Semi-Conductor Laboratory
(Department of Space)

FOOTPRINTS ON SILICON

NEWS LETTER

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CRYO-STAT FOR SUB-LN$_2$ TEMPERATURES

Electronic devices for use in certain applications are required to be tested at sub-Liquid Nitrogen (LN$_2$) temperatures. TSSG, SCL has embarked on the development of a 'cryo-stat' for achieving 65-80K (-208 to -193C). The concept of sub-cooling LN$_2$ to its triple point (Fig.1) was used to achieve temperatures upto 64K.

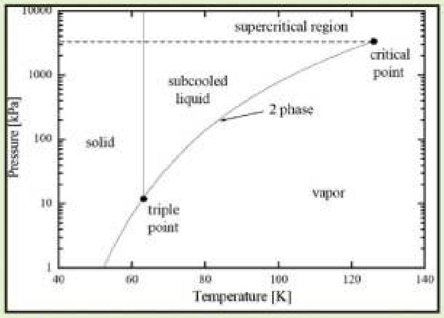


Fig. 1: Phase diagram of low temperature nitrogen

The boiling point of LN$_2$ (77K @ 1 atm) drops down when subjected to vacuum, resulting in enhanced rate of evaporation. The heat supplied by LN$_2$ in the vessel supports the evaporation to transform a part of liquid into vapours/gas. As the vacuum builds-up, the remaining LN$_2$ in the vessel is gradually sub-cooled and starts approaching the triple point temperature i.e. 64K @ 10 kPa.

The set-up used (Fig. 2) for sub-cooling LN$_2$ comprised of Dewar, Vacuum insulated cryogenic vessel with inlet valve, Safety Vent, Dual gauge for pressure and vacuum, temperature sensor and a vacuum pump.

Fig. 2: Setup

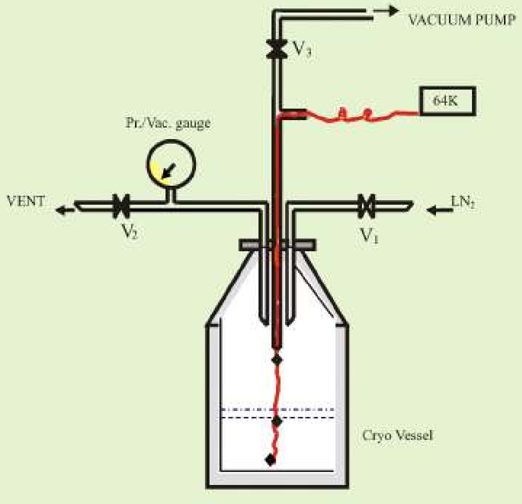


Fig. 3: Schematic of the set-up

LN$_2$ stored in Dewar was transferred to the cryogenic vessel through valve V_1 (fig. 3) keeping valve V_2 open to vent out the excessive pressure build up in the vessel during LN$_2$ fill. The cryogenic vessel filled with LN$_2$ upto half its capacity (so as to have adequate volume of sub-cooled LN$_2$) was subjected to vacuum by operating a vacuum pump while valves V_1 & V_2 remained closed. The temperatures achieved are as shown in figure 4.

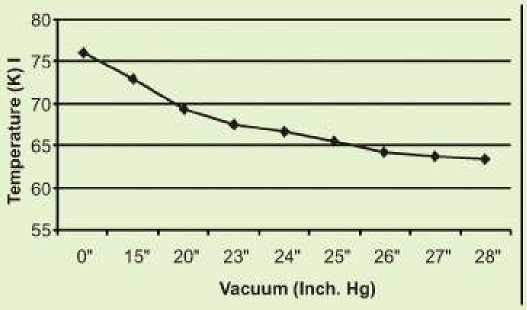


Fig. 4: Plot Vacuum Vs Temperature

Further improvements and modifications for operational use of the cryo-bath are planned.

TECHNOLOGY

ULTRASONIC LIQUID LEVEL SENSOR (USLS) ASSEMBLY STARTED AT SCL

SCL has initiated the assembly of Ultrasonic Liquid Level Sensor (USLS). USLS developed by LPSC, Bangalore is used in the L40, GS2 stages of GSLV and PS2 stage of PSLV launch vehicle for propellant loading operations. The propellant filling/draining operations are focused activities during countdown phase of the launch campaign.

