RAMA UNIVERSITY

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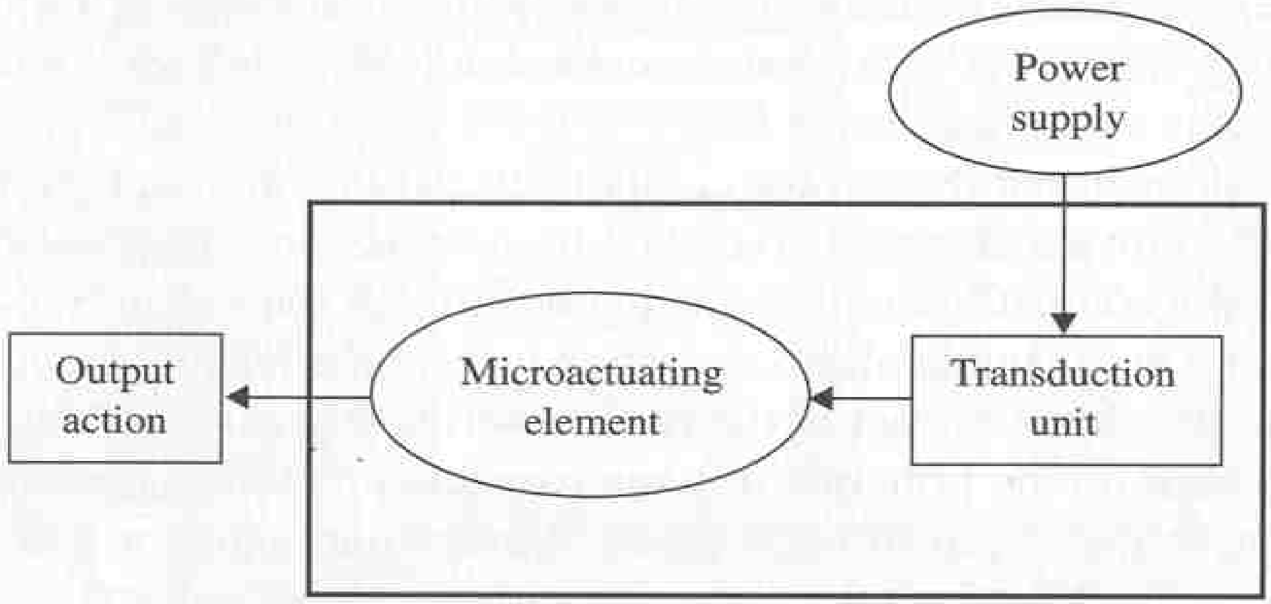
FACULTY OF ENGINEERING AND TECHNOLOGY

