先進量測暨科學計算研究室

Advanced Metrology and Scientific Calculation

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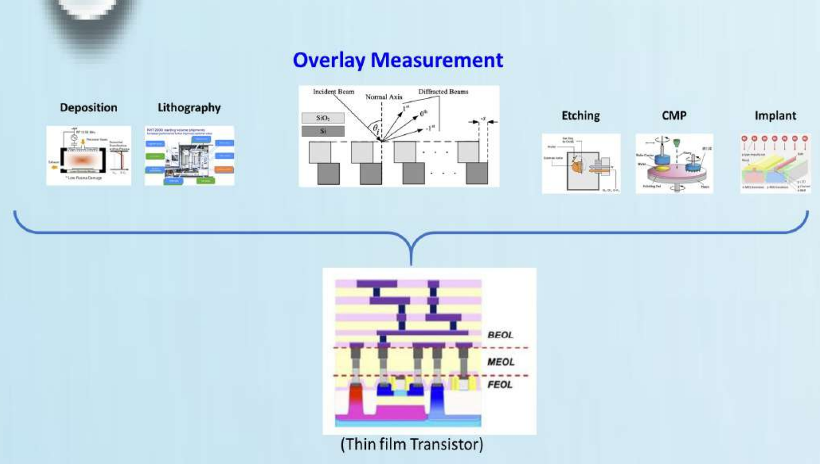
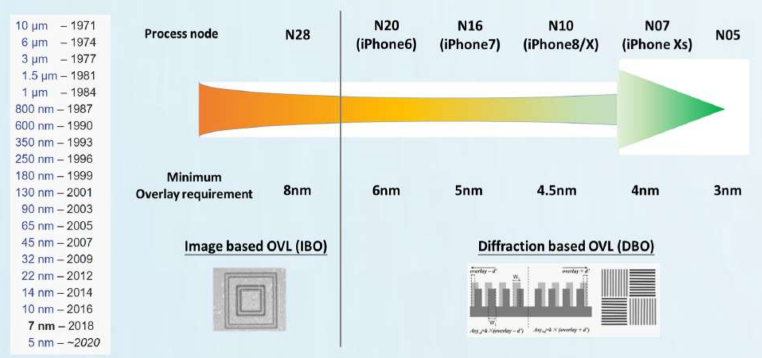
AMSC

半導體疊層對準(Overlay)

The "Eye" of Semiconductor "Lithography" Process



Process Node vs. Overlay Requirement



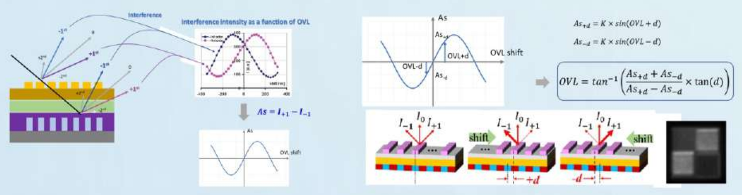
Overlay Metrology: IBO vs. DBO

- The measurement of **DBO is ~1nm more accurate than that of IBO**
- **Fast measurement** of DBO metrology (MAM time ~ 0.3sec)
- DBO metrology is more sensitive to process variation and can be a **process stability monitor tool**

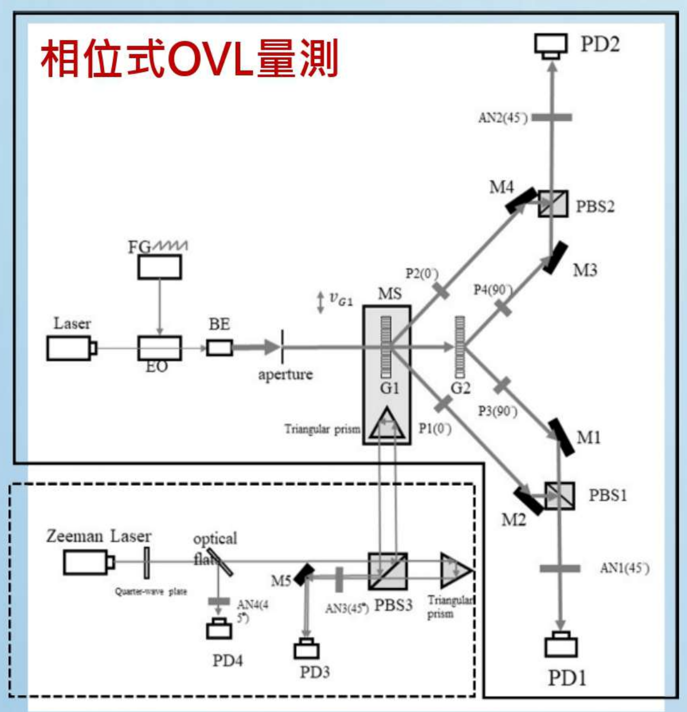
IBO (Image-based Overlay) | **DBO (Diffraction-based Overlay)**

