

Vapor Pressure Apparatus for Metal-Organic Samples

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In striving to adhere to Moore's Law, the semiconductor industry is designing and using new metal-organic compounds. The job of such a precursor compound is to deliver a metal atom, such as hafnium, to the surface of a hot silicon wafer. The most important physical property is vapor pressure because the compound is delivered as a vapor to the process chamber either by direct injection (flash evaporation) or by bubbling a carrier gas through the liquid held in a "bubbler". This apparatus was designed to measure the vapor pressures of metal-organic liquids in the pressure range from 10 Pa to 100 kPa and at temperatures from 25 °C to 200 °C. It uses capacitance diaphragm pressure gauges that operate at a temperature near that of the sample. This direct method was chosen over indirect methods that rely on, for example, thermogravimetric analysis or nuclear magnetic resonance. The liquid part of the sample is contained in a tube whose temperature is held 2 K below that of the surrounding oven; this ensures control over the location and temperature of the liquid-vapor boundary. A thermoelectric cooler controls the sample's temperature with a stability of 2 mK, and measurements of water's vapor pressure agree with accepted values to within 1 % at temperatures from 30 °C to 100 °C. Challenges for measuring the metal-organic compounds include handling hazardous samples and avoiding systematic errors due to the presence of decomposition products, dissolved gases, and other impurities. To measure thermal stability, a gas chromatograph / mass spectrometer has been incorporated into the apparatus.