



ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

AUTONOMOUS INSTITUTION

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VII Semester

AU3008 Sensors and Actuators

UNIT – 3 - Variable and Other Special Sensors

3.8 Humidity Sensors

- Humidity sensors are electronic devices that measure the amount of water vapor present in the air. They are widely used in various applications, from weather forecasting to HVAC systems.

3.8.1 Define: Humidity. - Definition:

Humidity refers to the amount of water vapor present in the air. It is an important atmospheric parameter that affects weather, human comfort, and various natural processes. Humidity can be described in different ways, including:

1. **Absolute Humidity:** The total mass of water vapor in a given volume of air, typically expressed in grams per cubic meter (g/m^3).
2. **Relative Humidity (RH):** The ratio of the current amount of water vapor in the air to the maximum amount it can hold at a given temperature, expressed as a percentage. For example, a relative humidity of 50% means the air contains half the water vapor it can hold at that temperature.
3. **Specific Humidity:** The mass of water vapor per unit mass of air, including the water vapor, typically expressed in grams per kilogram (g/kg).
4. **Dew Point:** The temperature at which air becomes saturated with water vapor and condensation begins. It provides an indirect measure of humidity.

3.8.2 Different types of Humidity Sensors:

1. Capacitive Humidity Sensors
2. Resistive Humidity Sensors
3. Thermal Conductivity Humidity Sensors
4. Optical Humidity Sensors

5. Piezoelectric Humidity Sensors
6. Gravimetric Humidity Sensors
7. Carbon Nanotube (CNT) Sensors
8. Dew Point Hygrometers

3.8.2 Capacitive Humidity Sensors:

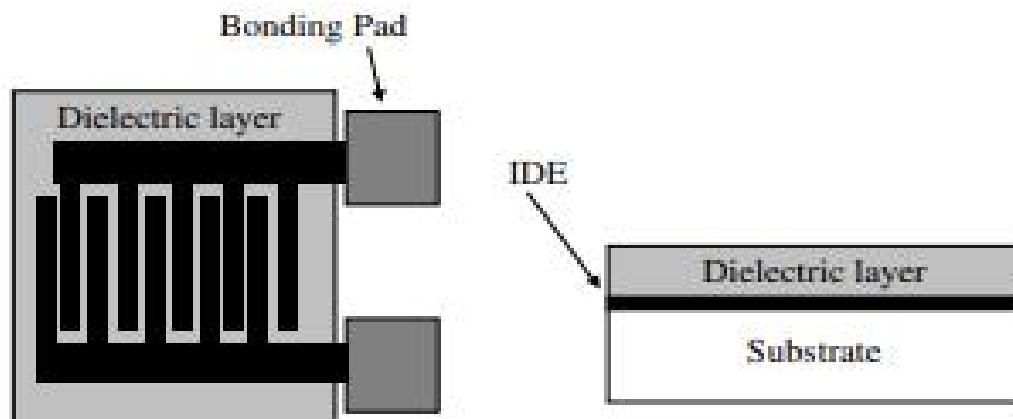


Fig. 3.8.1 Capacitive humidity Sensor

The Fig. 3.8.1 shows a capacitive humidity sensor. The components are explained below:

1. Dielectric Layer:

- ❖ This is the material that absorbs or desorbs water vapor from the air.
- ❖ The dielectric constant of this layer changes with humidity, which affects the sensor's capacitance.

2. IDE (Interdigitated Electrodes):

- ❖ These are the patterned conductive electrodes placed on the substrate.
- ❖ They form the capacitor's plates, with the dielectric layer in between.

3. Substrate:

- ❖ The base material that supports the sensor structure. It is usually made of materials like silicon, glass, or polymers.

4. Bonding Pads:

- ❖ These are used to connect the sensor to external circuits for signal measurement and processing.

Working of capacitive humidity sensors:

- The dielectric layer **absorbs water vapor** from the surrounding environment.
- The absorbed moisture **changes the dielectric constant** of the layer.
- This, in turn, causes a **change in the capacitance** between the interdigitated electrodes, which is measured and calibrated to correspond to relative humidity.

3.8.3 Resistive Humidity Sensors:

- ❑ Resistive humidity sensors measure the humidity level by detecting changes in electrical resistance caused by the absorption of water vapor in a hygroscopic material. These sensors are simple, cost-effective, and widely used in applications where moderate accuracy is sufficient.

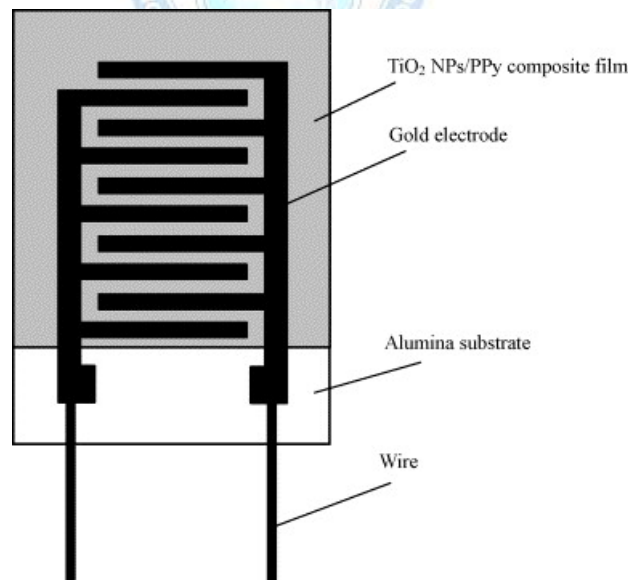


Fig.3.8.2 Resistive humidity sensor

The **Fig. 3.8.2** illustrates a **Resistive Humidity Sensor** and its components. The explanation for components is given below.

