Microstrip Antennas

(Chapter 14 in *Antenna Theory, Analysis and Design* (2nd Edition) by Balanis)

Microstrip antennas (AKA patch antennas) were first proposed in 1950s. The greatest interest in microstrip antennas, leading to development and research, started in 1970s.

Advantages:

- Low weight
- Low profile
- Low cost (can use printed circuit board techniques/tools)
- Conformable to surfaces
- Mechanically sturdy
- MMIC compatible
- Flexible with regard to polarization, frequency, pattern & impedance.

Disadvantages:

- Low efficiency
- Low power
- High Q (narrow bandwidth)
- Poor polarization purity
- Poor scan performance
- Spurious (i.e., unwanted) feed radiation

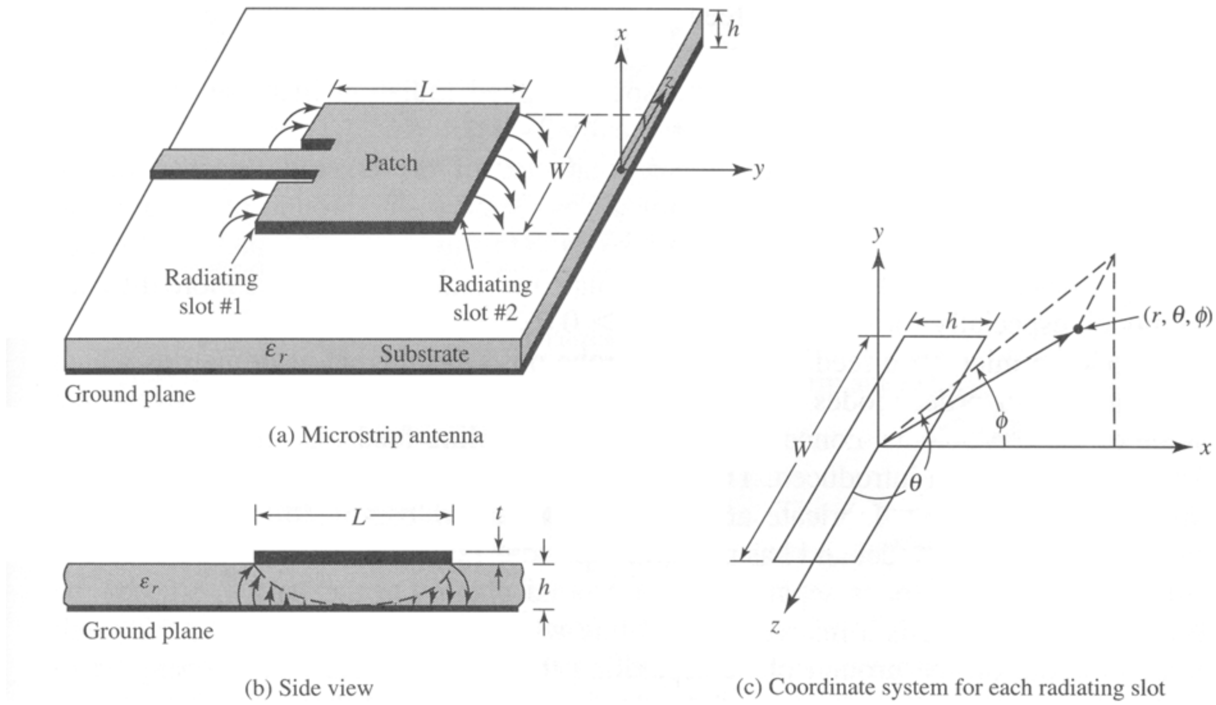

Figure 14.1 Microstrip antenna … (From Balanis, *Antenna Theory, Analysis and Design* (*Second Edition*))

Notes:

- Elements are thin metallic strips or patches (i.e., the metallization thickness $t \ll \lambda_0$, where λ_0 is the free-space wavelength).
- Elements typically placed above a ground plane and supported by a dielectric substrate (with the substrate thickness $h \ll \lambda_0$, typically $0.003\,\lambda_0 \leq h \leq 0.05\,\lambda_0$) where typical relative dielectric constants range from $2.1 < \varepsilon_r < 12$ for plastics to ceramics, respectively.
- Radiation pattern maximum is usually normal (broadside) to the patch.
- For the rectangular patch shown, $\lambda_0/3 < L < \lambda_0/2$.

