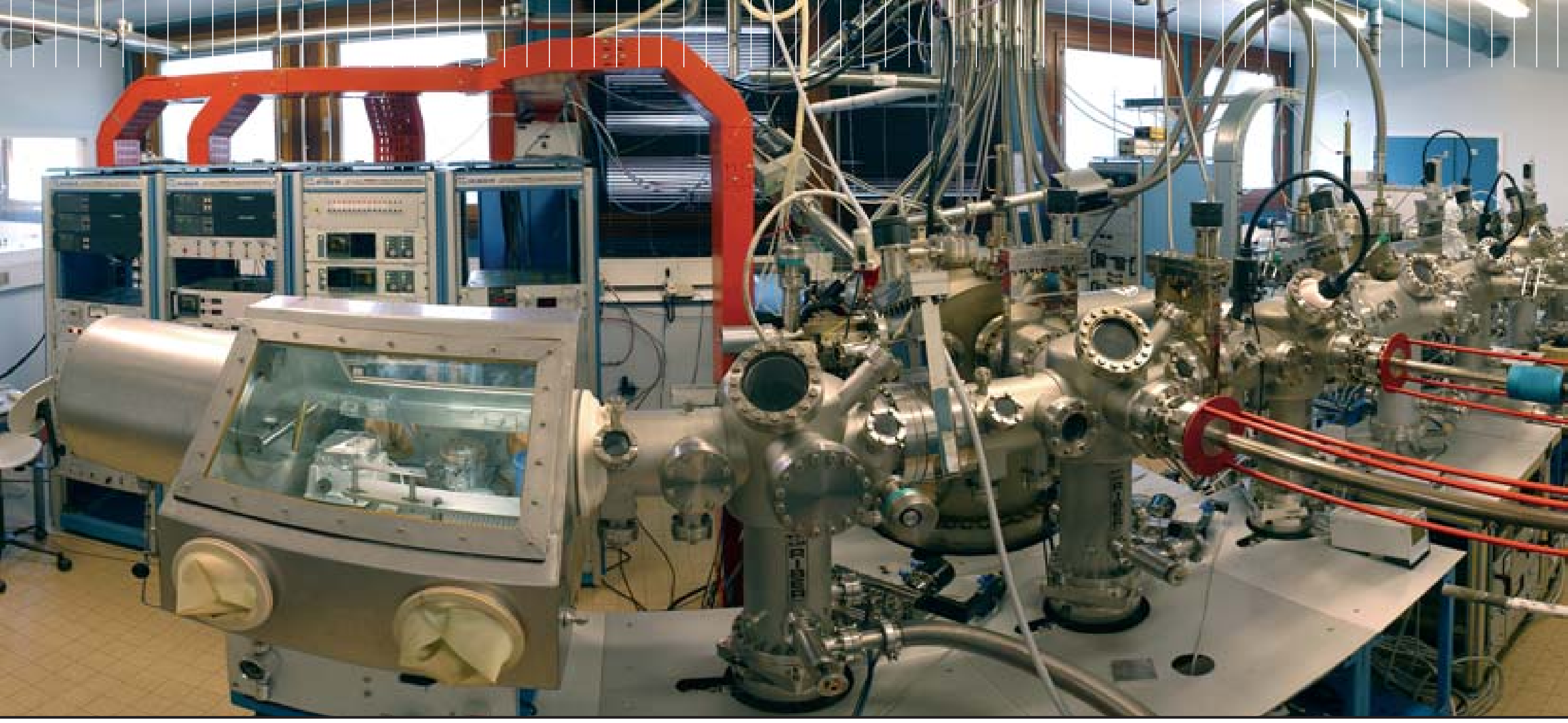

Artechnique/CEA

Overview of a molecular beam epitaxy apparatus at the CEA Grenoble centre. Two of the three chambers, all linked in ultra-high vacuum, are dedicated to growing semiconductor materials, and the third to metals.

I. FROM NANOSCIENCE TO NANOTECHNOLOGY

Information processing represents a fine illustration of the genesis of the subject of this chapter, nanotechnological innovation. The first section shows how studying the most fundamental properties of matter paved the way for designing new components. Magnetism leads to spintronics, a new way of processing and storing data by manipulating electron spin. The electronics of the future, via nanoelectronics, will be so extremely miniaturized that it can only be quantum-drived.
Acting as both particle and wave, the electron is delocalized into the heart of the whole component and the electrical conductor becomes a waveguide. Controlling the quantum states of materials within superconductor islands is paving the way for quantum calculation and computers, a far more powerful way of processing data than has so far been possible. Manufacturing quantum boxes in semiconductors will enable us to "tame" photons, choose their colours, emit them one-by-one, as required. A payback on the investment, nanometric MOSFET transistors are now applied to extending our knowledge of how electrons behave in very small-scale islands.
The second part underlines how progress in microelectronics stems from continuous ongoing improvement in miniaturization techniques, lithography, etching and many other technological advances. The targets are signposted by the microelectronics 'road map' set by industry, an extension of the famous Moore's law predicting the evolution of component size and complexity.
In the meantime, progress across the board is already transforming microelectronics into nanoelectronics.
Nanotransistors will be developed thanks to lithography technology capable of designing patterns whose feature size has been scaled-down to just a few nanometres, as well as many other conceptual steps forward. Extreme ultraviolet lithography (EUVL), which uses radiation close to X-rays, is the latest technical revolution, producing feature sizes smaller than 32 nanometres.
Molecular bonding, which can cut down chip energy consumption, is another essential innovation for tomorrow's microelectronics, opening up a gamut of possibilities for materials design and development.
To round up, photonics, using photons for logic and computation operations, shows promise as a future information processing approach. It should help to solve some of the problems electronics is set to face, provided of course that we learn how to integrate the various light generation, modulation, routing and detection functions into a chip. Photonic crystals should help us get there.