Silicon Photonics
矽光子學
1 Fundamentals of Photonics

課程編號：941 U0460
科目名稱：矽光子學
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Outline

- 1.1 WHAT IS PHASE?
- 1.2 WHAT IS POLARIZATION?
- 1.3 WHAT IS INTERFERENCE?

1.1 WHAT IS PHASE?

WHAT IS PHASE?

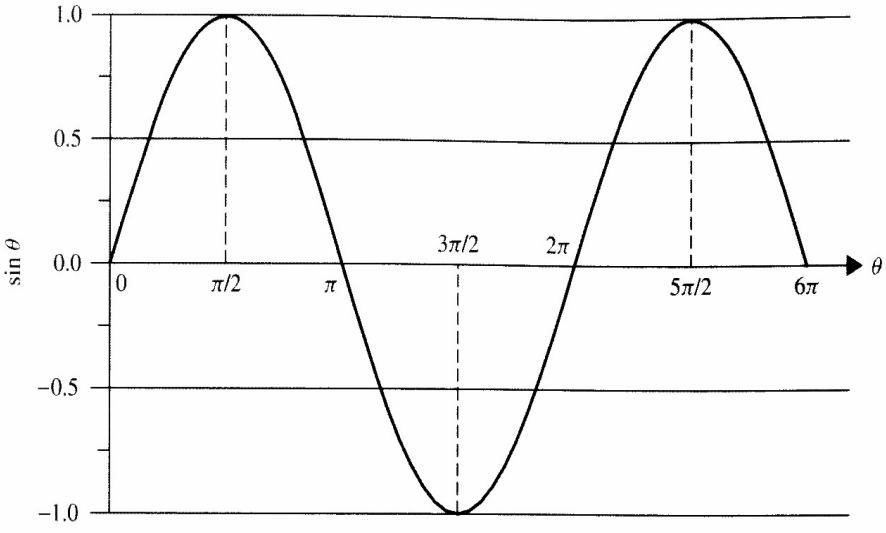

Figure 1.1 Plot of sin θ

WHAT IS PHASE?

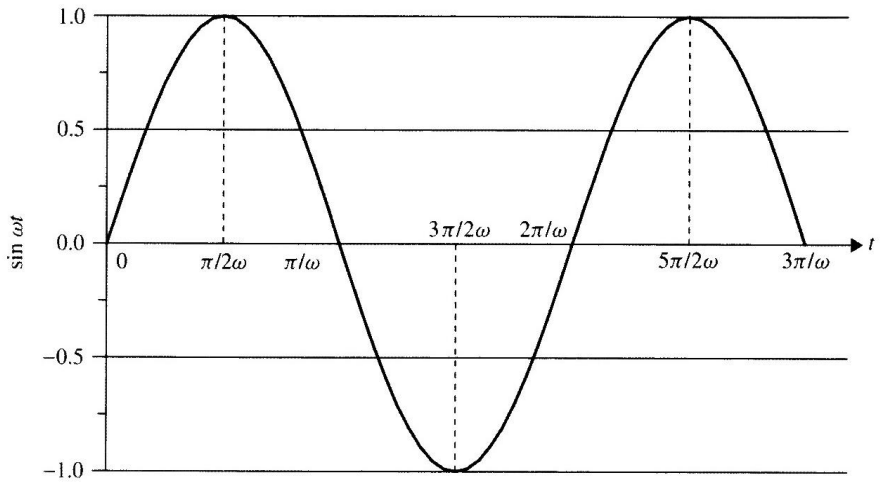

Figure 1.2 Plot of sin ωt

WHAT IS PHASE?

