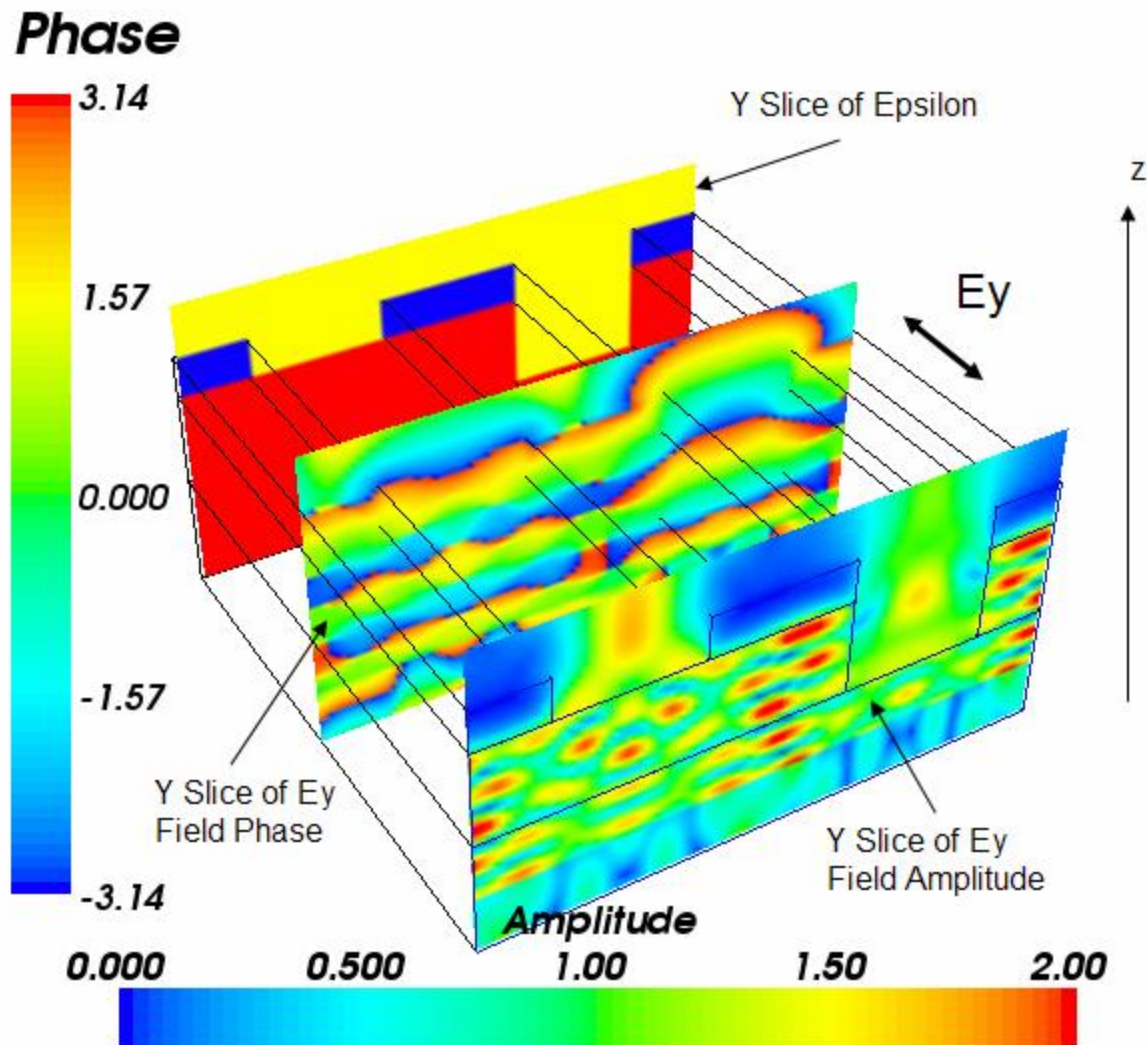


Simulation of 2D Line/Space Alternating Phase Mask

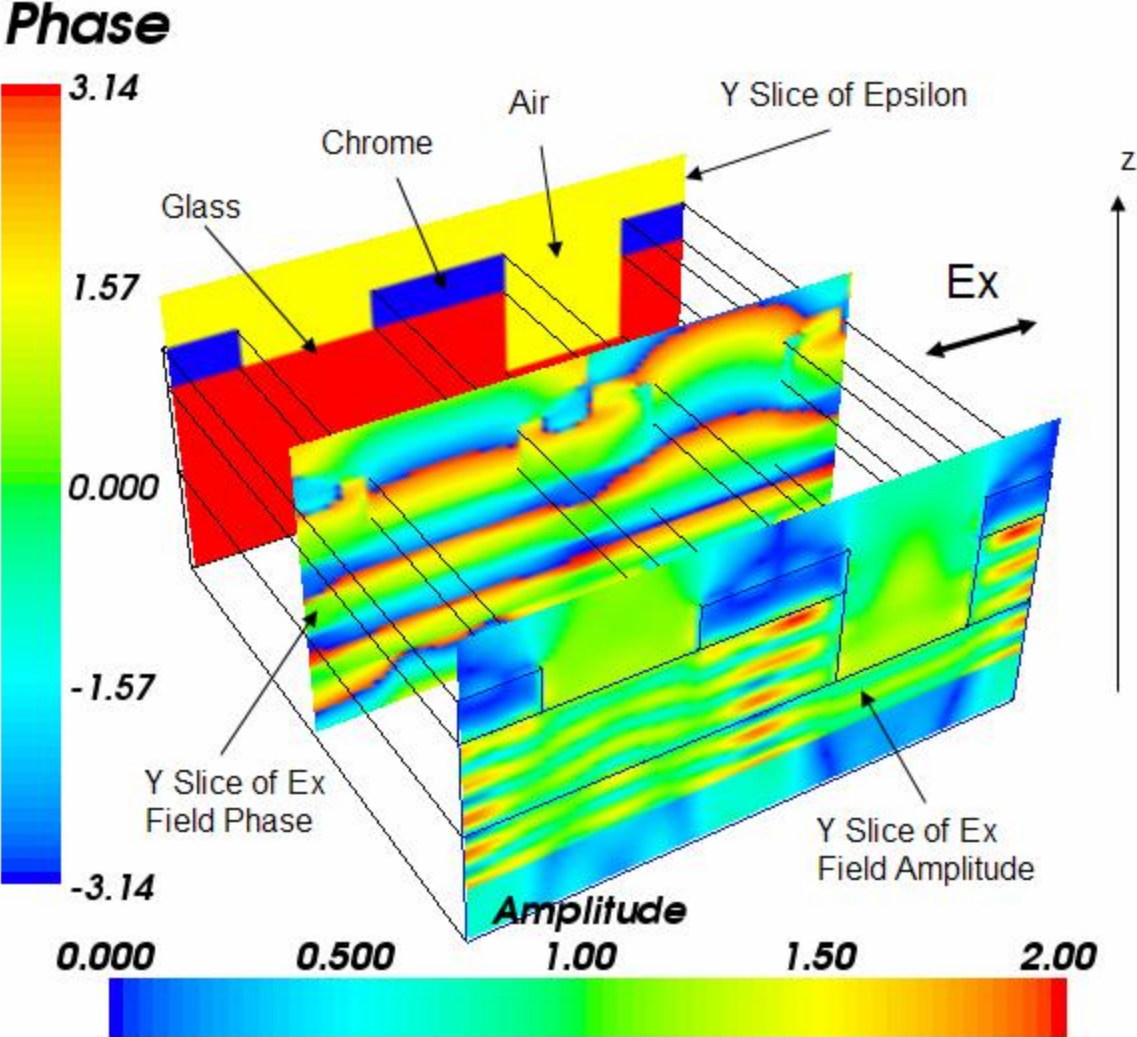
Simulation Setup

- ❑ Wavelength = 193nm
- ❑ Normal incidence (+z direction) to mask
- ❑ Chrome width = 250nm
- ❑ 0-degree phase shifter width = 250nm
- ❑ 180-degree phase shifter width = 250nm
- ❑ Yee cell size = 10nm
- ❑ All mask dimensions are in object space.

TE Polarization

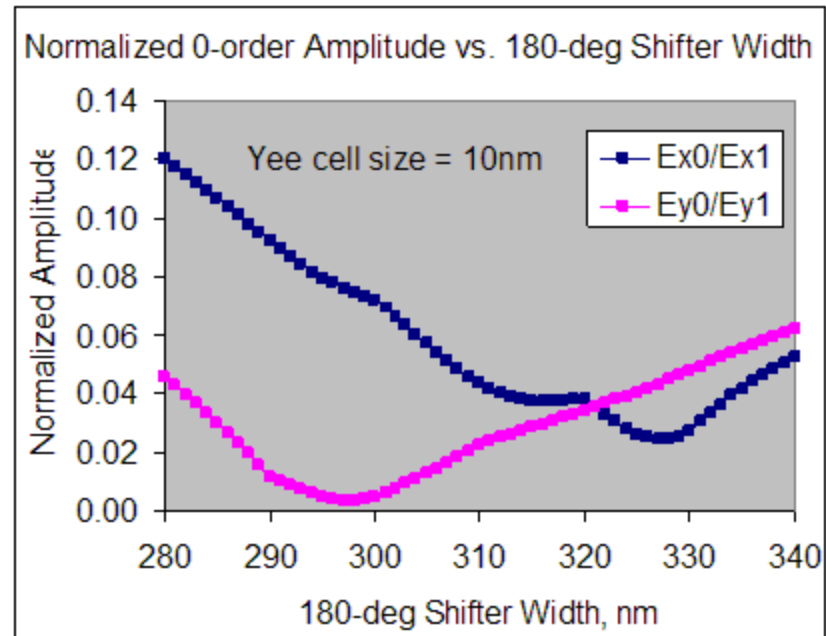


TM Polarization



Effects of 180° Phase Shifter Width

Note the design objectives of APSM are to eliminate the zero-order diffraction and to make +/- first-order diffractions equal in amplitude and 180-degree shift in phase. EM Explorer simulations show that not all of these properties are achieved, particularly that of the zero-order diffraction, if the 0-degree phase shifter and the 180-degree phase shifter have the same width. It causes the well-known image imbalance problem in photolithography. One of the remedies to this problem is to add positive bias to the 180-degree phase shifter width.



In the above simulations EM Explorer captured the shifter width change continuously with its sub-cell resolution capability, no staircase artifacts as in standard FDTD simulations. This is particularly important for accurate mask design and mask error evaluations.