The USLS is constructed of Stainless Steel 304L. The sensing part of the USLS, called Sensing Head, has Piezo electric ceramic crystals encapsulated on each side of the sensing gap. One is called 'Transmit crystal' and the other is 'Receive crystal'.

'Transmit crystal' is used to convert electrical signal into an ultrasonic vibration, which is then transmitted across the sensing gap. 'Receive crystal' on the other side of the sensing gap, receives this ultrasonic vibration and converts it into an electrical signal.

The amplitude of this signal depends upon the type of medium present across the sensing gap. The difference in the signal amplitude enables the electronic unit to sense the presence or absence of liquid.

FORCE RING DEVELOPMENT: AN INDIGENIZATION EFFORT

A number of environmental, electrical & mechanical tests are conducted on devices to qualify them for space grade applications. Constant Acceleration is one such screening/ qualification tests performed on Centrifuge Machine rotating at 20-30k r.p.m.

Conducting this test on 131mm long (non-standard size) imager device which is under development at SCL came as challenge since the existing fixture (Force Ring) could accommodate devices only up to 90 mm length.

The solution was to fabricate a customized Force Ring compatible to above Centrifuge machine to conduct the requisite CA test.

Accordingly, a force ring and loader plates to hold the non- standard imager device were designed, developed and fabricated.

UNDERSTANDING SHALOW TRENCH ISOLATION

Implementing electric circuits involves connecting isolated devices through specific electric paths. When fabricating silicon integrated circuits (ICs) it must therefore be possible to isolate devices, built into the silicon from one another. These devices can subsequently be interconnected to create specific circuit configurations desired.

Varieties of techniques have been developed to isolate devices in integrated circuits. But the most important isolation structure that would prevent the establishment of parasitic channels between adjacent devices was termed LOCOS (LOCal Oxidation of Silicon).

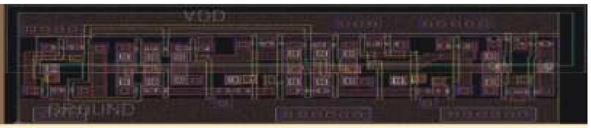
LOCOS isolation was developed in the early 1970s, and it remained the workhorse isolation structure for NMOS and CMOS ICs until these technologies reached the 0.35µm generation. However, for IC generation beyond 0.35µm, conventional LOCOS isolation technologies reached the limits of their effectiveness, and alternate isolation process for CMOS was needed. The successor to LOCOS in CMOS is shallow trench isolation (STI).

The drawbacks that the LOCOS could not overcome were the field oxide bird's beak (that encroaches into the active area of the chip) and the non-planar topology that results from thermally growing the semi-recessed field oxide. Both of these problems are avoided by the use of STI (See fig.).

WELCOME TO SCL

FPS extends a warm welcome to the members joining SCL Family during the year 2009

Harijot Singh Bindra (R&QA) **Anula Gupta (VDD)** **Meeta Vaney (PTDD)**



That is, in STI a relatively shallow trench is first etched into Si-substrate (0.3 to 0.5μm deep), which is then refilled with an insulator material (following a short thermal oxidation growth step that forms a thin film of SiO2 on the trench walls to control the Si-SiO2 interface quality).

This method of forming the isolation oxide does not produce a bird's beak. In addition, by using CMP to planarize the surface in the course of forming this isolation oxide-structure, the wafer surface is flat at the conclusion of the STI-formation sequence. This eliminates the topography that exists at the end of the LOCOS formation process.

Despite the impressive advantages of STI mentioned above, a variety of difficulties associated with the fabrication and process integration of STI structure.

The major one is, STI process involves a large number of steps than does LOCOS isolation process. Yet the overall benefits of STI over LOCOS provided the impetus for the industry to find ways to overcome these challenges. STI began to find use in mainstream IC technology when it was integrated into 166MHz Pentium microprocessor (which used a 0.35μm process).

The various steps of STI Process are given in brief:

First step is **trench opening.** Pattern of trench openings down to 0.15μm is accomplished using deep-UV lithography Control of trench profile and depth at narrow spaces is a key to scale isolation.

Second step is of **Linear Oxidation and Corner rounding.** The trench corners represent an abrupt transition from the transistor active are to isolation. Gate poly wraparound of a sharp trench causes a separate conduction characteristic of the corner resulting in a 'double-hump' in the transistor Id-Vg characteristics.

Corner rounding is improved by carrying out the linear oxidation at high temperature (1100°C) and by using Halogen ambients.

