Crystal Gazing

Making way for all-silicon

In the cell-phone component business some observers point to what they had long predicted—a surplus of supply over demand, with the boom-bust cycle of silicon coming to GaAs for the first time. While this persists, the wiser companies are making their plans for the return of better times, including those banking on the market going to an all-silicon process. There are now signs that this technology is ready to move in on the key slots in handsets.

To illustrate this, you only have to look closer at what companies such as Philips are doing in silicon and SiGe mixed-signal processes. IBM, Motorola, STMicroelectronics and newer players (e.g. the re-named SiGe Semiconductor) are looking like strong challengers. Philips, for example, claims that its silicon process delivers performance equal to GaAs or SiGe at price levels significantly below these technologies.

Philips’ QUBiC4 is an evolution of a well-established process, ‘Quality BiCMOS’. It is targeting RF MMICs for advanced mobile networks, but it is an ‘all-silicon’ process designed for 3G. QUBiC4 is already on-line commercially, with standard products expected soon. Test chips have been developed for leading mobile telecom companies. Philips also has three fabs supporting QUBiC4—all on 200 mm wafers.

A good MHz/mW ratio is especially significant, enabling a move to the higher frequencies needed for 3G networks without adversely affecting the lifetime of handset batteries. Reduced power gives the reserve battery the power to execute the interactive multi-media applications of 3G. This performance derives from the very low noise figures of QUBiC4’s optimised NPN devices.

High Power-Added Efficiency enables integration of the power amplifier into 3G transceivers, where RF output powers of about 100 mW are needed. The ability to integrate more complex RF circuits also gives reduced component count for multi-mode handsets. Advanced isolation techniques promise single-chip transceivers handling full duplex requirements. Thus a single-chip multi-mode 3G transceiver looms large.

To provide this previously unattainable performance, new to the process are two more critical isolation techniques—shallow- and deep-trench isolation—designed to reduce parasitic capacitance and cross-talk to the level at which full-duplex (simultaneous transmit and receive) operation is possible on the same chip. It is also very area-efficient in implementing inductors, tantalum pentoxide dielectric capacitors and highly stable resistors. The use of low-k dielectrics also reduces unwanted parasitics. Lightly doped high-resistivity substrate materials critically reduce substrate losses. These processes are not simple to set up or make work routinely but, given the enormous investments, success is more a case of ‘when’ than ‘if’.

Deep-trench isolation involves etching 6 µm-deep trenches around critical components and filling them with a combination of insulating materials. The depth not only minimises component-to-component parasitic capacitances, but also reduces substrate-borne interference. Shallow-trench isolation is also used to increase packing density and reduce specific device capacitances. Successfully integrating the deep-trench isolation within areas of shallow-trench isolation is a critical feature of QUBiC4.

Finally, while standard silicon QUBiC4 meets all 3G RF performance needs, a SiGe version (QUBiC4G) with $f_T = 75$ GHz and $f_{max} = 110$ GHz addresses even higher-frequency wireless applications such as HiperLAN, as well as applications in fibre-optic networking.

Companies have targeted virtually all of the wireless cellular CDMA/GSM standards for handsets and base-stations. Wireless LAN and Bluetooth at 2.4 GHz are also key markets for SiGe devices where reduced chip-count and lower power consumption are important. Other applications include LNAs, VCOs, mixers, PAs and GPS receivers. IBM has a series of initiatives in applying silicon technologies to these RF circuits, one of which includes SiGe. It is offering standard, high-volume SiGe ICs targeted at designers of cell phones, pagers etc. with extended battery life, multi-functional capabilities but smaller, lighter and lower-cost. Higher integration levels also confer lower overheads from test and packaging, giving a reduction in total systems cost. GaAs MMICs have traditionally been used for VCOs over 5 GHz, but SiGe is now under consideration because of its low frequency noise characteristics, important for the design of low-noise, non-linear VCOs etc.

While standard silicon QUBiC4 meets all 3G RF performance needs, a SiGe version (QUBiC4G) with $f_T = 75$ GHz and $f_{max} = 110$ GHz addresses even higher-frequency wireless applications such as HiperLAN."