- Microstrip antennas can take many forms or shapes. Those shown below are just a small sampling.

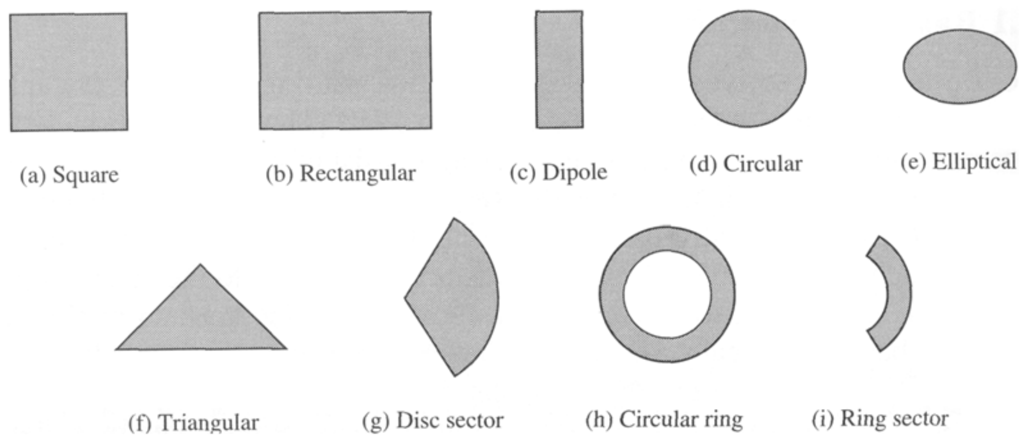

Figure 14.2 Representative shapes of microstrip patch elements. (From Balanis, *Antenna Theory, Analysis and Design* (*Second Edition*))

<u>Feed methods</u>

The four most widely used feed methods are: 1) microstrip transmission line, 2) coaxial probe, 3) aperture coupling, and 4) proximity coupling.

