Microsystems Fabrication and Engineering Initiative Through CARE-2008

(Progress Report of Activities-2009)

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Our Vision:

Our Long term vision would be to establish a working micro-engineering center for excellence in functional micro-scale prototypes. The goal would be to promote basic MEMS research and training, developing MEMS sensor modules for commercial and futuristic applications, generate resources for the institute through grant proposals, sale of patented technologies and developing MEMS educational modules. The bigger objective of this center would be to develop the 21st century engineering and technical task force who would take up the technological challenges of the future decades.

Tangible Impacts to the institute:

(1) Development of MEMS technology and products through a heavily iterative design process and reliability analysis of prototypes.

(2) State of the art MEMS fabrication facility for national and international users from neighboring nations. This would generate a lot of institute good will and also monetary resources and would increase the visibility of IIT-Kanpur in the global arena.

(3) Possibility of getting foreign scholars and students for training modules from the neighboring nations and Asian and Middle Eastern countries in general. The institute can eventually think of establishing MEMS engineering school associated with the design/ prototyping center for excellence.

(4) Possibility of getting funded research projects from industries and national agencies by demonstrating the capabilities.

Global Impacts:

(1) There are very less complete design/ fabrication facilities for MEMS within the nation. Strengthens the existing position of IIT-Kanpur in the MEMS communities world over.

(2) Companies and government agencies needing sensory systems particularly the law enforcement agencies within Northern zone can approach IIT-Kanpur for technology development.

(3) New startups and spin offs can be emerged from incubation facilities already housed within IIT-Kanpur which would promote entrepreneurship opportunities among graduating students at UG/ PG level. This way in general the national technological manpower generated per annum going into hardcore engineering research / development areas and remaining within the nation would get a tremendous impetus. Why MEMS can be the buzzword for this revolution is primarily because designing, prototyping and testing realizes a complete working module which sells very well. So there is definitely an economic angle to this endeavor.

Funding sanctioned through CARE-2008 and Extended CARE-2008 by DORD:

Sl. No.	Project	Amount
1.	CARE 2008	Rs. 4 1,00, 000/-
2.	Extended CARE 2008	Rs. 1,8 0,00,000/-

Extended Care- 2008 Expenditure status

Sl. No.	Item Name	Quantity	Value/ Price	Indian Price
1.	PECVD/ Sputtering Systems	01	US$/ 2,25,000/- 15% Custom Duty	Rs. 1, 17,00,000/- Rs. 17,55,000/-
2.	Mask Aligner	01	YEN/ 65,00,000/- 15% Custom Duty	Rs. 35,10,000/- Rs. 5,26,500/-
3.	Air Cooled Chiller	01	INR	Rs. 1,26,000/-
4.	Optical Table	01	INR	Rs. 2,91,375/-
Total Spending				Rs. 1,79,08,875/-

CARE-2008 Expenditure status

Sl. No.	Name of Items	Vendor	USD / EURO	Price
01	Wire - Bonder	Best Bond Inc. USA	19920 /USD	INR. 996000/-
02	MRL Furnace	MRL Industries 19500 Nugget Blvd. Sonora CA 95370, USA	26,341/- USD	INR- 16,35,776/-
03	Dicing Saw	Semiconductor technology & Applications USA	10733 / USD	INR- 5,36,650/-
04	Spin Coater	SPS Semiconductor Production Systems, The Netherlads	4112.98 / EURO	INR- 2 ,67,343.7
05	Fume Hood	Mahendra Scientific 84/6 Factory Area , Kanpur		INR- 1,66,400/-
06	10 Kva UPS online	M/s Uniline Energy Systems Ltd, New Delhi		INR- 3,39,768/-
Total Spending				**39,41,937.7/-**

Principle of operation of the various equipments:

