

## Chapter 1: Introduction

Donhee Ham, Hakho Lee, and Robert M. Westervelt

The second half of the 20<sup>th</sup> century witnessed the metamorphosis of silicon, an element common in the Earth's crust, into silicon integrated circuits (ICs), complex superstructures that can contain hundreds of millions of complementary-metal-oxide-semiconductor (CMOS) transistors in a tiny footprint of only a few square centimeters. An arsenal of planar microfabrication technologies made possible the rock-to-IC transformation of silicon at surprisingly low costs. Now consider the phenomenal ability of silicon ICs. Hundreds of millions of CMOS transistors interconnected via a labyrinthine maze of metallic wires all work together to process data at gigahertz frequencies.

With their amazing capabilities, inexpensive production, and tiny physical size, ICs have come to have a major affect on our daily lives. As computer microprocessors, they significantly assist our intellectual endeavors. Silicon ICs profoundly enrich our ability to communicate, enabling communication technologies with high speed and data capacity over long distances. In addition, they provide entertainment: music and movies from handheld multimedia devices are a 21<sup>st</sup> century triumph of silicon technology. People on treadmills with tiny iPods can choose from thousands of musical tunes, ranging from Mariah Carey's songs to Ludwig van Beethoven's symphonies. This scene would be hard to imagine, were it not for silicon ICs.

While the dominance of silicon ICs in data processing, communication, and multimedia will undoubtedly continue into the foreseeable future, there are growing efforts to utilize the power of silicon technology for new types of applications. An important area is biology and medicine. Bioanalytical instruments are being miniaturized to make labs on a chip to perform a variety of experiments: to probe DNA, to monitor electrochemical activity, to examine neural functioning, and to actuate biological cells, for example. Microfluidic systems are being developed to provide a biocompatible environment on chips. By exploiting the power of silicon technology, one can combine CMOS ICs with microfluidic systems to make hybrid chips that perform standardized, and repeatable biological experiments more quickly, with a smaller sample volume, at lower costs than conventional approaches. Research activities in this new field, which we call **CMOS Biotechnology**, are expected to enjoy substantial growth. This trend is reflected by an increasing number of publications in major conferences and journals for IC design.

This book, consisting of ten technical topics contributed by experts in the field, will share some of the exciting developments in CMOS Biotechnology with readers from different disciplines. A large amount of high quality research is being done in this rapidly developing field, making it difficult to select only ten topics. Our selection presents examples of outstanding work to form view of CMOS Biotechnology.

We structured this book by sub-grouping the ten select topics into four parts, based on shared themes.