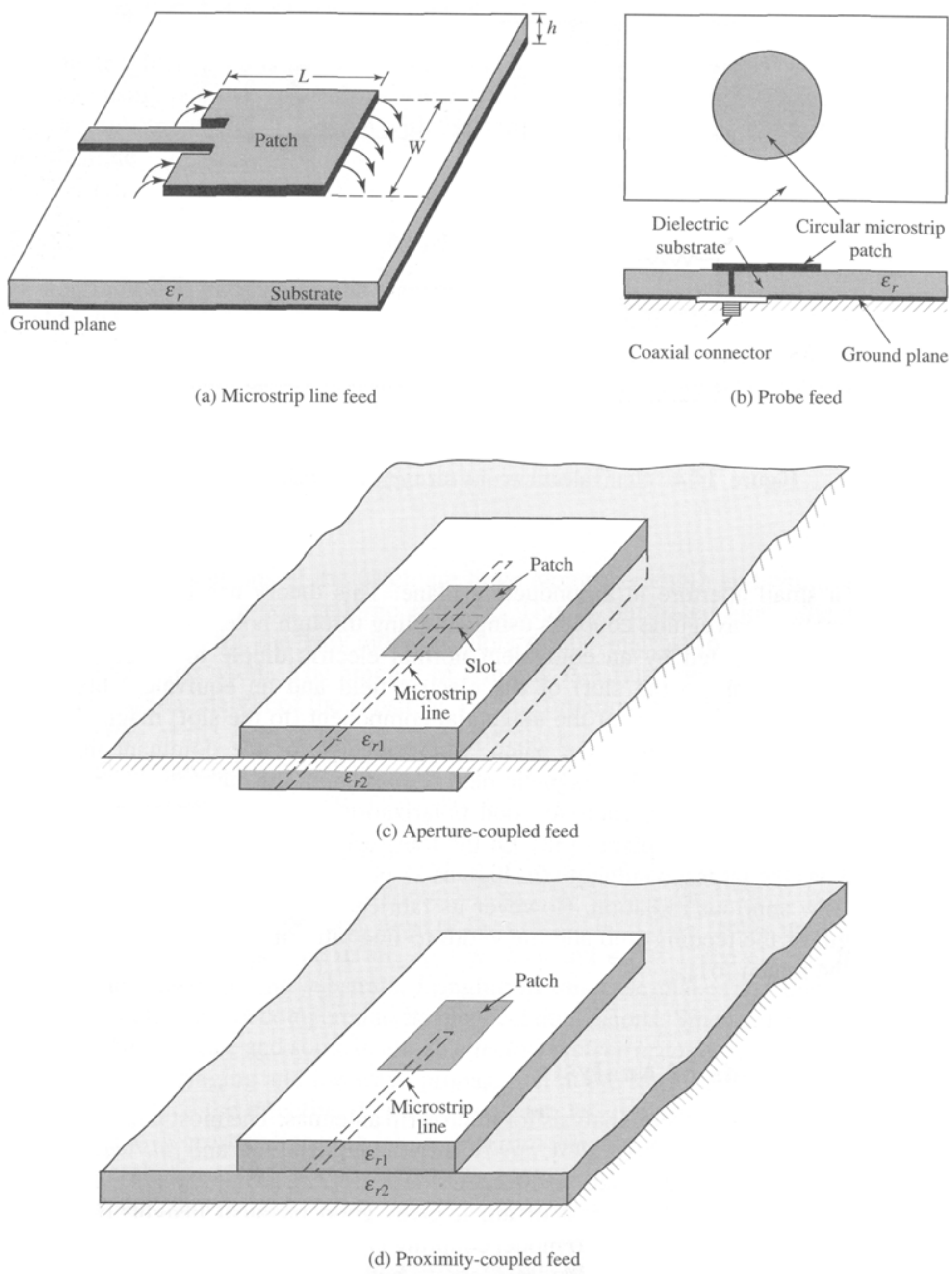

Figure 14.3 Typical feeds for microstrip antennas. (From Balanis, *Antenna Theory, Analysis and Design* (*Second Edition*))

Comments on feeding methods:

1) Microstrip transmission line
   - easy to make, match, & model
   - asymmetric feed (cross-polarization problems)
   - can excite surface waves (i.e., waves inside dielectric) if *h* too big
   - can get spurious feed radiation
   - BW ~ 2 to 5%

2) Coaxial probe
   - easy to make & match
   - harder to model, particularly as *h* increases
   - asymmetric feed (cross-polarization problems)
   - not much spurious feed radiation
   - BW ~ 2 to 5%

3) Aperture coupling
   - harder to make & match
   - easier to model
   - symmetric feed (if slot centered)
   - low spurious feed radiation (ground plane in between)
   - BW ~ 2 to 5%

4) Proximity coupling
   - harder to make & match
   - easier to model
   - symmetric feed (if transmission line centered)
   - low spurious feed radiation
   - largest BW, up to 13%

Analysis Techniques

There are three primary models for analyzing microstrip antennas.

1) Transmission line
    - Easiest
    - Good physical insight
    - Less accurate
    - Difficult to analyze coupling

2) Cavity
    - More accurate
    - More complex/difficult
    - Good physical insight
    - Difficult to analyze coupling

3) Full-wave (e.g., CST, XFDTD, ... numerical packages)
    - Very accurate
    - Very flexible (single elements, arrays, arbitrary shapes, …)
    - Can handle coupling
    - More complex
    - Less physical insight