- *Phase angle* θ
- *Frequency, f,*
- *Angular frequency* ω

- In sin ωt $\omega = 2\pi f$
  - the phase of the function is the angle, ωt,

Propagating Optical Wave

- Exponential Form

$$E = E_0 \exp\left[j\left(kz \pm \omega t\right)\right]$$

- Sinusoidal Form

$$E = E_0 \sin\left(kz \pm \omega t\right)$$

- Phase

$$\left(kz \pm \omega t\right)$$

- k is known as the *propagation constant*
- λ is the wavelength

Propagation Constant and Wavelength

- Consider the variation of the wave with distance at a fixed time

$$\lambda = \frac{2\pi}{k}$$

$$k = \frac{2\pi}{\lambda}$$

$$\phi = kz$$

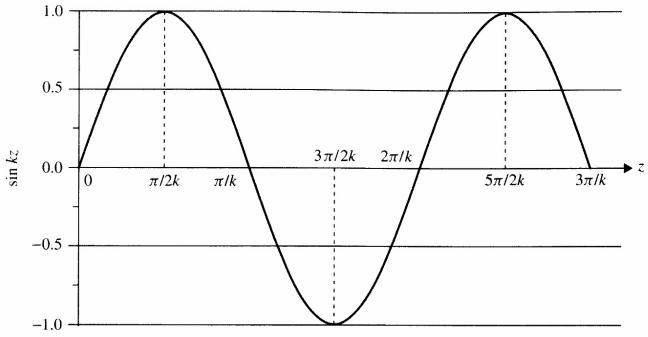

Figure 1.3 Plot of sin *kz*

1.2 WHAT IS POLARIZATION?

WHAT IS POLARIZATION?

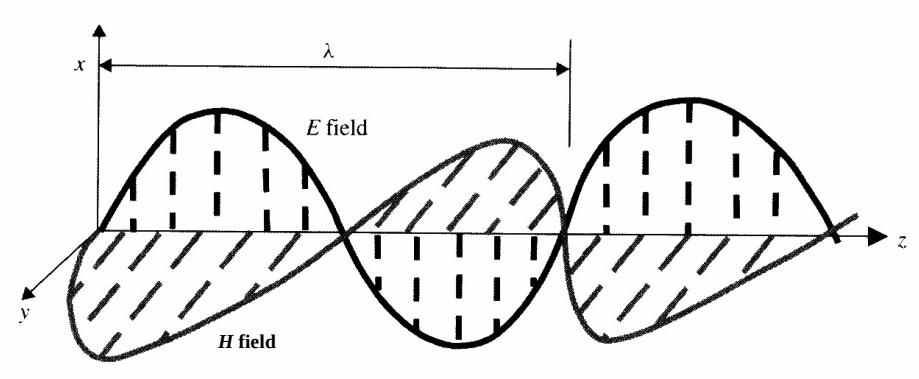

Figure 1.4 Sinusoidal plane wave showing electric and magnetic fields. Reproduced with permission from Palgrave Macmillan

WHAT IS POLARIZATION?

- Figure 1.4 shows three characteristics.
  - Firstly, the wave is a *plane* wave
  - Secondly, the wave is *transverse*
  - Finally, the wave is *polarized*
- POLARIZATION *is the direction of the electric field associated with the propagating wave.*
  - *Plane,* circular and elliptical *polarized light*
  - Unpolarized light

Unpolarized Light

- Unpolarized light can be regarded as a combination of these two plane polarized waves, since a wave polarized at an arbitrary angle to the waveguide surface can be resolved into a omponent parallel to the surface and a component perpendicular to the surface

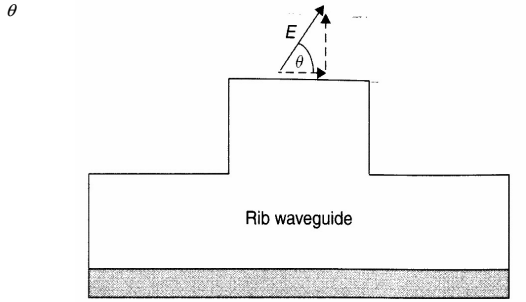

Figure 1.5 Light polarized at an arbitrary angle θ can be resolved into components parallel and perpendicular to the waveguide surface.

1.3 WHAT IS INTERFERENCE?

WHAT IS INTERFERENCE?

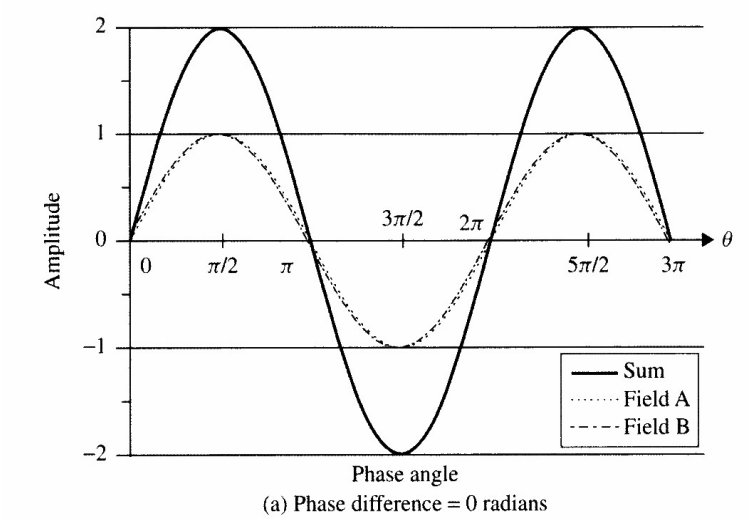

Figure 1.6 Interference of two waves of varying phase difference (a) if they are in phase constructive interference results

WHAT IS INTERFERENCE?

