

Foreword

I am happy to bring to you the 2019 Annual Research Report of the Microsystems Technology Laboratories. It highlights the research and educational activities of faculty, staff, students, postdocs, and visitors associated with MTL during MIT Fiscal Year 2019.

MTL's mission is to foster world-class research, education, and innovation at the nanoscale. This mission is predicated on the notion that nanoscale science and technology can help solve some of the world's most pressing problems in areas of energy, communications, water, health, information, and transportation, among others. In all these and other important areas of human concern, as showcased in this report, researchers at MIT are engaged in fundamental science and technology research in materials, structures, devices, circuits, and systems. A hallmark of MTL's research is its interdisciplinarity. MTL brings together scientists and technologists from different disciplines and operating at different levels of abstraction to collaborate in identifying solutions to some of the world's most persistent problems. MTL's activities encompass integrated circuits, systems, electronic and photonic devices, MEMS, bio-MEMS, molecular devices, nanotechnology, sensors, and actuators, to name a few.

Fiscal Year 2019 marked the beginning of a new era for the "nano" community at MIT. It saw the completion of the new Bldg. 12 and its new world-class infrastructure for nanoscale research. FY19 also witnessed the launch of MIT.nano, a new administrative entity created to run the facilities and programs enabled by the new building. With this new beginning and after 35 years of service to the MIT community, last year MTL transferred administrative oversight of its facilities and toolset of over 150 nanofabrication and analytical instruments in buildings 39 and 24 to MIT.nano.

Yet, our commitment to our mission is undiminished. In close collaboration with our colleagues in MIT.nano, the MTL administration continues to steward the extraordinary capabilities of the Bldg. 39 fab. These facilities are open to the entire MIT community and the outside world. Around 400 MIT students and postdocs from 27 different MIT Departments, Laboratories, or Centers carried out their research in the Bldg. 39 facilities in the last fiscal year. In addition, numerous researchers from several companies, as well as government research laboratories and domestic and international universities, took advantage of these capabilities last year.

Throughout the transition to the new building, the Bldg. 39 facilities will strive to continue to provide a flexible fabrication environment that is capable of long-flow integrated processes that yield complex devices while, at the same time, presenting low-barrier access to fast prototyping of structures and devices for users with very different levels of experience. Our fabrication capabilities include diffusion, lithography, deposition, etching, packaging, and many others. Our lab supports substrates from small, odd-shaped pieces to 6-inch wafers. The range of materials that the lab can handle continues to expand well beyond Si and Ge to include III-V compound semiconductors, nitride semiconductors, graphene, and other 2D materials, ferroelectric and magnetic materials, complex oxides, polymers, glass, organics, and many others.

MTL also manages an information technology infrastructure that supports state-of-the-art computer-aided design (CAD) tools and process design kits for device, circuit, and system design. Together with a set of relationships

with major semiconductor manufacturers, MTL enables access to its community to some of the most advanced commercial integrated circuit fabrication processes available in the world today. In FY19, nearly 230 students and postdocs took advantage of these services in their research projects.

MTL could not accomplish its mission without the vision, engagement, and generosity of the companies associated with the Microsystems Industrial Group (MIG). The MIG has supported MTL's programs for 35 years and its commitment now propagates to the new facilities and services in Bldg. 12. The MIG also advises the faculty on research directions, trends, and industrial needs, an invaluable resource. The list of current MIG members can be found in the "Acknowledgments" section of this report.

The research activities described in these pages would not be possible without the dedication and passion of the fabrication, IT, and administrative staff of MTL. Day in and day out, rain or shine, the MTL staff strives to support the realization of the dreams of the MTL community. They do this in a professional and unassuming manner. Their names are often mentioned in the acknowledgment section of research papers, and, from time to time, also in the author list! To them and to all of you who support in your own way the activities of MTL, a most sincere thank you!

Jesús A. del Alamo
Director, Microsystems Technology Laboratories
Donner Professor
Professor of Electrical Engineering
Department of Electrical Engineering and Computer Science
July 2019