Q. 1 Write short note on smart surfaces, Skin, Paint, Matter and Dust.

Ans: Nano Markets believes an emerging opportunity for advanced materials, sensors firms and others is presented by so-called smart surfaces. Smart surfaces are most broadly defined as any material surfaces that re-arrange their morphology or composition and self-enhance their functionality in response to changes in the ambient environment.

MEMS can be permanently attached to some fixed substrate forming smart surfaces or be more free standing, forming smart structures that can reorganize.
An example of a smart surface is a paint that is able to sense vibrations because it is loaded with a fine powder of a piezoelectric material called lead zirconatetitanate (PZT).
When PZT crystals are stretched or squeezed, they produce an electrical signal that is proportional to the force (Berlin and Gabriel, 1997).
MEMS could be mixed with a range of bulk materials, such as paints, gels, and spread on surfaces or embedded into surfaces or scattered into and carried as part of other media such as air and water.
For example, coating bridges and buildings with smart paint could sense and report traffic, wind loads and monitor structural integrity.
A smart paint coating on a wall could sense vibrations, monitor the premises for intruders, and cancel noise (Abelson et al., 2000). Smart surfaces can also be woven out of organic polymers that have light emitting and conductive properties.
Organic computing can be used to form smart skin and smart clothes.
Similar to sensor nets, MEMS can also be networked in MEMS nets.
The Smart Dust project led by Kris Pister produced prototypes of many novel types of low powered networked MEMS sensors. In the Claytronics Project,10 Goldstein et al. (2005) have proposed using masses of thousands to millions of sensor, actuator and locomotion MEMS devices that can behave as malleable programmable matter and can recreate artefact's for a wide range of physical shapes and objects.
A long term goal of such MEMS ensembles is to enable these to be self assembled in any arbitrary 3D shape, to achieve a synthetic reality.
Synthetic reality, unlike virtual reality or augmented reality, allows users to experience synthetic reality without any sensory augmentation, such as head mounted displays and so to be able to physically interact with any object in the system in a natural way.
The programmable matter idea introduced in the Claytronics Project uses re assembly and the use of moving electronics around for communication to produce new forms for matter. Perhaps the ultimate programmable matter is to base it upon nanotechnology, to be able to engineer matter on the molecular level, moving molecules around not just electrons. Others refer to such ensembles of computational particles, dispersed irregularly on a surface or throughout a volume where individual particles have no a priori knowledge of their positions or orientations, as amorphous computing and spray computing. These particles are possibly faulty, may contain sensors and effect actions, and in some applications might be mobile and referred to as amorphous computing particles .New design and fabrication models are needed to engineer such systems. Novel techniques are needed to manage groups of MEMS devices perhaps by incorporating behaviors based upon self organizing interaction mechanisms.

Q. 2 Explain the main functional characteristics for sensor net deployment.

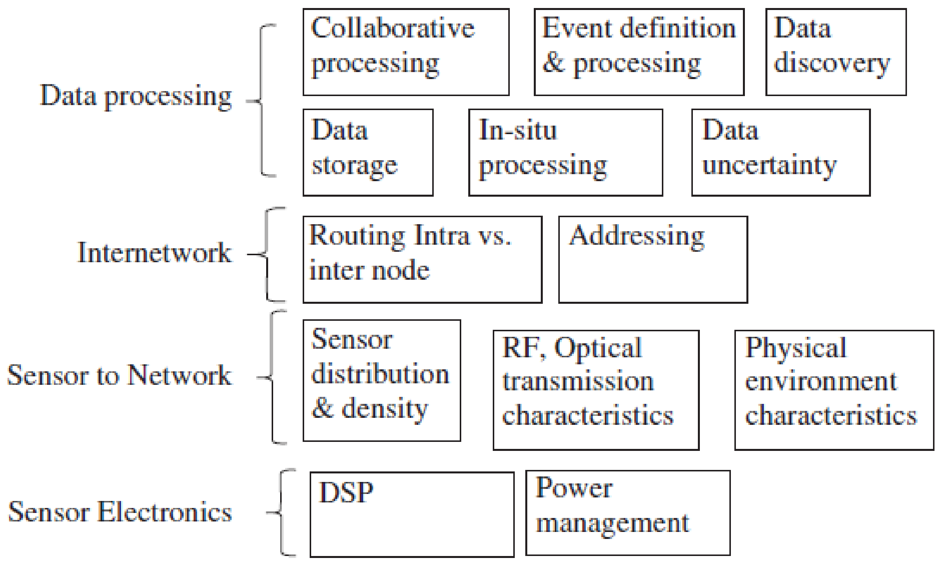

Figure: Functional Characteristics for sensor net deployment

Data Processing:
The Data processing is also likely to be more complex for sensors than tags. Sensors mayrange in scale from nano sensors to macro sensors such as a windsock used to indicate the wind direction.

Sensor to network:

Sensors are a type of transducer that converts some physical phenomenon such as heat, light, sound into electrical signals. Sensors often act as an enabler, as inputs to a system behaviour so that it can more favorably adapt, often embedded as part of a control loop in pre programmed systems that perform specialized rather than general purpose functions, e.g., a temperature sensor may be hard wired into a heating system.Sensors like RFID tags are networked. The basic architecture is similar: sensors can act as datagenerators, intermediate or services nodes receive, post process and store data, possibly remotely. However, whereas tags just generate a fixed electrical signal, sensor data may change because it is the output from a transducer that converts varying physical phenomena into varying signals.
Sensor

Electronics:

It split into four functions: sensing, processing, transceiving and power related. The signal from the sensor is filtered and amplified, converted into a digital signal by the analogue to digital converter (ADC), some simple digital signal processing (DSP) is performed at the sensor before the signal is modulated for transmission. The MEMS design of the sensor is able to decrease the size and power consumption of the sensor by aggregating multiple separate electronic components into a single chip. Sensors often need to be able to operate unattended, long lived, low duty cycle systems.

Q. 3 Explain challenges in designing and deploying sensors and some corresponding solutions.

Challenges of sensor net system	Designing Solutions
Sensor energy is a scarce resource for data transmission	Use a sensor net that deploys, low power, short range transmissions Network sensors into mesh networks and use multi hop transmissions
Limited memory and computation power in sensors	Filter data in situ and transmit only filtered data Harvest renewable energy from the environment and store
Dynamic and non deterministic spatial temporal distribution of events. May not be able to pre determine how to optimally deploy individual sensors	Use a sensor net to increase the sensor density around estimated signal source positions when deterministic; Design sensor distributions to be reconfigurable, self organizing, to be mobile Support variable sampling and support bursty data collection
Sensor failure is common due to a lack of power, physical damage, active (jamming) or passive environmental interference of the transceiver, access node or non optimal positioning	Use dense networks of low power sensors with redundant paths to route data through the network Use of counter measures and frequency shifts Locators and trackers are needed to locate (moving) sensors and can be used to position them
Multi hop sensor networks may have a dynamic topology. No global knowledge about structure of network may be known Sensors can be too costly to update once deployed	Use specialised routing protocols to work over dynamic mesh topologies
Sensors can generate huge quantities of data	Design sensors and sensor access nodes to be low maintenance. Support sensor redundancy Use in situ data processing both in the sensor and the sensor access node