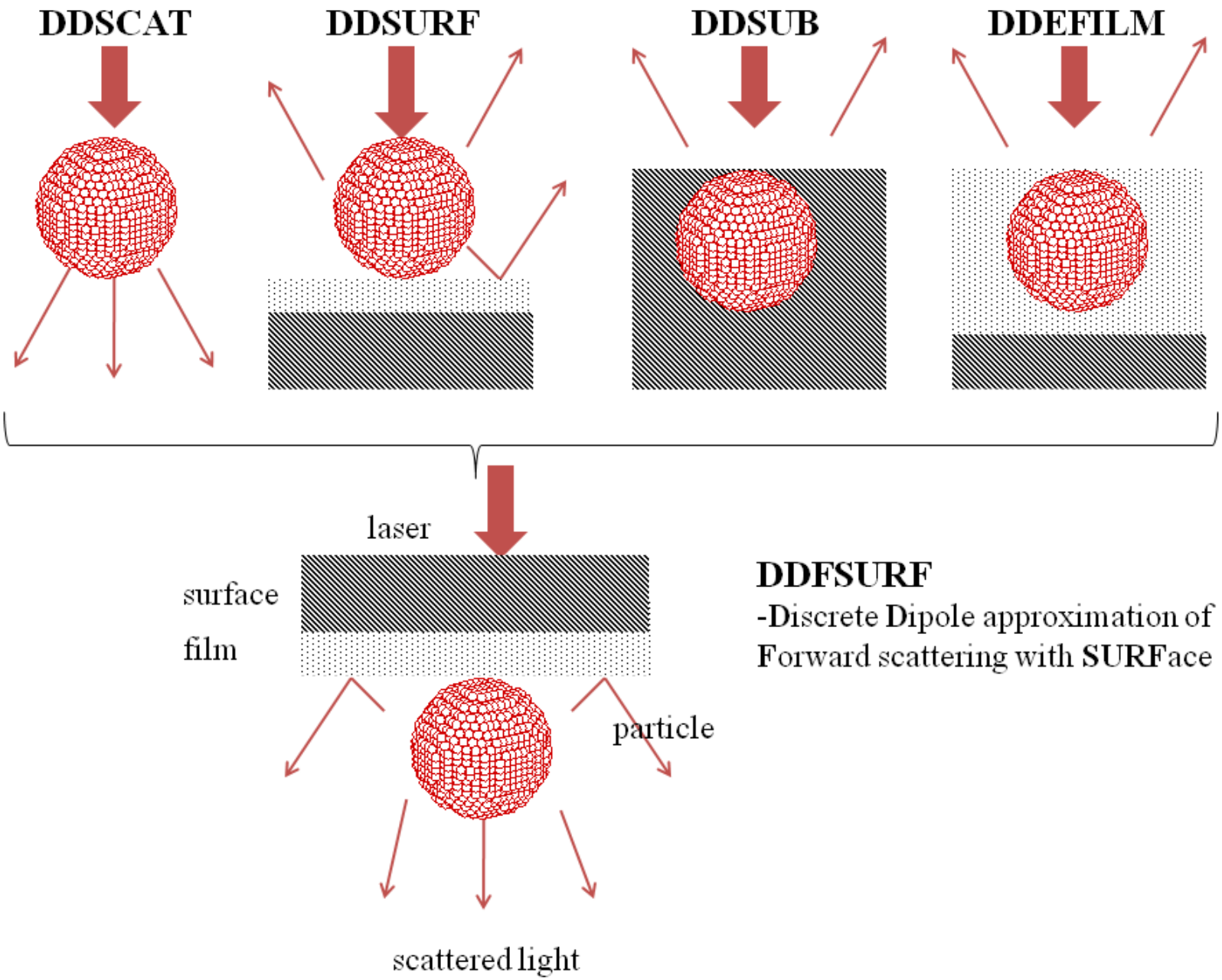


DDFSURF

-Discrete Dipole approximation of Forward scattering with **SURF**ace

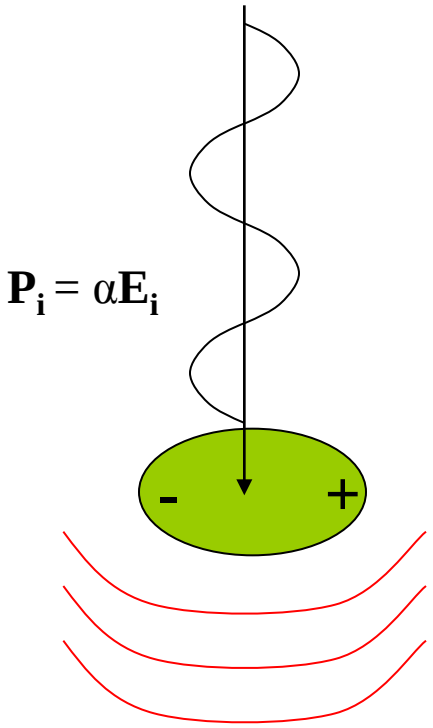
Discrete-Dipole approximation method

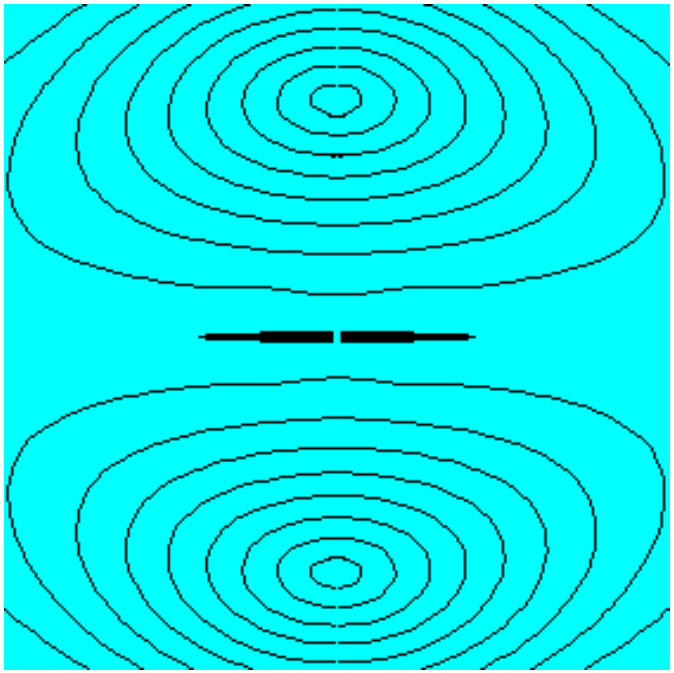
DDSURF is a group of software codes developed to model electromagnetic light scattering from small, arbitrarily shaped features on or near flat surfaces. These codes were developed especially to be used as a tool for the semiconductor industry where optical detection and characterization of structure defects and particle contamination on silicon wafers is essential to improve production yield. The three main codes of DDSURF are CREATETAR (*Create Target*), DDSURF (*Internal Dipole Moment*) and FFSURF (*Far-Field)*. The scattering response of an illuminated feature is modeled by using the discrete-dipole approximation method (DDA). In this method discrete electric dipoles are used to simulate the electromagnetic response of a feature. CREATETAR creates that lattice array where dipoles are positioned to model a feature geometry. By the numerical solution of the interaction equations of electromagnetically excited dipoles, DDSURF computes the dipole moment distribution within the scattering feature using the array created by CREATETAR. Using the dipole moment distribution found by DDSURF, FFSURF computes the external scattered far-field by applying the Green's function for a radiating source.

The present version of DDSURF was developed using Digital Visual FORTRAN 90 and is the result of efforts by Brent M. Nebeker, Haiping Zhang, Euiwon Bae and E. Dan Hirleman of Purdue University, and Roland Schmehl of the University of Karlsruhe, Germany.