MEMS-035

Lecture -03

MEMS AS A MICROACTUATOR

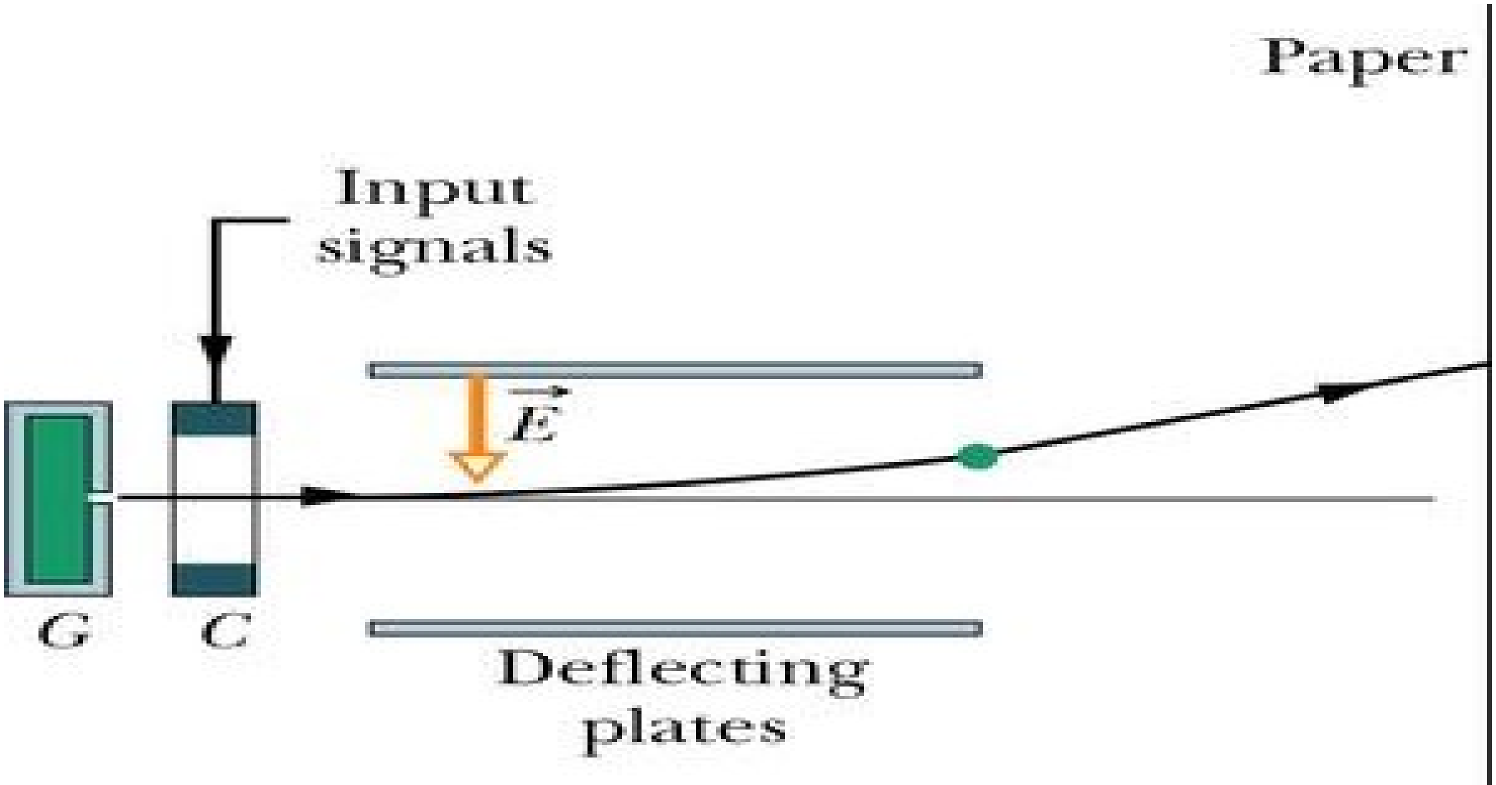
Figure 1.3 | MEMS as a microactuator.