Sl. No.	Equipment	Principle of operation
1.	Wire Bonder (Fig.1)	Wire bonding is a method of making interconnections between a microchip and other electronics as part of semiconductor device fabrication.
2.	Desk Top Mask Aligner (Fig.2)	Mask aligners are used in most microfabrication research laboratories and in even in low- volume production facilities. Almost any microscale device or structure requires more than one photomask step. The job of the contact aligner is to allow its user to align features on a substrate (wafer) to features on a photomask. The production of sophisticated electronic devices may involve ten or more of these alignment steps.
3.	DI water system (Fig.3)	Distilled water is perfect for applications where minerals and contaminants would cause problems. Distilled water can be used in irons for steam settings or as coolant for car engines. Because there are no minerals that can stain or build up, distilled water is mostly recommended for use in machinery and cleaning products. The system produces Distiller water by heating and vaporization followed by collection and condensation of the vapors.
4.	Chemical Balance (Fig.4)	A beam balance of great precision used in quantitative chemical analysis.
5.	Fume Hood (Fig.5)	A **fume hood** or **fume cupboard** is a type of local ventilation device that is designed to limit the user's exposure to hazardous or noxious fumes, vapors or dusts. A fume hood is typically a large piece of equipment enclosing five sides of a work area, the bottom of which is most commonly located at a standing work height.
6.	Gravity Convection Oven (Fig.6)	A special gas or electric oven equipped with a fan that provides continuous circulation of hot air around the sample to be heated.
7.	Optical Table (Fig.7)	A rigid horizontal bar or track for holding optical devices in experiments; it allows device positions to be changed and adjusted easily. The vibration isolation table is used along at the base for prevention of vibration transmission to the optical setup kept over this.
8.	Spin Coater (Fig.8 a& b)	Spin coating is a procedure used to apply uniform thin films to flat substrates. In short, an excess amount of a solution is placed on the substrate, which is then rotated at high speed in order to spread the fluid by centrifugal force. A machine used for spin coating is called a spin coater, or simply spinner.
9.	Air cooled Chiller (Fig.9)	A chiller is a machine that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle. A vapor-compression water chiller comprises the 4 major components of the vapor-compression refrigeration cycle (compressor, evaporator, condenser, and some form of metering device). The chiller will be used to fed the PECVD/ Sputtering systems etc.
10.	Sputtering / PECVD Dual System (Fig.10)	Chemical vapor deposition (CVD) is an important technique for creating material films on a substrate. In a CVD process, gaseous reactants are introduced into a reaction chamber. Reactions occur on heated substrate surfaces, resulting in deposition of the solid product. Other gaseous reaction products leave the chamber. The gas that carries the reactants is called carrier gas. Various types of CVD reactors are built to perform the CVD processes. PECVD processes have a part of their energy in the plasma; thus lower substrate temperature is needed, typically of the order of 100-300 deg. C.
11.	Oxidation Furnace (Fig.11)	Thermal oxidation is a simple route to cover a silicon substrate with oxide. In microdevices oxide may be used for a variety of purposes from chemical attachment and modifiability of surfaces to using oxide as a filler material in gaps etc. in microfluidic channels with submicron accuracy level or making microcantilevers. Based on the type of oxidation thermal oxide may be categorized as dry and wet oxides. In dry oxidation pure oxygen reacts with silicon at high temperatures from 800 deg. C to about 1200 deg. C.
12.	Dicing Saw (Fig. 12)	A dicing saw employs a high-speed spindle fitted with an extremely thin diamond blade to dice or groove semiconductor wafers and other work-pieces.

List of equipment already Purchased, Received/ Installed, Equipment Capabilities:

Sl. No.	Equipment	Specification	Capability Demonstration of important tools	Current Status
1.	Wire Bonder (Fig.1)	Wedge-Wedge Wire Bonders, Manual X-Y-Z, 15X Eyepieces Substrates size: 0.500” x0 .500” to 2.00” x 2.00”	Microscopic Images of Wire Bonding appended as Annexure 1	Installed
2.	Desk Top Mask Aligner (Fig.2)	Total magnification 100X, X, Y Movement range of stage ±5 mm, Adjustment ±5°, Vacuum source - Below 21.3 Kpa (-80 Kpa from atmospheric pressure), Effective exposure area Max 100 mm, Intensity of illumination 20 mW/cm^2 (405 nm)	Microscopic image of SU8 2025 photolithography module, Minimum feature size upto 15 microns can be obtained Annexure 2	Installed
3.	DI water system (Fig.3)	Output 10 lt/hr, Reservoir capacity 25 ltrs		Installed
4.	Chemical Balance (Fig.4)	220 gram capacity x 0.0001 gram resolution, RS232 Output, Platform Size 3.3" diameter.		Installed
5.	Fume Hood (Fig.5)	Inner working size: 4'x2'x2'		Installed
6.	Gravity Convection Oven (Fig.6)	2.5 CU. FT., Microprocessor Control, Maximum temperature 275°C, Temp range Range 50°C to 275°C, Temp control accuracy ±0.5°C, Watts 1300, Overall dimensions 25.8 x 26 x 23.5 in., Shipping weight 54 kg		Installed
7.	Optical Table (Fig.7)	Vibration isolation system – Pneumatic (4 high pressure cylinder), Table size 6’ x4’ x2”		Installed
8.	Spin Coater (Fig.8 a& b)	Dimensions: 28 (w) x 45 (d) x 24 (h) cm Substrate size: fragments and substrates up to Ø160 mm (or 6”) or 4"x4", Speed 1-10.000 rpm		Installed
9.	Air cooled	2 TR capacity, Temperature range: - 55^{0}C		Installed