Basic Principle of DBO Metrology

- "**Asymmetry Intensity (As)**" defined as the intensity difference btw the interference lights of +1 and -1 order diffraction light
- **Shifted bias** $+d$ and $-d$ of top and bottom grating
- **OVL value** calculated by the "Asymmetry Intensity" and "Shifted bias"



相位式OVL量測



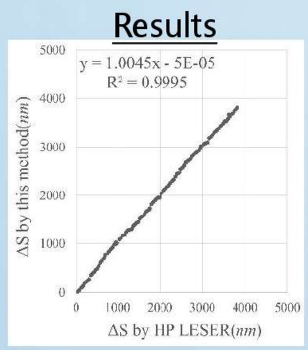
外差干涉術

EO modulator

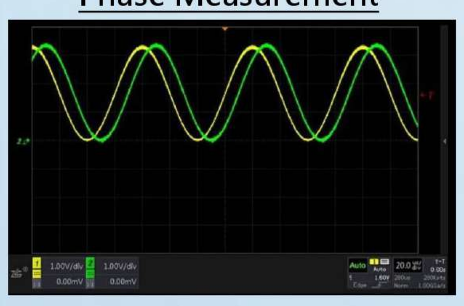
Lock-in Amplifier

Oscilloscope

Results



Phase Measurement



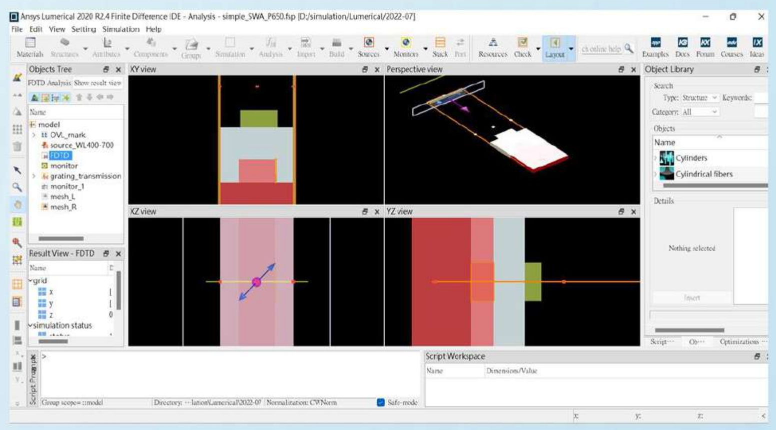
科學計算工作站

OVL simulation workstation Setup

- **Simulation software**: Finite-difference time-domain (FDTD)
  - A numerical analysis technique used for modeling computational electrodynamics
  - Finding approximate solutions to the associated system of differential equations
- **Workstation**: Lenovo P920

