GREEN CHEMISTRY
REAL APPLICATIONS - (d)

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SUPERCRITICAL CARBON DIOXIDE FOR CLEANING IN MANUFACTURE OF COMPUTER CHIPS

Supercritical carbon dioxide is a fluid state of carbon dioxide where it is held at or above its critical temperature and critical pressure. Carbon dioxide usually behaves as a gas in the air at standard temperature and pressure (STP), or as a solid called dry ice when frozen. If the temperature and pressure are both increased from STP to be at or above the critical point for CO_2, it can adopt properties midway between a gas and a liquid. Super critical CO_2 is one of them: It is a fluid with poor solubility for ionic and high-molecular-weight organic compounds, combined with so-called green chemical properties (i.e it is nonflammable and environmental friendly)

Supercritical Carbondioxide ($ScCO_2$) is an established precision cleaning technique with applications in many different industries. The gas like viscosity and the liquid-like density of CO_2 are the key characteristics that allow the process to be tuned to the application. In addition, very low surface tension of $ScCO_2$ ensures high wettability and makes it very attractive for precision cleaning applications. The cleaning process is operated at nearambient temperatures. Applications range from cleaning and drying of micro and nano structures such as carbon nano tubes; terminal sterilization of microbial organism and food Pasteurization, cleaning of metal surface, Silicon wafers, etc.

Computer chips :- To manufacture computer chips, many chemicals, large amounts of water, and energy required. In a study conducted in 2003, the industrial estimate of chemicals and fossil fuels required to make a computer chip was a 630:1 ratio! That means it takes 630 times the weight of the chip in source materials just to make one chip. Compare that to the 2:1 ratio for the manufacture of an automobile.

Scientiste at the Los Alamos National Laboratory have developed a process that uses SCCO_2 in one of the steps of chip preparation, and it significantly reduces the quantities of chemicals, energy and water needed to produce chip. ACRES program at the university of Delaware, found a way to use chiken feathers to make computer chip.

Scientists at the Department of Energy's Los Alamos National laboratory have developed new technology application that could

all but eliminate the use of hazardous
corrosives and the production of wastewater in the
fabrication of integrated circuits, or chips, for computer
chip making is sometimes called a "clean
industry" because of the images of technicians in
white lab suits working in ultra-clean rooms with
shiny pristine silicon wafers. But it is estimated
that, on the average day of operations at a chip-
making plant, four million gallon of wastewater
are produced, and thousands of gallons of
corrosive hazardous materials like hydrochloric
and sulphuric acid, are used.

The new Technology, called
SCORR focuses on photoresist removal, one of the
steps in a process called photolithography, where high
intensity light, along with aggressive acids and corrosives
are used to creat a chip's tiny integrated circuits
by altering the topography of a silicon wafer.
using CO_2 at high temperature and pressure, known
as (SCCO_2), in place of the hazardous materials,
researcher replaces the solvents as well as
the tremendous quantities of ultra-pure water

that are used to wash those solvents away.

" CO_2, at pressures above 1,050 pounds per squar inch and temperatures above 31 degree centigrade, becomes supercritical" said Craig Taylor, who leads the SCORR team in the laboratory's Applied Chemistry Technologies group " In its supercritical phase, the gas becomes liquid, but behaves a little like both giving it the ability of act as a solvent. But $scCO_2$ alone is somewhat ineffective, so it is combined with minor amounts of a more effective cosolvent, and we have seen that this mixture is quite effective at photoresis removal".