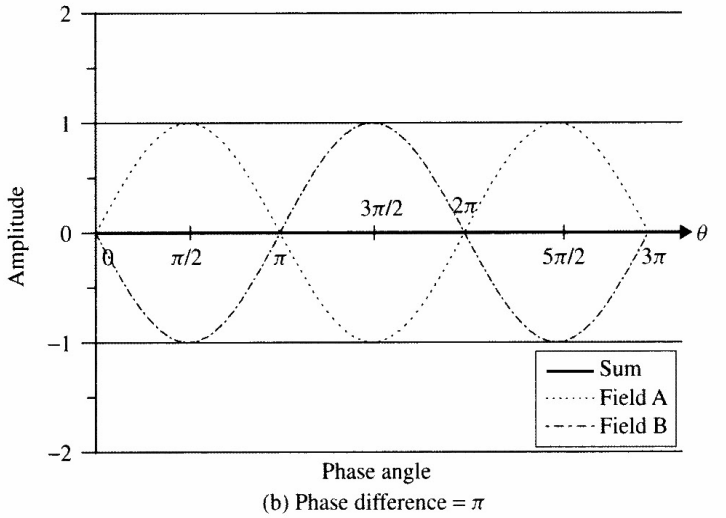

Figure 1.6 Interference of two waves of varying phase difference (b) if they are exactly out of phase they cancel one another

WHAT IS INTERFERENCE?

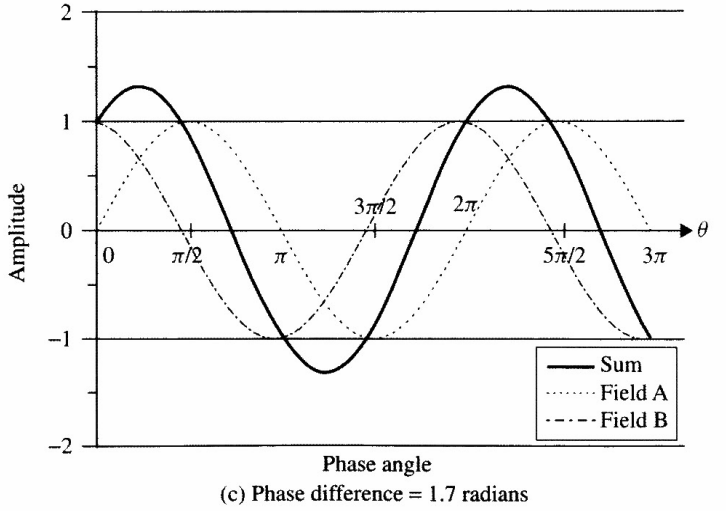

Figure 1.6 Interference of two waves of varying phase difference (c) if they are out of phase by an intermediate amount, the resultant field sum is still a sinusoid of the same frequency, but shifted in phase and amplitude.

WHAT IS INTERFERENCE?

- **INTERFERENCE occurs only when**
  - **the two waves are aligned in terms of polarization**
  - **the two waves are coherent**

1. Aligned Polarization

- If two fields are not of the same polarization, the electric and magnetic vectors are not aligned, and the fields will not interfere.
- If the waves are both linearly polarized, but the polarization directions are different, only the components of each field that have common polarization will interfere.

2. Coherent

- Two waves will only interfere if they are *coherent.*
- If two waves are coherent they have a constant phase relationship.
- If on the other hand the two waves have no fixed phase relationship, they are said to be *incoherent*

Coherence Length

- The coherence length is the distance over which the light retains coherence.

$$L_c = \frac{c}{\Delta f}$$

  - c is the velocity of light
  - Δf is the spectrum of frequencies contained within the light source
- When using an interferometer, it is important to ensure that the path length difference between the interference waves is much less than the coherence length of the optical source.