
Preface

I discovered the impressive potentiality of miniaturization and integration very early in my career. In 1984, when I concluded my university studies, IBM on one side and Olivetti on the other side were struggling to reduce computer dimensions. The dream was to shrink into a tabletop machine a system occupying several great closets.

That dream now seems quite old: we hold in our hands electronic devices much more powerful, easier to use, and functionally richer than 1984 computers. Integrated electronics has radically changed our way of living: neither the Internet nor mobile communications would have been possible without it.

Miniaturization has been applied to many fields since the first revolutionary successes: miniaturized optical components, mechanical, chemical and optical sensors, and micro-actuators are present in huge numbers in our homes, in our cars, and even on our person.

Currently, a new revolution seems near the edge, with the potential to change the lifestyle itself all over the world—miniaturized biochemical analysis performed via small, electronic-like chips, called lab on chip.

A lab-on-chip device, also known as a micro-total-analysis system (μ TAS), is a device that can integrate miniaturized laboratory functions on a single microprocessor-like chip, such as separation and analysis of components of a mixture. It uses extremely small fluid volumes, nanoliters or even picoliters, thus eliminating the need for large samples.

Integration also promises huge cost reduction, strong resilience, and ease of use, up to conceiving systems that can be used with no training whatsoever.

From the beginning, the first application predicted for this technology was monitoring of human health, even if huge application opportunities also exist in the fields of environmental control, food industry, security, and more.

Extended and inexpensive prevention and screening could be introduced using labs on chip while reducing the need for centralized structures. In-field diagnosis in emergencies can dramatically change the possibility of a correct intervention and save a huge number of human lives. Home monitoring of chronic patients can improve their quality of life while increasing their general health.

In advanced countries, a lab on chip could give a substantial contribution to the required decrease of healthcare expenses while improving the quality of the service. In developing countries, labs on chip can be key in allowing an effective, in-field prevention strategy without the need for expensive structures. An effective prevention and an early solution to small problems can be a way to reduce the number of critical patients in developing countries, allowing the development of a sustainable healthcare system.

The huge potential of the lab-on-chip idea fascinated me ever since I started working in this field several years ago. A huge research effort was made in the past two decades to discover and refine microfluidic systems, biochemistry miniaturization, and new technology processes. Nevertheless, about 20 years were required to arrive at the edge of a widespread introduction of a lab on chip, and a huge scientific, industrial, and engineering research study is still required.

The mere nature of a lab on chip as the synthesis of microfluidic systems, biochemical sensors, and miniaturized technologies is one of the causes of this long struggle. It is practically impossible to collect specific competencies and experiences in all these fields in a single person, and integration between researchers and engineers with different attitudes and skills is a key to succeed in this field. Such an integration is frequently difficult in universities and industries due to the strongly specialized education of technical people and the sectorial structure of many organizations.

This book is meant to be an instrument for such an integration, presenting a global view of the lab-on-chip field. The treatment of each specific subject is intended to provide a path starting with a recap of basic elements and progressing toward advanced concepts typical of a lab-on-chip study. This structure allows the different parts of the book to be useful both for specialists of the sector and for professionals coming from different specializations.

I hope this will be a small but useful contribution to the way of lab-on-chip diffusion causing a widespread, low-cost availability of effective diagnostic and prevention systems to all humankind.