The third step is of **Trench Gapfill.** High-density plasma CVD oxide, CVD TEOS-O3 and sub-atmospheric SACVD have been widely reported as trench gapfill material. An important requirement for gapfill materials is to fill the minimum dimension trench free of voids. A major reliability concern with gapfill material is the stress on underlying silicon.

The stress may be present in the material as deposited, or may appear as a result of shrinkage of material during densification. The stress can create defects later on in the process especially in heavy dose Arsenic implanted source-drain regions leading to increased diode leakage.

The fourth step is **CMP.** Chemi-mechanical polishing (CMP) planarizes the top surface of the wafer by removing the oxide on the top of the nitride. The challenge is to stop the process controllable on the nitride without damaging the underlying silicon.

However, the CMP process is inherently pattern sensitive. It removes oxide rapidly and exposes nitride over isolated active areas, before all the oxide is removed from large or dense areas. This process creates non-uniform step heights between active and field areas after nitride strip.

The final step is **Well and Channel Stop design for isolation and latchup.** Optimization of well and channel stop (CS) implants is required for providing interwell (N$^+$-NWell and P$^+$-Pwell) isolation and preventing latch-up of P$^+$-Nwell-Pwell-N$^+$ thyristor.

At sub-0.5μm trench widths, interwell isolation and latch-up become sensitive to misalignment between well and active areas. The use of channel stop implants positioned optimally above the trench bottom, minimizes this sensitivity and enables an N$^+$-P$^+$ isolation space of 0.3μm.

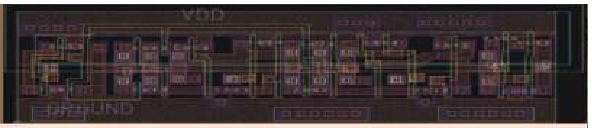
Illustrative Comparison between LOCOS and STI:

LOCOS with non-planer topology and bird's beak encroachment

STI with planer topology and no bird's beak

-SANTOSH KUMAR

EVENTS / NEWS



SCL WINS TITLE IN VOLLEYBALL

SCL participated for the first time in 'ISRO Inter Centre Outdoor Games Meet 2009' held at VSSC, Thiruvananthapuram from 24th February to 6th March 2009.

SCL took part in seven events, namely Volleyball, Hockey, Cricket, Football, Basketball, Kabaddi and Lawn tennis, with 66 players. Showing good skills and team spirit, SCL secured semi-final berths in Hockey, Basketball and Volleyball events.

Exhibiting fine combinational play in semi-finals, the Volleyball team defeated VSSC in straight two sets and secured place in the finals. SCL met SDSC in the volleyball finals. Continuing with their fine run SCL defeated SDSC in an entertaining and hard fought contest in straight three sets 25-12, 25-15 and 25-18 and won the title.

Sh. Satish Bhagi of HFF, captain of SCL volleyball team, was declared the best volleyball player of the tournament.

GENERAL HEALTH CHECK-UP CAMPS

A free general health check-up camp was organised from 15th to 25th December 2008, at IVY hospital for SCL employee's aged 45 and above. Employees evinced great interest in the camp. 161 employees participated in the camp to discern the status of their over all health.

Also, a free Eye check-up camp was held at SCL on 26th December 2008, in association with SGHS Eye Institute & Multi Specialty Hospital, Sohana. 102 employees took benefit of this camp.

BLOOD DONATION CAMP

SCL has been organizing Blood Donation Camps from time to time in association with PGI, Chandigarh. One such camp held on 14th October 2008 at SCL witnessed a great enthusiasm among employees and CISF personnel.

A total number of 62 people donated blood on this occasion.

AID FOR FLOOD AFFECTED PEOPLE IN BIHAR

The rainy season in year 2008 witnessed large areas of Bihar inundated by flood in river Kosi that played havoc with the lives and homes of people. Thousands of people became shelter-less.

SCL employees, like many other citizens of the country, donated one-day salary to provide some respite to the affected people of Bihar. 286 employees volunteered to support this noble cause and contributed an amount of Rs. 1,62,976 to 'Chief Minister Relief Fund'.

OBITUARY

FPS deeply condoles the sad demise of

Late Sh. RAM BHAGAT
VMFD

Late Sh. DEVKINANDAN SHARMA
SAD

Late Sh. NARESH KUMAR
R&QA

Please email your valuable suggestions/feedback at fps@sclchd.co.in

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