	Chiller (Fig.9)	to + 30^{0}C, Finned tube condenser, 2.4 kW Power		
10.	Sputtering / PECVD Dual System (Fig.10)	Plasma Source: Three mass flow controllers (SiH_4/ Ar,NH_3, NO), 8” SS Heated (300 deg. C) temp. controlled biasable rotating1-3 RPM Chamber: 14” x 14” x 14” stainless steel. & wafer load 8”, Vacuum base pressure 5x10^{-7} Torr		Yet to be installed
11.	Oxidation Furnace (Fig.11)	Dims: 710 x 650 x 460, Vacuum capacity: 5 x 10-2 mbar Max, Heating: 6 heaters, Max capacity: Wafer: 40 x 100mm Dia, 4.76 mm pitch, Ceramic: 40 pieces 2" x 2 ",Substrate: 10 pieces 4" x 4", Flat zone: 100mm Dia, Temperature: 1000 Deg C Continuously		Installation planned on 19th January 2010
12.	Dicing Saw (Fig.12)	Fully automatic dicing saw for up to 150mm substrates, air bearing spindle, split field video alignment, 0-120 degrees wafer chuck rotation, 5,000 to 45,000 rpm spindle speed, minimum index step 3 microns		Installation planned on 21st January 2010

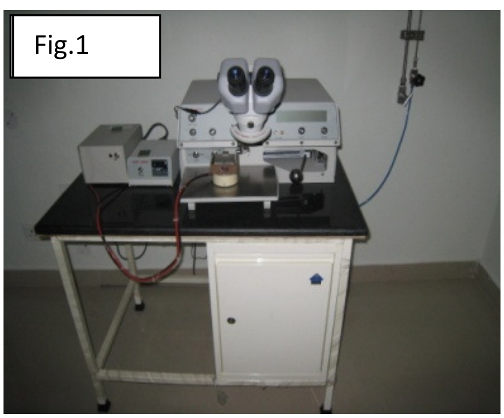


Fig.1

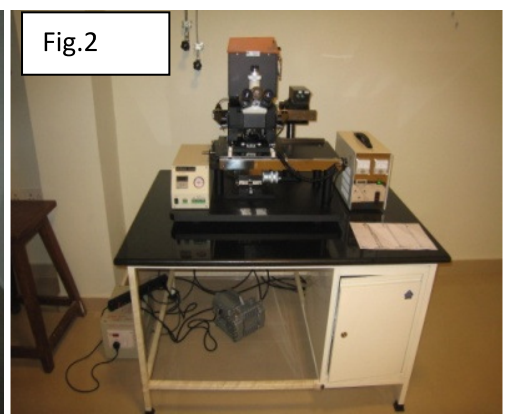


