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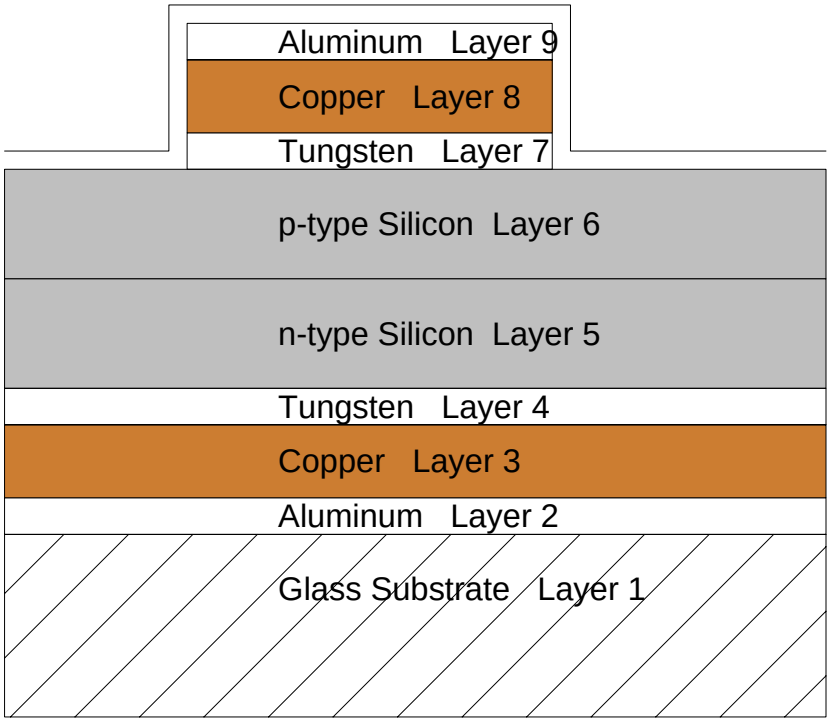
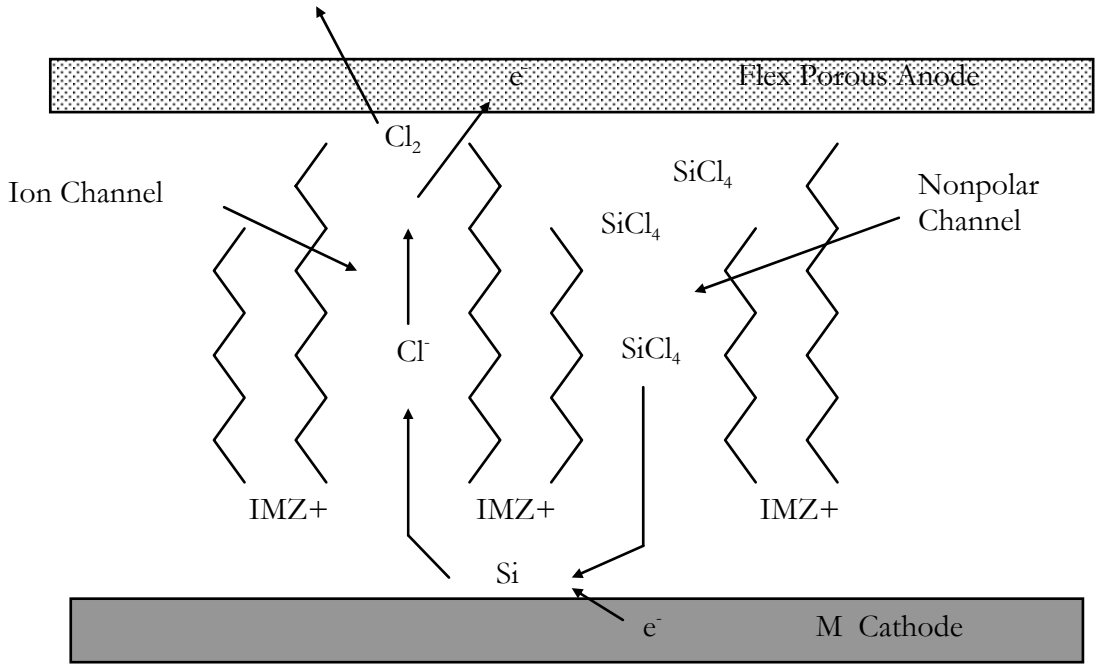
Electrochemical Deposition of Single Crystal Silicon over Polycrystalline Metal

Electrodeposition is typically an inexpensive way to coat, or layer materials over one another. Electrochemical methods are used to produce aluminum and purify copper on a large scale for example. This approach offers the possibility of manufacturing large scale photovoltaic solar panels at a low cost. As an example, the work in our laboratory at San Juan College centers on the electrochemical layering of materials to form the device cross section shown here.



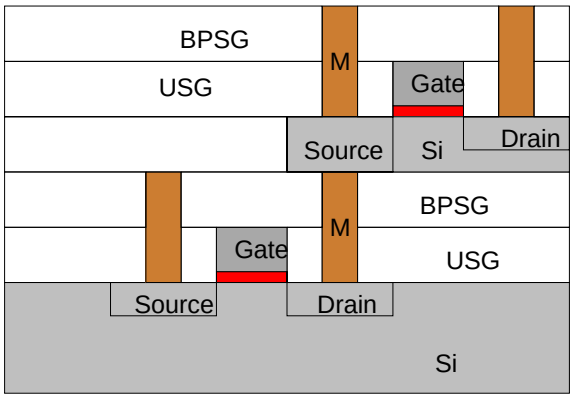
The basic idea is to form the silicon pn junction electrochemically rather than the traditional methods of growing silicon crystals, which are then sliced, polished, and dopants diffused into them. This requires many steps and high temperatures.

One of the problems we face however is in depositing quality silicon over polycrystal surfaces. Not only has there not been a good method of electrodeposition of high purity silicon discovered, there is also no known method to deposit highly ordered single crystal materials over poly crystal surfaces. Therefore we are working towards a directed molecular assembly approach at depositing silicon at low temperatures over polycrystal surfaces. One idea is shown here.



In this example we imagine having molecules that order themselves to create channels that direct silicon precursor reactants to specific reduction sites that create the first layer of silicon atoms on the surface. This could be thought of as sort of a highly modified lipid bilayer found in cell walls. Alternatively, we are working on designing new silicon precursor molecules that self order themselves as a template in an attempt to be able to position the silicon in a regular array for building silicon thin films at room temperature.

The successful low temperature deposition of high quality silicon would also enable the manufacture of three dimensional electronic devices. At present, the transistors in computer chips are built as one layer. Here we show what we mean by a truly stacked multilayer silicon transistor device.



Currently, the deposition of silicon thin films requires elevated temperatures, in excess of 500 C, in a chemical vapor deposition (CVD) reactor. This temperature would cause problems in unwanted alloying of interconnect metals with the silicon, or unwanted flow of interlayer dielectric glass. In addition, silicon deposited by CVD is polycrystalline, where as highly ordered single crystal silicon is required for good device performance. A molecular approach to single crystal silicon assembly would revolutionize the silicon electronics industry.