Effects of Supercritical CO_2 on the Electrical Characteristics of Semiconductor Devices

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Supercritical fluids are highly compressed gases, which combine properties of gases and liquids in an intriguing manner. A pressure-temperature (P-T) phase diagram, shown in Fig 1, illustrates the nature of a supercritical fluid. A supercritical fluid actually has physical properties somewhere between those of a liquid and a gas. Supercritical fluids are able to spread out along a surface more easily than a true liquid because they have lower surface tensions than liquids. At the same time, a supercritical fluid maintains a liquid's ability to dissolve substances that are soluble in the compound, which a gas cannot do.

Existing cleaning processes available to the Electronics industry include RCA[1] based cleans for semiconductors, flux cleaning for oxides in electronics and solvent cleaning of flux residues in electronics present severe limitations including adequate level of cleanliness, volumes of waste solvents generated, worker exposure to solvents, costly chemicals and expensive equipment. As such, there is a requirement for the development and integration of a closed loop, environmentally and substrate compatible, cost effective technology resulting in significant savings in solvent and associated energy costs. Recent work on supercritical fluids indicate that as well as successively removing organic contaminants, the technology may also be used to remove or extract metals by using metal complexing ligands[2] . These discoveries open the potential for a multi-purpose (organic and metallic or ionic contaminant removal) clean compatible with environmentally conscious manufacturing and the process requirements of contaminant-sensitive materials.

In this work we measured the effects of various supercritical conditions of temperature and pressure on a semiconductor device.

A chip that was designed as the process evaluation 'test chip' for the NMRC's 15 volt, 5µm CMOS process is used in the NMRC to evaluate contacts, gate oxide integrity, diode leakage, field device leakage, line-width, contact resistance, inter layer and intra layer isolation, electromigration, transistors, capacitors and resistors. This chip was used to determine the effects, if any, that supercritical carbon dioxide has on a number of the above parameters.

Each wafer contained approximately 60 PM5 chips.

The wafermap in Fig 2 shows the leakage current values for a p+ diode. A chip is in Bin 1 if its source/drain leakage current is between 1e-12 and 0.0001 Amps/cm^2. As can be seen, nearly all of the chips measured lie within this range. A chip has passed the electrical test for this parameter if the values lie within Bin 1.

Wafermaps were generated for 19 different electrical parameters for each chip.

The various electrical characteristics of each chip was measured before and after exposure to supercritical temperatures and pressures (Fig. 3). There does not appear to be any evidence to suggest a change in the electrical characteristics of these chips when exposed to supercritical CO_2.

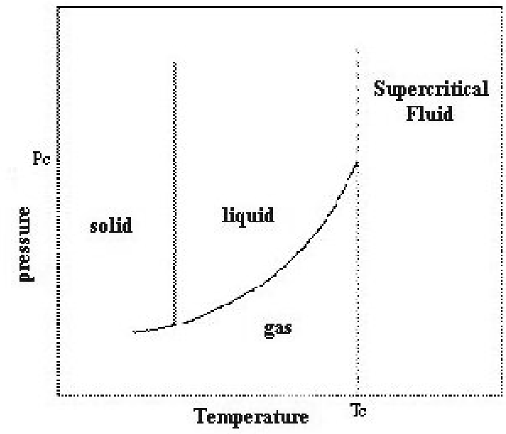

Fig 1. Generic Phase Diagram for a pure compound

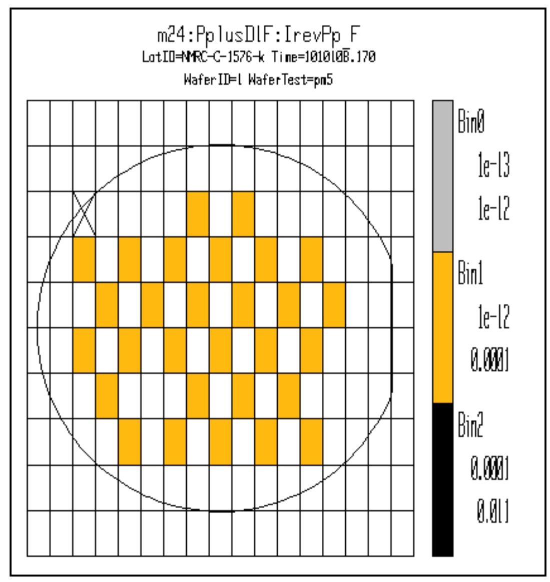

Fig 2. Example of a wafermap

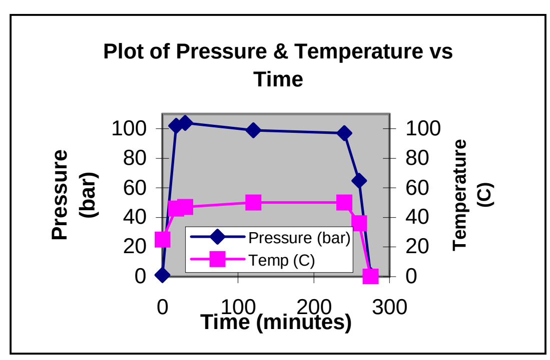

Fig 3. Supercritical fluid extraction conditions

References

1. W.Kern and D.Puotinen, RCA Rev. 31, 187(1970)
2. Glennon, J.D., Hutchinson, S., Walker, A., Harris, S.J. and McSweeney, C.C. J. Chromatography A, 770 (1997) 85-91