Introduction - Light scattering

- Physics of scattering – internal charge distribution from incident wave($\mathbf{E_i}$) generates a electric dipole moments($\mathbf{P_i}$) and reradiates a secondary wave

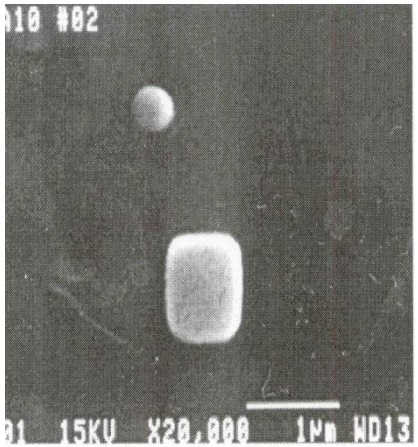


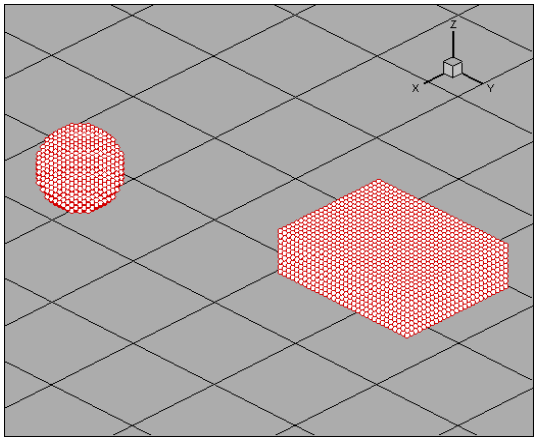


Introduction - discrete dipole approximation(DDA)

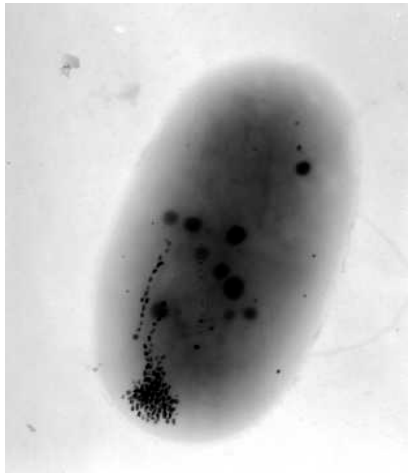
- There exists theoretical EM scattering solution for spheres in space, but for arbitrary shaped geometry, DDA is applied. This was extended when particles on located on surface – DDSURF(DDa on SURface)

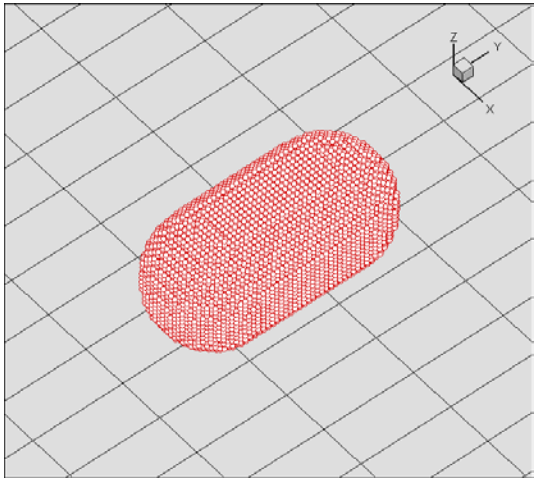
Semiconductor field
PSL sphere
with SiO_2 pattern





