



# MANIPULATION OF LIGHT IN THE NANOWORLD

## Development Team Members:

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## Approach

### Pedagogy

(anchoring an Idea In the world of the students)

The **macro** world of students awareness

The **nano** world that can affect their lives

### Concept

(Linking known concepts applied at nanoscale)

## Size determines the nature of Interaction between Light and Matter- Application Examples

### Glass Cup



Transparent

### The Lycurgus Cup



Due to tiny crystals of metal, as small as 70 nm across, The cup shows different color when shone from outside and inside

### Commercial Cosmetic (Sunscreen)



Nano-Sunscreen  
 Nano-cosmetic: no pasty white look; higher SPF ratings

## Conventional Physics:

### Interference

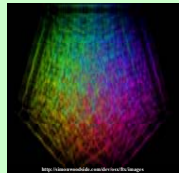
All waves have interference, combining constructively and destructively

- Optic and acoustic wave
- Thin film interference
- Bragg reflection

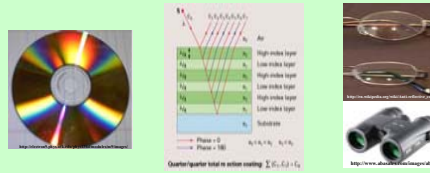
### Water wave



### Optical wave



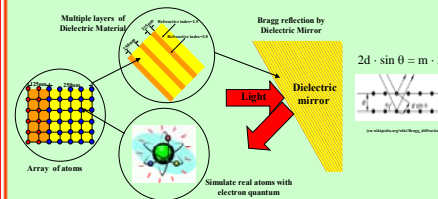
### Thin Film Interference



Interference on CD surface

Anti-reflective coating

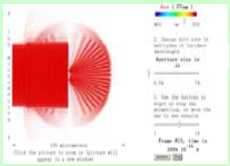
### Bragg Reflection



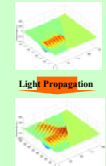
$$2d \cdot \sin \theta = m \cdot \lambda$$

### Simulation of Interference

#### Interactive User Interface



#### Bragg reflection Simulation



## Nano Concept:

### Photonic Band Gap

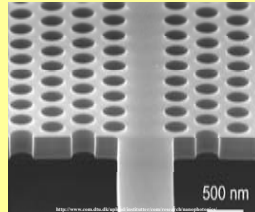
- PBG Nanostructure materials.
- Confined light in nanostructure depends on structure size
- Design Project combines PBG nanostructure synthesis and simulation

### Big Holes on Grill (1cm diameter)



### Nano Holes!

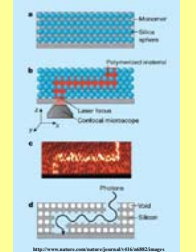
### Nano Holes Squeeze & Confine Light, <math>< \lambda</math> (300nm diameter)



### Periodic refractive Index

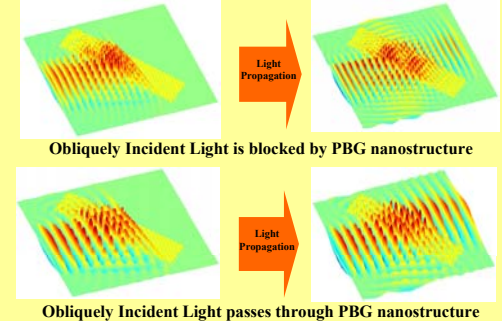
Periodic change of refractive index is formed, similar to Bragg reflection!

### Photonic band Gap



Light confined in PBG nanostructure

### Simulation of PBG nanostructure

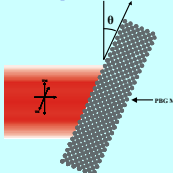


## Simulation Tools:

### Simulation Tool:

- Interactive User Interface
- Finite Difference Time Domain (FDTD)
- Electromagnetic field of the light is calculated to high precision

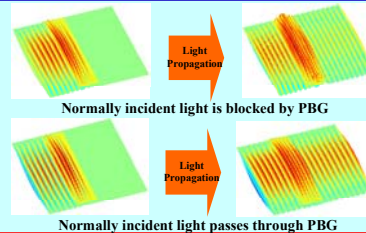
### Scheme of Photonic Band Gap Simulation



### Properties of Photonic Band Gap Material:

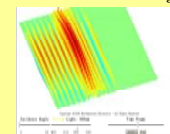
- $\lambda$  Input light  $\neq \lambda_{PBG}$  : Pass through
- $\lambda$  Input light =  $\lambda_{PBG}$  : Blocked

### Simulation results of PBG nanostructure



### Design Project

#### Simulation for Prediction and understanding



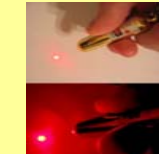
Online user interface for PBG

#### Synthesis of PBG material



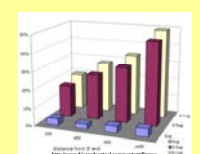
Students work in team

#### Determination of $\lambda_{PBG}$



Different colored light shining

#### Comparison and analysis



Reports and analysis