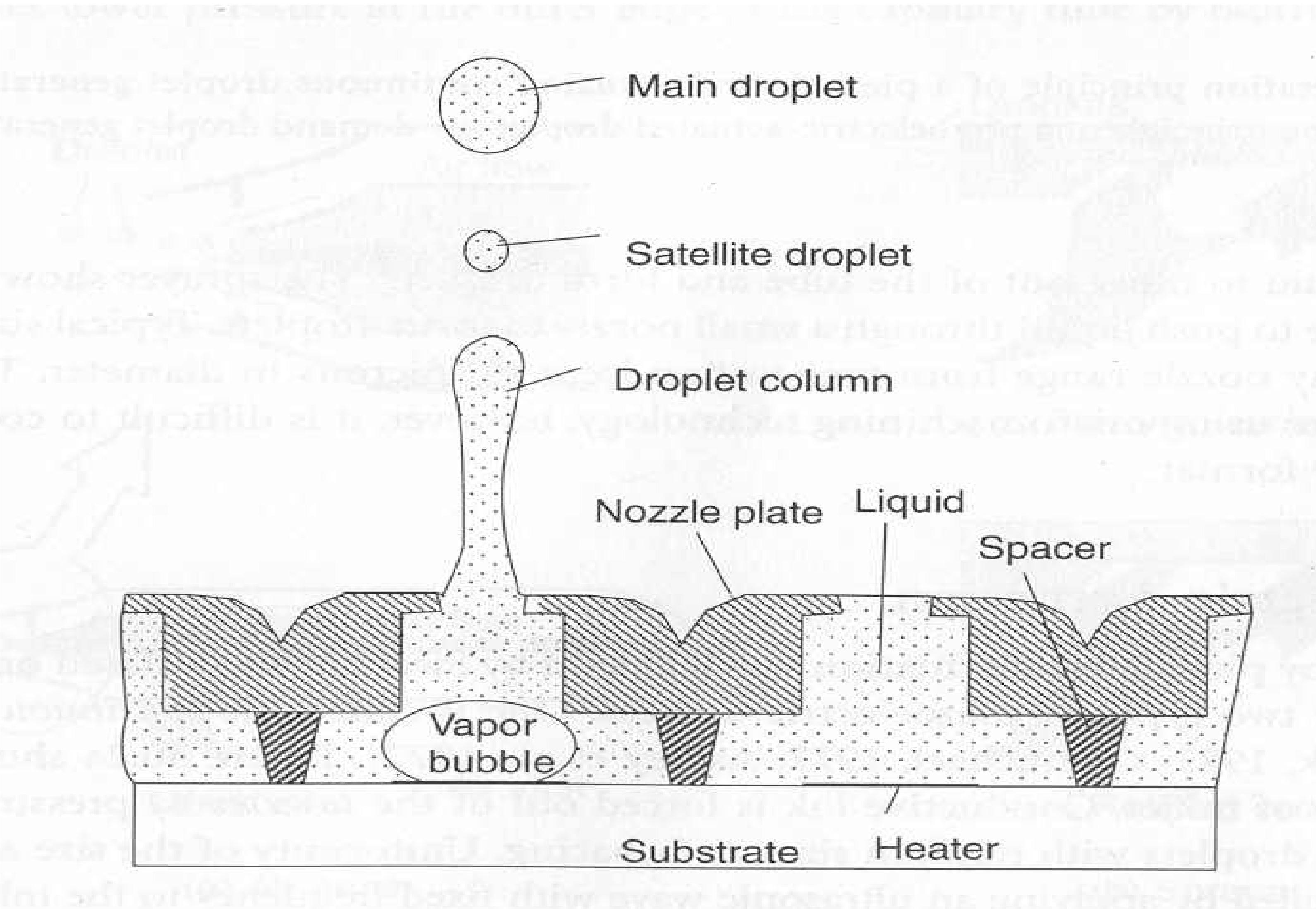
Ink-jet Printing Head

Principles of Ink-jet Printing:

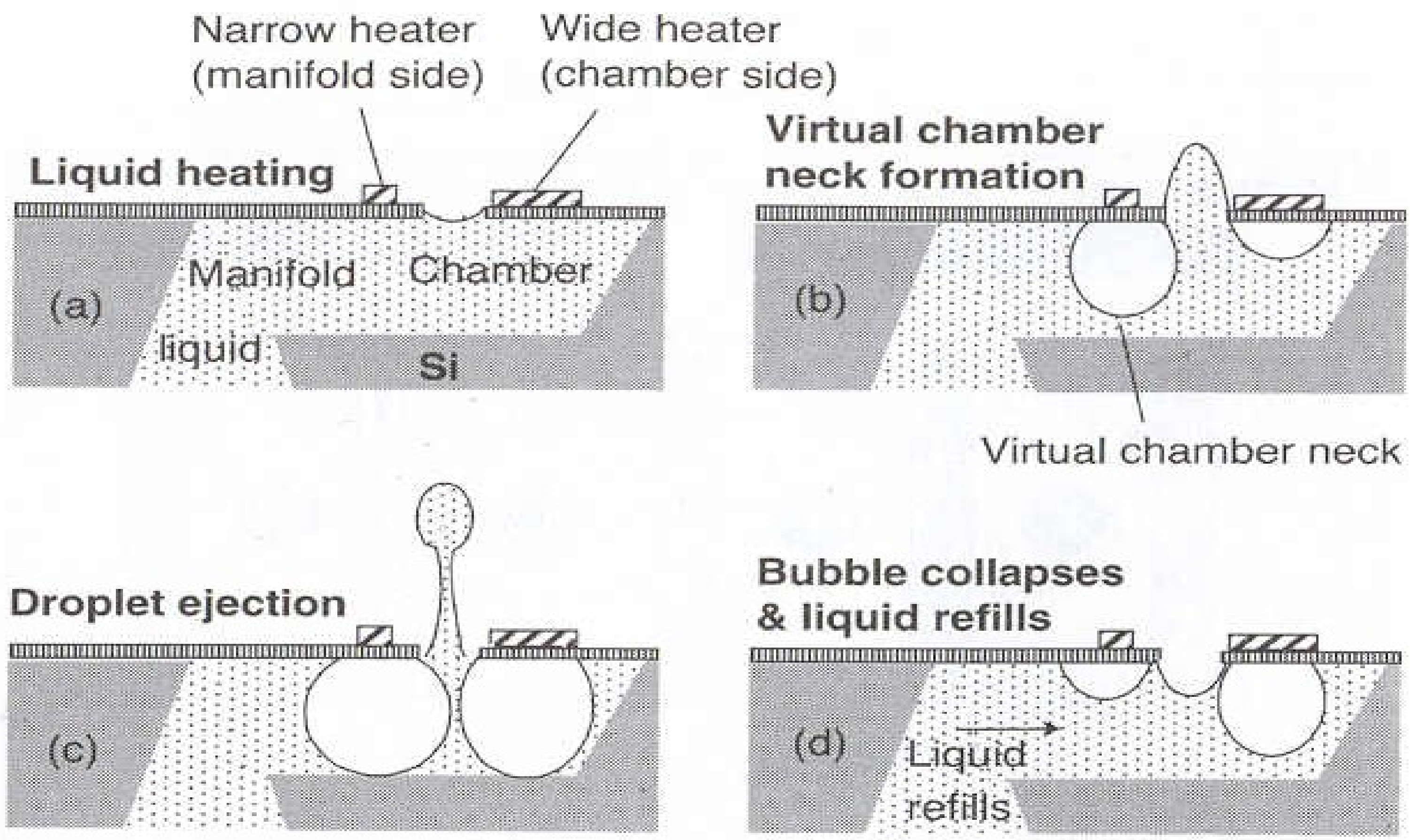
- Drops are shot out from generator *G*.
- Drops receive a charge in charging unit *C*.
- The Electric field *E* deflects the motion of the drop.
- The drop lands at the position on the paper.