workstation

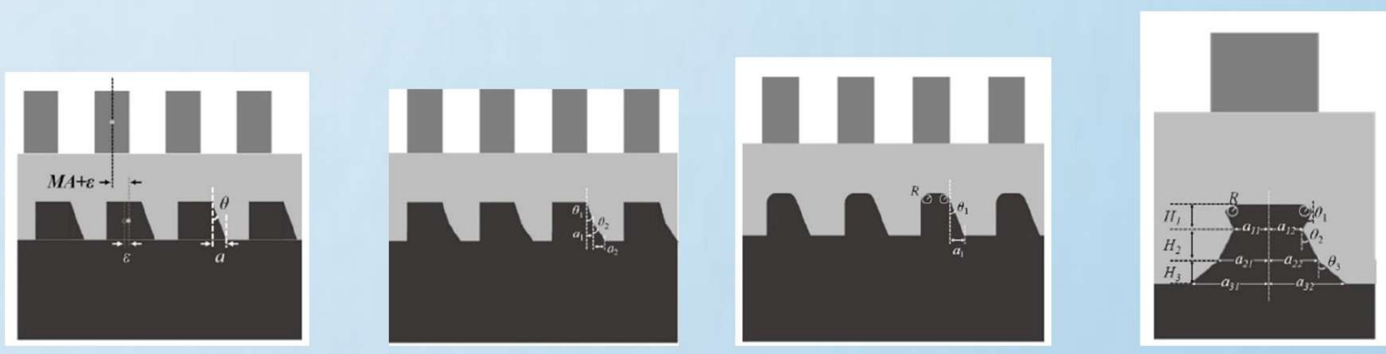
Lumerical FDTD



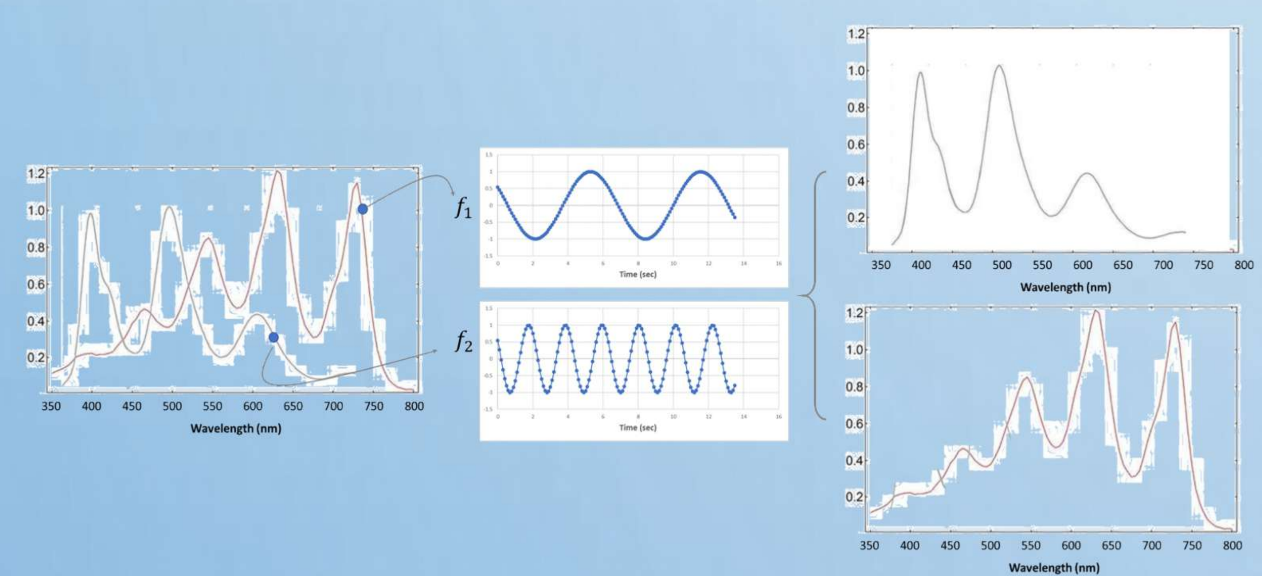
Structures for OVL Error Simulation

- **4 asymmetric OVL target structures** for OVL error simulation
- **Asymmetric bottom grating** due to the loading effect of etch and CMP processes

Simple Sidewall | **Two-level Sidewall** | **Round corner** | **Three-level Sidewall**



調制光譜分離術



3-Parameter Sine Curve Fitting

- 假設有一組弦波訊號包含了N 個資料點
- 每個資料點的訊號強度分別為$y_1, y_2, \ldots, y_N$，所對應的時間為$t_1, t_2, \ldots, t_N$
- 在沒有誤差的情況下所記錄到的信號強度可表示為

$$y_n = A_0 \cos(\omega t_n) + B_0 \sin(\omega t_n) + C_0$$

- 然而實際上量測值 y_n 不可能沒有誤差，使得方差合S 不為零

$$S = \sum_{n=1}^{N} [\underbrace{y_n}_{\text{量測值}} - \underbrace{A_0 \cos(\omega t_n) - B_0 \sin(\omega t_n) - C_0}_{\text{弦波擬合值}}]^2$$

- 為了擬合出一個最接近的弦波
- 首先以 A_0, B_0, C_0 分別對 S 做一次微分，找出S 極小值的位置
- 因此只要將 $\partial S/\partial A_0 = 0,\ \partial S/\partial B_0 = 0,\ \partial S/\partial C_0 = 0$ 三式聯立
- 即可解出極小值的位置 A_0, B_0, C_0
- 這組聯立方程式的解，即為該組弦波訊號的最小方差解
- 用矩陣表示可寫成

$$x_0 = (D_0^T D_0)^{-1}(D_0^T y)$$

$$x_0 = \begin{pmatrix} A_0 \\ B_0 \\ C_0 \end{pmatrix} \quad D_0 = \begin{pmatrix} \cos\omega t_1 & \sin\omega t_1 & 1 \\ \cos\omega t_2 & \sin\omega t_2 & 1 \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ \cos\omega t_n & \sin\omega t_n & 1 \end{pmatrix} \quad y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}$$