1. TiO₂ NPs/PPy Composite Film:

- ❖ This is the hygroscopic layer made of a composite material (e.g., titanium dioxide nanoparticles and polypyrrole).
- ❖ It absorbs water vapor from the air, altering its electrical conductivity, which is used to determine the humidity level.

2. Gold Electrode:

- ❖ These are conductive electrodes that allow the measurement of electrical resistance changes in the composite film.
- ❖ Gold is often used due to its excellent conductivity and resistance to corrosion.

3. Alumina Substrate:

- ❖ The base material that provides mechanical support for the sensor components.
- ❖ Alumina (Al₂O₃) is commonly used because of its stability, durability, and electrical insulation properties.

4. Wire:

- ❖ The wires connect the sensor to the external circuitry for power supply and signal measurement.

Working of Resistive humidity sensors are,

- The composite film absorbs moisture from the air.
- As the film absorbs water, its ionic conductivity increases, which decreases its electrical resistance.
- The change in resistance is measured via the gold electrodes, and this value is converted into a humidity reading.

Applications of Resistive humidity sensors are,

- ❖ Industrial monitoring.
- ❖ Environmental control systems.
- ❖ Medical devices.
- ❖ Food storage monitoring.

3.8.4 Optical Humidity Sensors:

- ❑ Optical humidity sensors measure humidity by detecting **changes in the optical properties** of a medium caused by water vapor.
- ❑ These changes could involve light **absorption, reflection, scattering, or refractive index** modifications.
- ❑ They are non-contact sensors that rely on optical principles and are highly precise.

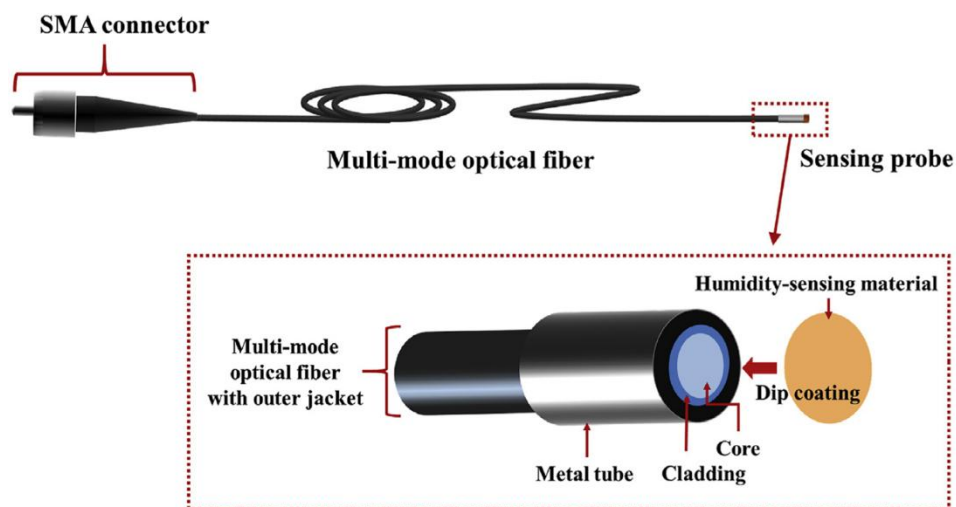


Fig.3.8.3. Fiber optic humidity Sensor

The Components of Fiber optic humidity sensors are,

Components:

1. **SMA Connector:**

- ❖ The connector interfaces the optical fiber with external light sources or photodetectors. It ensures efficient light transmission.

2. **Multi-Mode Optical Fiber:**

- ❖ A type of optical fiber used to guide light. It has a larger core compared to single-mode fibers, enabling multiple light paths (modes).
- ❖ The fiber is coated with an outer jacket for protection.

3. **Sensing Probe:**

- ❖ The active sensing area of the optical fiber where humidity is detected.
- ❖ Includes the following sub-components:

- ✓ **Core:** The central part of the optical fiber where light propagates.
- ✓ **Cladding:** Surrounds the core and helps confine the light within the core by total internal reflection.
- ✓ **Humidity-Sensing Material:** A hygroscopic material applied to the fiber via dip-coating. This material absorbs moisture, altering its optical properties (e.g., refractive index).

4. **Metal Tube:**

- ❖ Provides structural protection for the sensing area, shielding it from mechanical damage and environmental contaminants.

5. **Humidity-Sensing Material (Dip-Coated):**

- ❖ The layer that responds to humidity changes by altering its optical behaviour, such as refractive index, light transmission, or scattering.

The working of fiber optic humidity sensors are as follows

1. **Light Transmission:** Light is emitted from a source (e.g., LED or laser) and travels through the optical fiber to the sensing probe.
2. **Humidity Detection:** When the surrounding humidity changes, the hygroscopic material absorbs or desorbs water vapor.
3. This changes the material's **optical properties** (e.g., refractive index), which affects the light traveling through the fiber.
4. **Signal Processing:** The modified light signal is detected at the output end by a photodetector.
5. Changes in the **light intensity**, phase, or wavelength are analyzed and correlated with humidity levels.

Advantages:

- High precision and sensitivity.
- Immune to electromagnetic interference.
- Suitable for harsh and remote environments.
- Compact and lightweight.