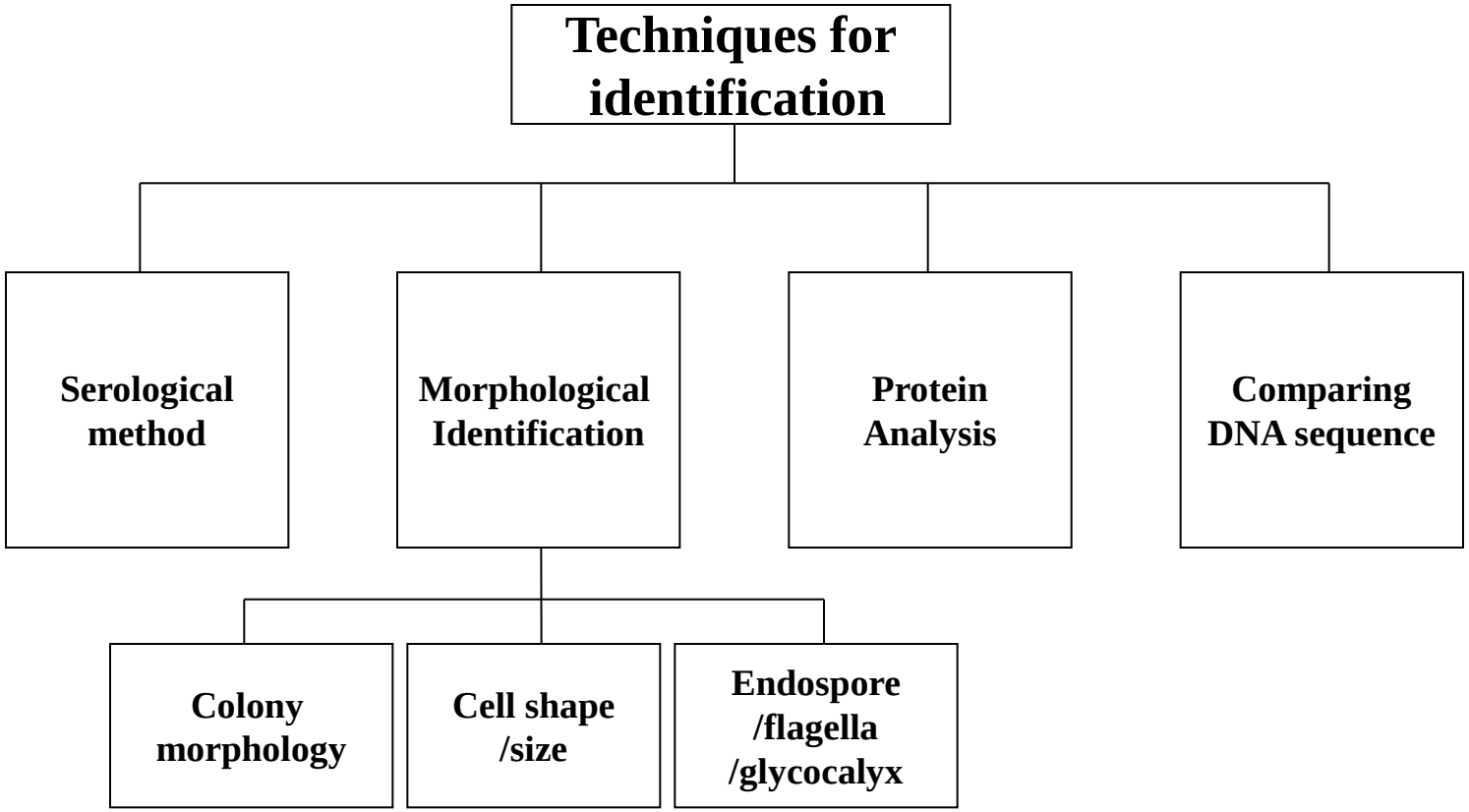
Biological field
Single bacteria
on surface





Introduction - Characterization of biological samples

- Various characterization and identification technique exists for biological samples
- If different morphology (shape, refractive index) exists, light scattering method could be applied to differentiate the types of bacteria



Introduction - Multi-scale object

- Single bacteria - ~ 1 μm in length, easy to model with DDSURF
- Colony of bacteria - ~ 10^6 – 10^8 individual bacteria depending on the size
- What would light scattering pattern provide for this large spectrum of object?

Multi-scale modeling -

- Overview of the Light scattering method with multi-scaling