A thermal-bubble-actuated droplet generator

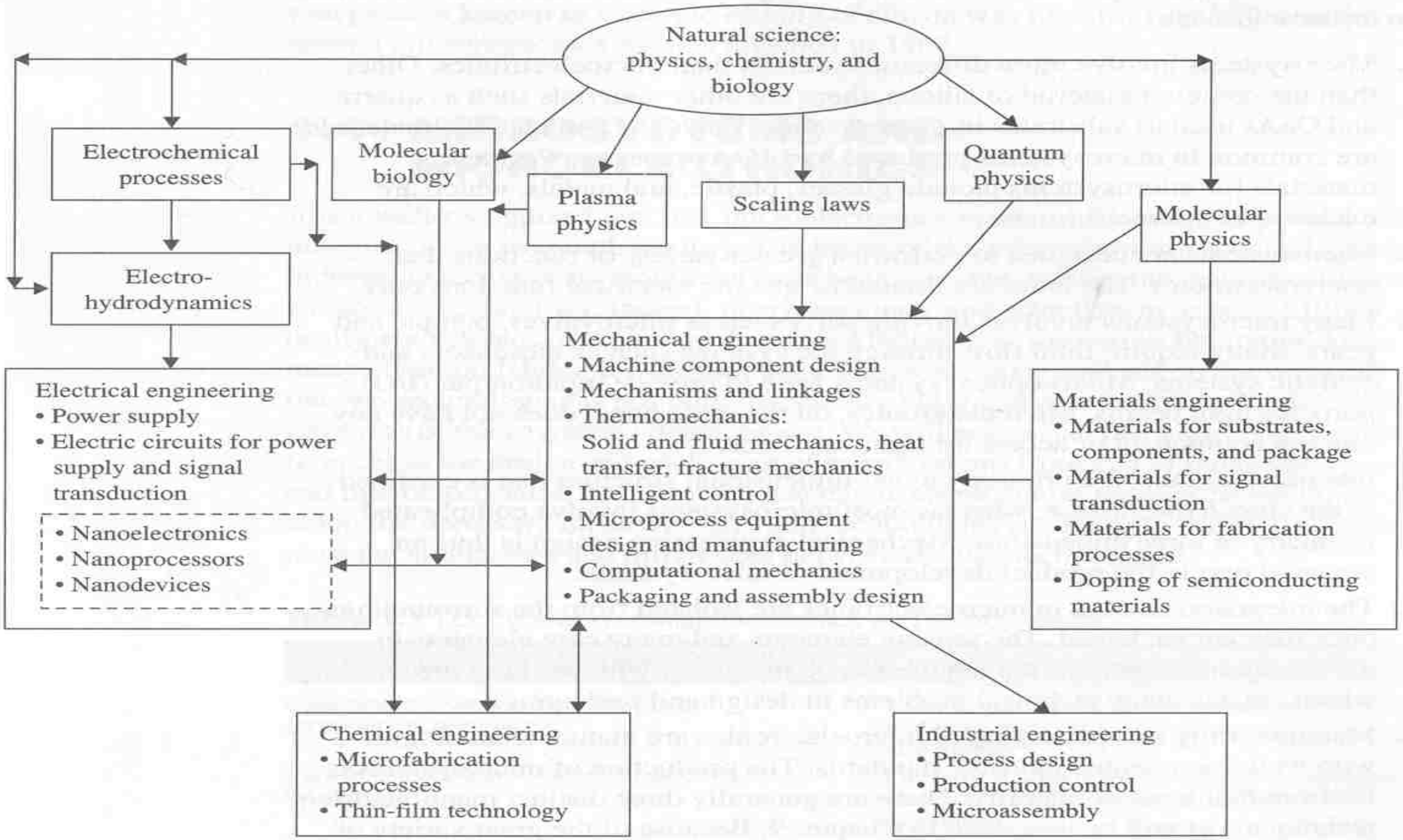


An improved droplet generator:



The Multidisciplinary Nature of Micro-system Design and Manufacturing

Figure 1.14 | Principal science and engineering disciplines involved in microsystem design and manufacture.



SCALING LAWS

In this era of “think small,” one would intuitively simply scale down the size of all components to a device to make it small. Unfortunately, the reality does not work out that way. It is true that nothing is there to stop one from downsizing the device components to make the device small. There are, however, serious physical consequences of scaling down many physical quantities.

Miniaturizing machines and physical systems is an ongoing effort in human civilization. This effort has been intensified in recent years as market demands for: Intelligent, Robust, Multi-functional and Low cost Consumer products have become more strong than ever. The only solution to produce these consumer products is to package many components into the product – making it necessary to miniaturize each individual component. Miniaturization of physical systems is a lot more than just scaling down device components in sizes. Some physical systems either cannot be scaled down favorably, or cannot be scaled down at all!

TYPES OF SCALING LAWS:

Scaling in Geometry

Scaling of Phenomenological Behavior

SCALING IN GEOMETRY

- ✓ Volume (V) and surface (S) are two physical parameters that are frequently involved in machine design.
- ✓ Volume leads to the mass and weight of device components.
- ✓ Volume relates to both mechanical and thermal inertia. Thermal inertia is a measure on how fast we can heat or cool a solid. It is an important parameter in the design of a thermally actuated device.
- ✓ Surface is related to pressure and the buoyant forces in fluid mechanics.

For instance, surface pumping by using piezoelectric means is a practical way for driving fluids flow in capillary conduits.

If we let ℓ = linear dimension of a solid, we will have:

The volume: $V \alpha\, l^3$

The surface: $S \alpha\, l^2$

Then S/V = ℓ^{-1}

SCALING IN RIGID-BODY DYNAMICS

- ❑ Forces are required to make parts to move such as in the case of micro actuators.
- ❑ Power is the source for the generation of forces.
- ❑ An engineer needs to resolve the following issues when dealing with the design of a dynamics system such as an actuator: The required amount of a force to move a part, how fast the desired movements can be achieved, How readily a moving part can be stopped.
- ❑ The resolution to the above issues is on the inertia of the actuating part.
- ❑ The inertia of solid is related to its mass and the acceleration that is required to initiate or stop the motion of a solid device component.
- ❑ In the case of miniaturizing these components, one needs to understand the effect of reduction in the size on the power (P), force (F) or pressure (p), and the time (t) required to deliver the motion.

Scaling in Electrostatic Forces

Scaling in Electromagnetic Forces

Electromagnetic forces are the principal actuation forces in macro-scale, or traditional motors and actuators.

Scaling in Fluid Mechanics

Scaling in Electricity

Scaling in Heat Conduction