Fig.2


Fig.3

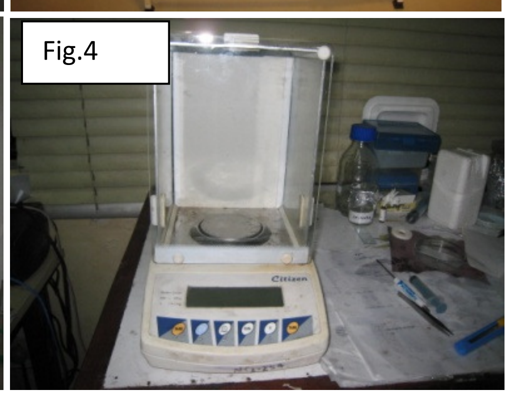


Fig.4

Fig.5

Fig.6

Fig.7

Fig.8a

Fig.8b

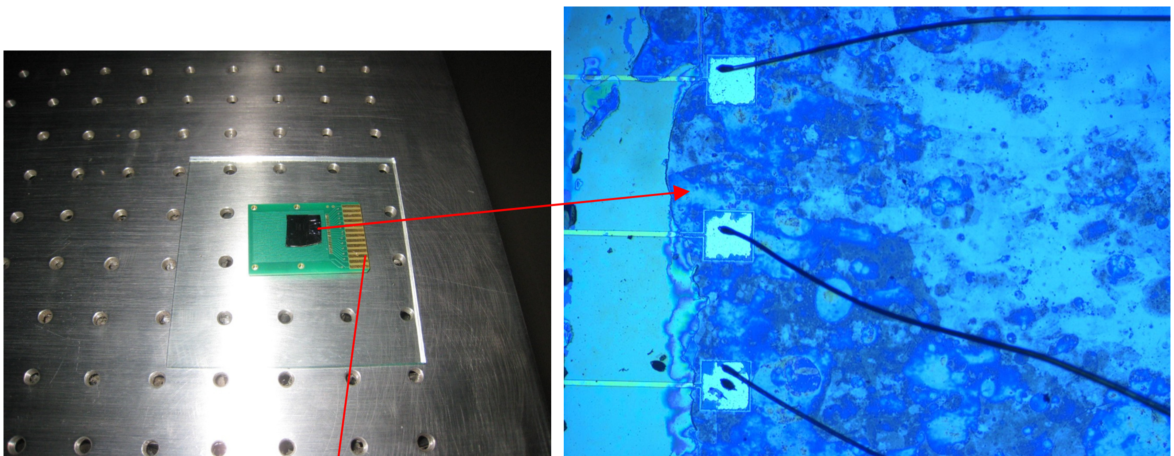
Fig.9

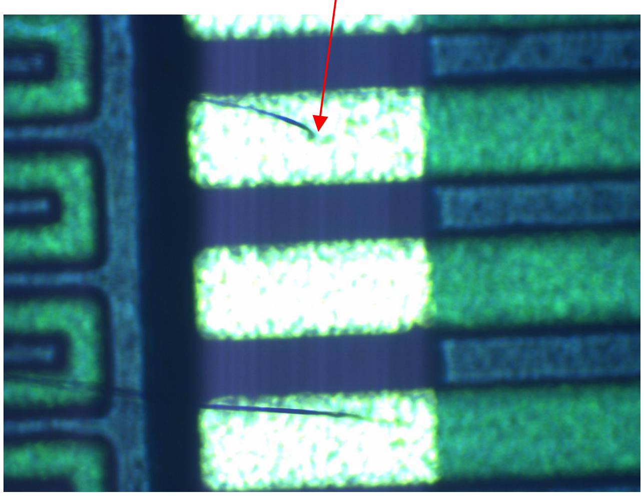
Fig.10

Fig.11

Fig.12

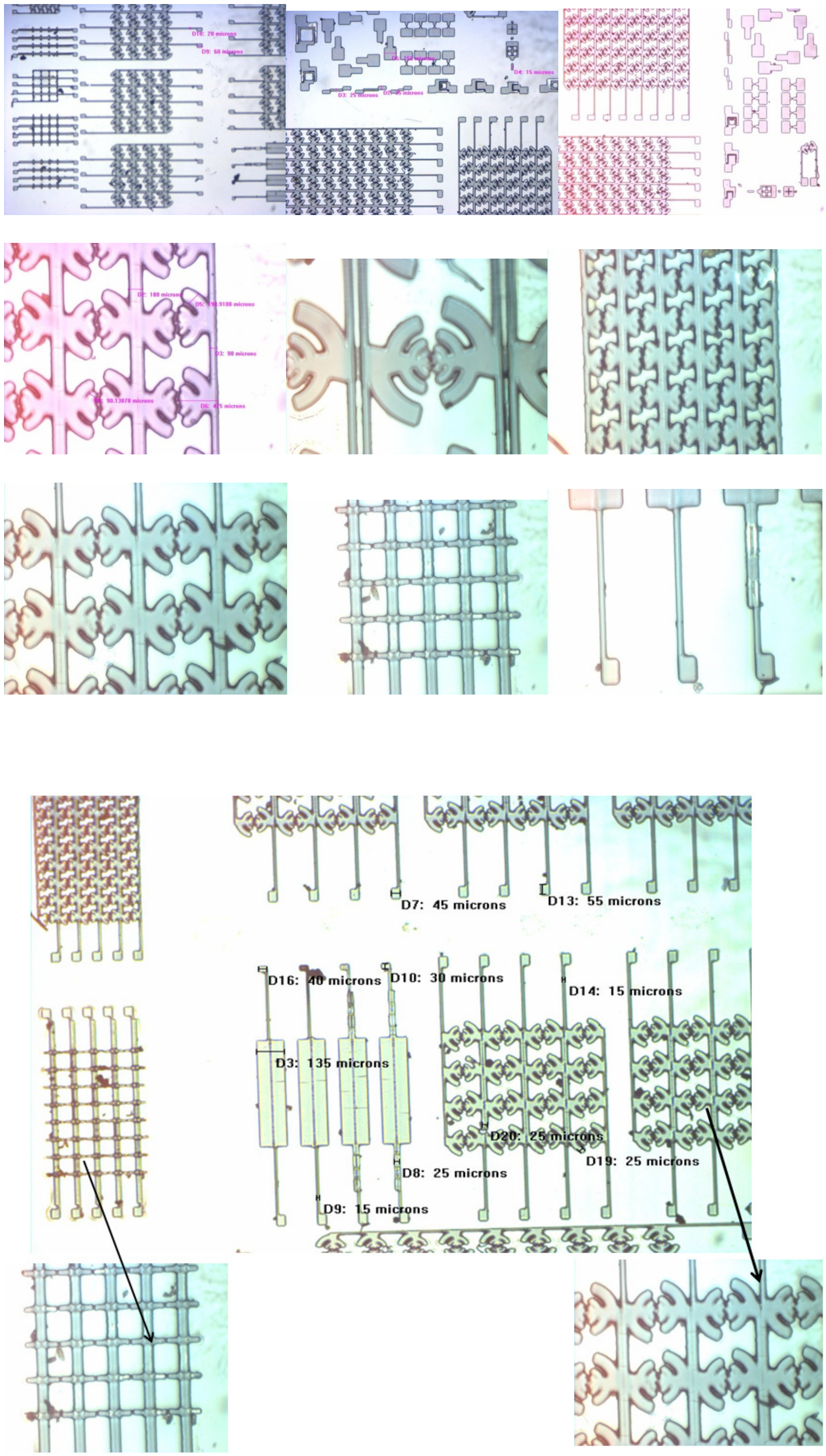
Annexure 1: (Wire bonded Chip, different views)





Wire-bonded microchip different views

Annexure 2: (Optical Micrographs of output from Mask Aligner on Spin Coated SU8 2025 photoresist)



Facility Layout done within the Mechanical Engineering Department:

