On-Chip Miniaturized Slot Antennas in 0.13μm CMOS Process

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Integration of antennas with the rest of the RF transceiver systems on a single integrated circuit (IC) chip is perhaps the last barrier that must be overcome before achieving a totally integrated single-chip wireless system becomes feasible. To be economically viable, such antennas must be compatible with the same standard processes used to fabricate the integrated circuit parts. This way, entire wireless microsystems could be fabricated on very small microchips. Such systems will have numerous applications in different areas ranging from miniaturization of personal wireless devices to implantable biomedical devices and miniaturized sensors constituting the nodes of an environmental sensor network.

Semiconductor substrates used in IC manufacturing processes are extremely lossy at RF and Microwave frequencies. Therefore, placing an antenna in close proximity to such a substrate could drastically reduce the performance of the antenna. Furthermore, to limit the cost of the wireless system, the chip area used must be reduced as much as possible. This necessitates using miniaturized antennas for on-chip applications, especially at frequencies below the millimeter-wave range. It is a well known fact that antenna miniaturization adversely affects the radiation efficiency and gain of the antenna. Therefore, in on-chip antenna applications, the combination of using a miniaturized antenna and the presence of the lossy silicon substrate can drastically reduce the performance of the antenna. Consequently, any solution that attempts to address this problem must effectively address these two sources of decreased radiation efficiency.

In this paper, a miniaturized, on-chip slot antenna fabricated in 0.13μm CMOS process will be presented. The antenna operates in the 9-10GHz frequency band and has a much higher gain and radiation efficiency compared to the state-of-the-art on-chip antennas operating in a similar frequency range. Two main factors contribute to this enhanced performance: the choice of a miniaturized slot-type antenna (as opposed to a wire-type antenna) and the effective shielding of the antenna from the low resistivity silicon substrate underneath it. The proposed antenna occupies a die area of only $0.3mm^2$ and is integrated with a low noise amplifier (LNA) on the same chip. The antenna has a measured active gain of -4.4dBi at 9.3GHz and measured efficiency of 9%.