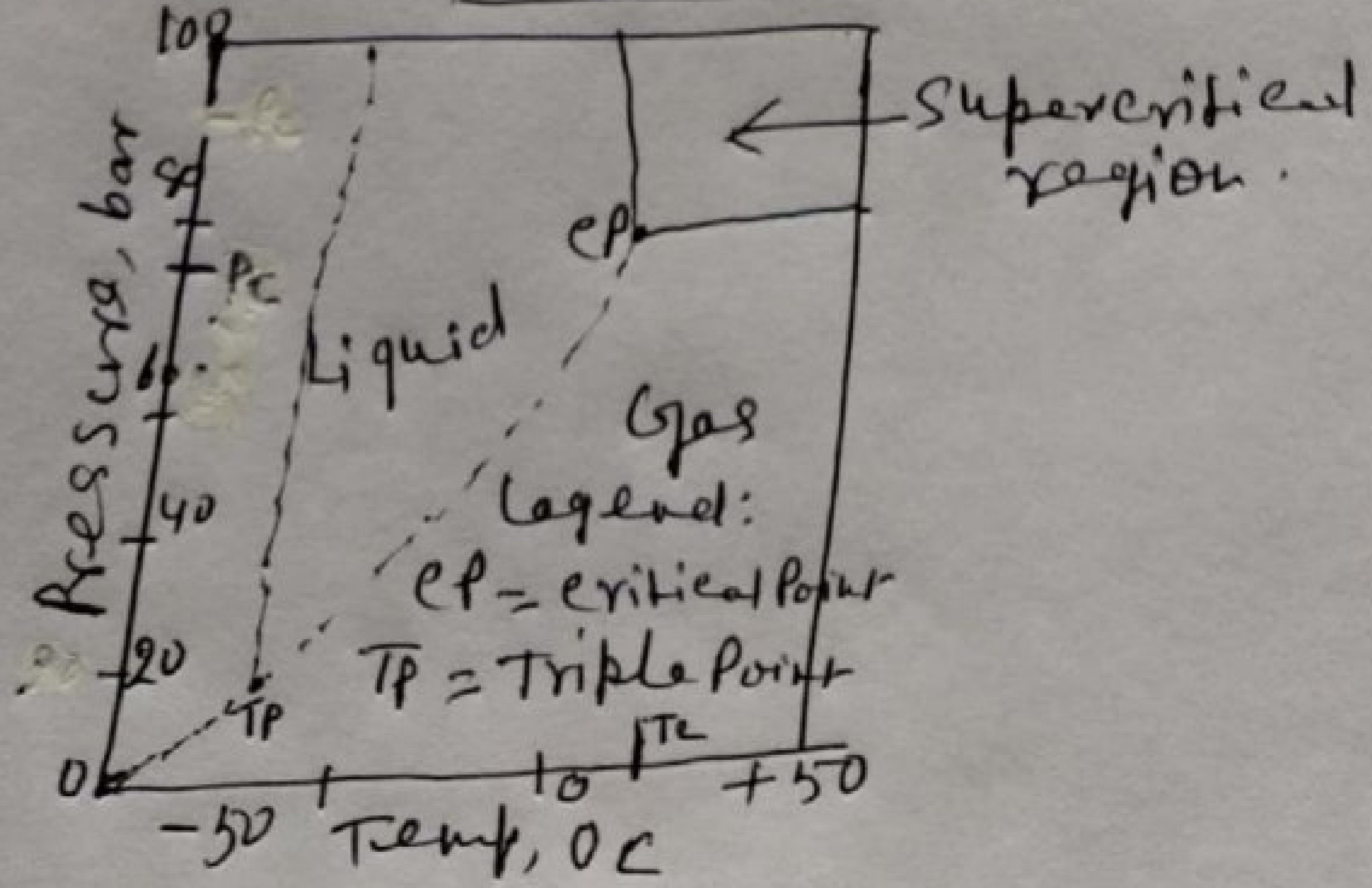
On top of that, when the pressure and temperature are lowered the $scCO_2$ returns to its gas phase, leaving the silicon wafer bone-dry and virtually of free of any dirt, eliminating the need to rinse with ultra-pure water and dry with isopropyl alcohol. CO_2 is cheap, nonflammable, nontoxic, biodegradable, recyclable and plentiful.

The Los Alamos photoresist removal technology produces virtually zero hazardous waste. It is designed as a closed-loop system that reuses the CO_2 in the process, adding no greenhouse gas to the atmosphere. Because of their low vapour pressur, the additive cosolvents are easy to separate from the mixture, and so they, too, are collected and reused.

A Key element in the Process is a tiny high-pressure sprayer that Pulses the $scCO_2$/cosolvent onto the Silicon wafer to assist in dislodging the Photoresist. Developed by technician Jerry Barton, the sprayer creates enough surface drag to dislodge softened up by minutes-long soaking in the $scCO_2$/cosolvent mixture. This combined process of soaking and spraying, along with an $scCO_2$-only wash, has produced results that equal the chip fabrication standards currently accepted industry.

Said Taylor: Even if we were to set aside the hazards and pollution associated with the corrosive materials used in chip making, you still have the issue of water use and that is especially critical in the Southwest where several large chip fabrication facilities are located. We believe that the $scCO_2$ process has the potential to save hundreds of millions of gallons of water every year even if it were installed in just one factory, making it not only a very important technological advance, as well! advance, but an environmental advance,

The Phase diagram for carbon dioxide



T_c = critical temp.
= (32.1°C)

P_c = critical Pressure
= 73.8 bar.