. High performing inductors, capacitors, transformers and resistive elements are included during a MMIC's simulation offering ease-of-design features for space equipment developers.

Cost-effectiveness
The volume demands of typical space projects are quite low. Relative to Silicon, GaAs processes use a small number of mask layers on 100mm or 150mm substrates to provide customers with their full quantity requirements from small, manageable lot sizes. Furthermore, GaAs processes do not need to be very complex to achieve high performance. Reducing complexity keeps cost in check.

For designers of microwave MMICs, Multiproject (shared mask) foundry runs are a cost-effective way to test various designs with very short turn times. This is valuable to the designer who receives a small number of his prototyped parts back soon after submitting his design. First time success is typical! Development foundry runs can cost just a few $10K's and short production runs are inexpensive compared to large scale silicon.

Longevity and Stability
Space electronics companies need to be confident that the process technology utilized in their designs will be available long term. Though TriQuint continues to expand its technology portfolio, it does so by building on the back of well established processes. Thales Alenia Space is a good example of a company which has used TriQuint's well established processes for its space qualified MMIC's for many years.

Jean-Louis Cazaux from Thales Alenia Space says "*Whatever the technology, qualifying a process for use in space is an investment and we must get long term return on this work. We* *have to be confident that the qualified process will be stable and available for many years so that further investment in qualification will be mitigated. Unlike some silicon processes where there seems to be continual pressure to shrink geometries and make other changes, GaAs processes tend to stay in production for a long time. We have qualified a number of processes from TriQuint which have been used for many projects over more than 20 years with great service. The first satellites including space qualified TriQuint MMICs, designed by Thales Alenia Space, were launched in 1996 following co-operation and development activities which started in 1988. Even though some space projects span over a number of years, we sometimes have to rely on well understood, stable technology and models to turn a MMIC design quickly, reliably and cost effectively into parts for assembly into modules. Well established GaAs technology allows us to do this   With a long term stable process, a foundry run can be repeated after many years with the same performance expectations and existing designs can easily be tweaked for different performance without the need for a full-up redesign.   Long term availability of an off the shelf MMIC is also very desirable.*

TriQuint supports satellite and other space related projects either with GaAs components from our catalog of standard MMIC's or the industries largest technology portfolio. We work with customers from all over our planet and look forward to working with you.