None of the many technological revolutions of this century has been as sweeping as the quiet global takeover by tiny wafers of silicon, particularly in a form called "microchips." These small giants turn up everywhere — in faceless watches on the wrists of bushmen and businessmen, in computers the size of portable television sets, in fact wherever electrical signals need to be generated, processed, or stored. As well, large areas of silicon wafers are used to make the shining panels that generate electricity directly from the Sun. This amazing diversity of application is due to the properties of silicon, and to the specialized manufacturing technology that permits high control over the formation and growth of what are called "thin films" on the silicon surface.

Techniques that put thin layers of different substances atop one another in a sandwich fashion literally underlie not only the ubiquitous microchip but also such products as reflective windows and chrome-plated auto parts. Because thin films loom so large in our society, a group of researchers at the National Research Council has made them and their production techniques the subject of an intensive investigation.

According to Dr. Digby Williams of NRC's Division of Chemistry, the recent demand for new products using semiconductors has outstripped the existing thin-film technology that creates them. "Most of the deposition methods have been around for a long time," says Williams, "and they could stand improvement. They waste energy and material, and they cost too much. Although industry wants to correct these conditions, it hasn't sufficient time or facilities; so we're studying methods and materials to determine just what improvements can be made — not for quick changes, but for the longer time frame."

To make microchips, thin-film techniques deal with a family of materials known as semiconductors. These substances are a kind of compromise: they transmit electricity, but not with the cool efficiency of the copper wiring in your house. Most semiconductors are in fact not metals but other elements or compounds, which are considered insulators at low temperatures and thus unable to conduct electricity at all. That semiconductors buck the odds and do pass current — making possible all those watches, computers, and solar panels — is all due to the way thin films are made. The trick, says NRC's Williams, is to incorporate just the right amount of a known impurity into the thin film.

Thin-film methods generally build layered crystals. Starting from a base of silicon, the structure is constructed layer by layer, until a sandwich is created. Introducing various impurities into these crystal layers lets electrons find paths across the completed structure and thus conduct current. The whole deposition process is a delicate one. According to Dr. Jim Webb, Williams' colleague in the Chemical Physics Section, "subtle variations in technique cause wild changes in the characteristics of the completed crystal. Sometimes these changes can be useful, but other variants are simply failures, and costly rejects to industry."

Of the many thin-film techniques that are potentially useful to industry, the NRC research team has so far concentrated on two of them for detailed study. These have the tongue-twisting technical names "magnetron sputtering" and "metalorganic chemical vapour deposition" (or MOCVD).

One of the simplest, oldest — and least reliable — ways of depositing thin films uses a vacuum chamber and heat to vaporize the material to be layered on a substrate. After vaporization, the material simply drifts onto the cooler substrate surface and condenses on it, forming a solid layer. One problem with this vacuum evaporation technique is that the film produced is sometimes lumpy, particularly when compounds rather than elements are used, and often does not stick very well to the substrate surface.

Jim Webb's magnetron sputtering technique, on the other hand, uses an ionized gas rather than heat to get the material for deposit into the gas phase. He starts with a vacuum chamber, in which he has placed a target plate of this material and, facing it, the substrate on which he will lay down his film. He first evacuates the chamber, and lets in a little argon gas, which is thereupon ionized by

Digby Williams: "Canadian industry can enjoy significant benefits from the technology we have developed."