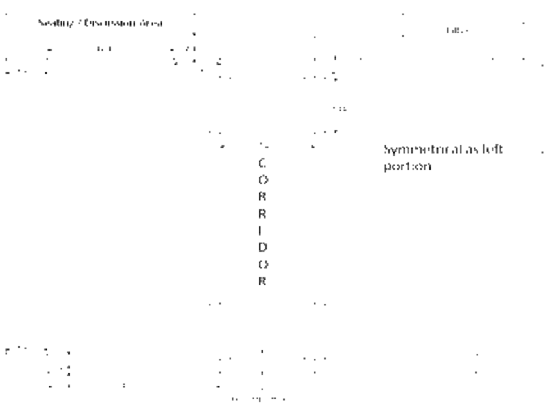


Fig.: Outer layout

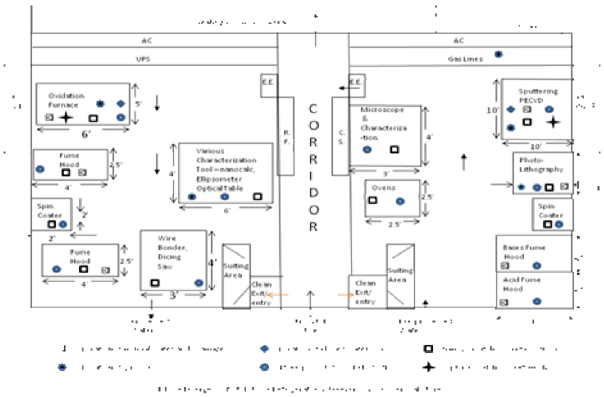


Fig.: Equipment layout

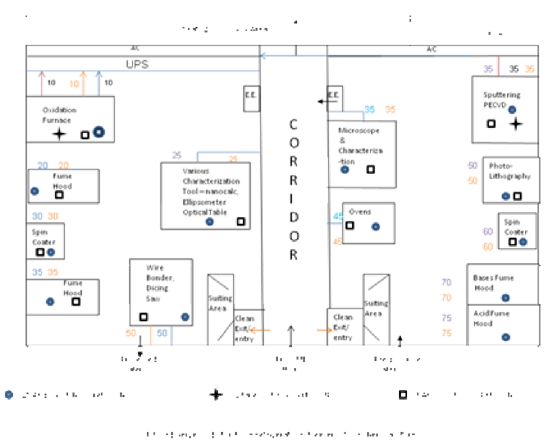


Fig.: Electrical system layout

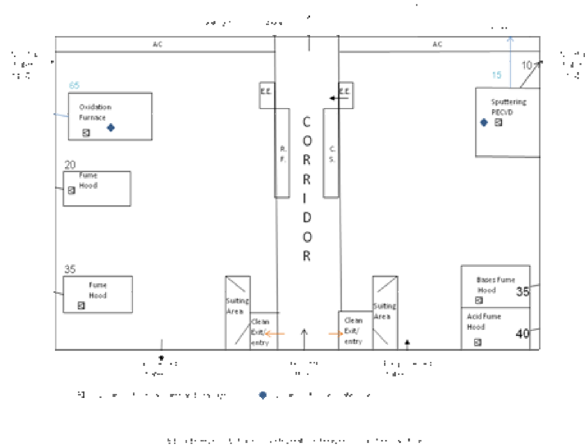


Fig.: Plumbing system layout

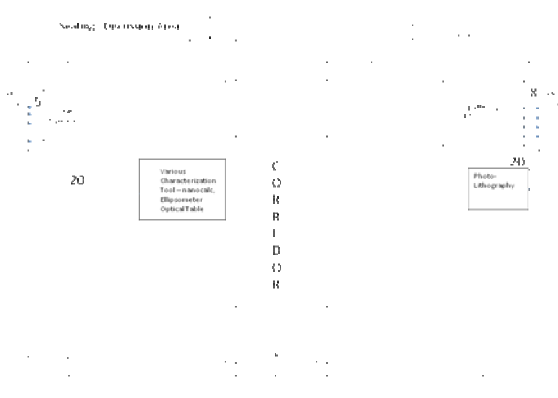


Fig.: Gas pipeline system layout

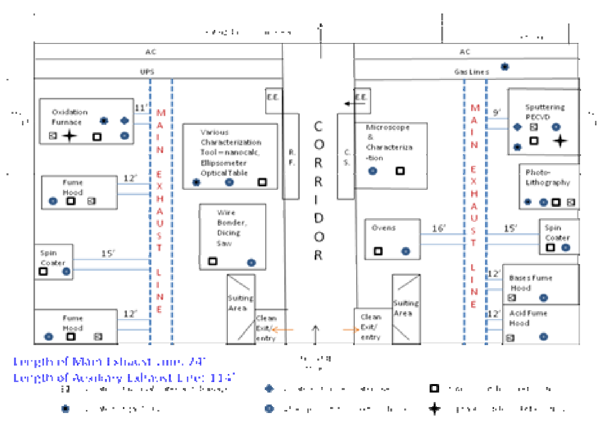


Fig.: Exhaust system layout

Facility Inauguration done on 09th September, 2009 followed by a workshop titles "National workshop on MEMS technology and its applications" sponsored by the NPMASS (National program on materials and smart structures) :