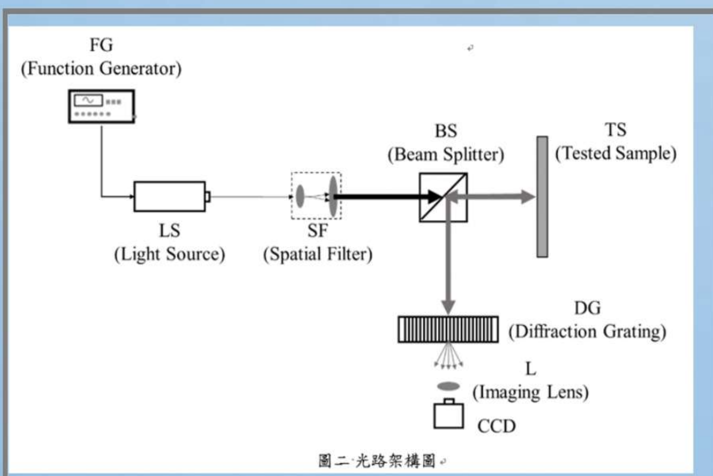
- 擬合後的弦波為

$$y'_n = A_0 \cos(\omega t_n) + B_0 \sin(\omega t_n) + C_0 = A\cos(\omega t_n + \varphi) + C_0$$

- 其中弦波的振幅與相位分別為

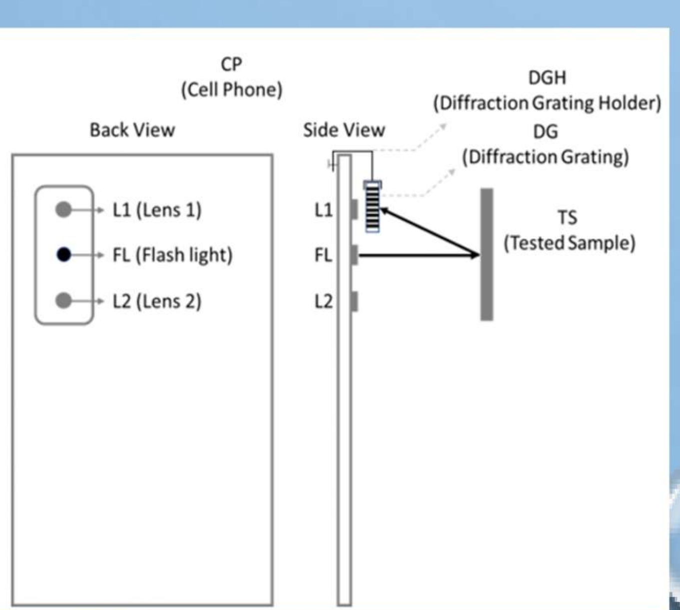
$$\boxed{A = \sqrt{A_0^2 + B_0^2}}$$

$$\boxed{\phi = \tan^{-1}[\frac{-B_0}{A_0}]}$$



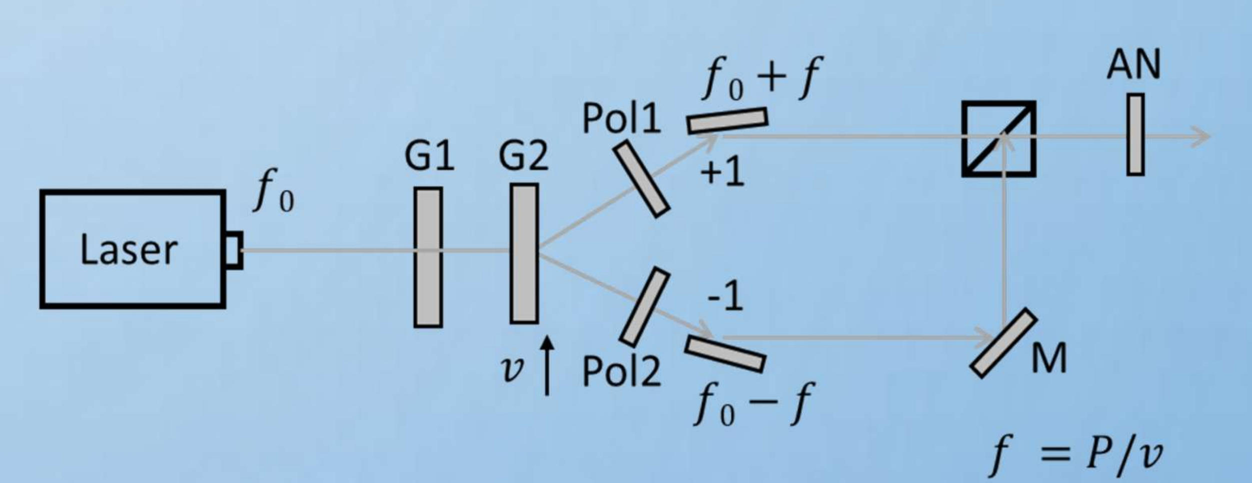
圖二 光路架構圖

商用化產品光路圖



新穎光源技術開發

Two-Grating Heterodyne Light Source



Color-mixing Light Source