

## CoE Technology Exhibition

Date: 9<sup>th</sup> – 13<sup>th</sup> March 2004

Venue: Exhibition Hall, Nanyang Auditorium.

**Nanyang**  
Technological University

### Project Summary

**Project Title: Metamaterials – Beyond the Laws of Nature**

**Exhibit ID:** EEE-RDP-35

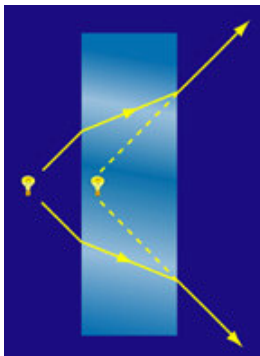
**School / Division:** 5

**Group members:** R.S. Kshetrimayum, S. Sun, H. Shi, R. Fu, H. Wang and J. Gao

**Supervisor (s):** L. Zhu

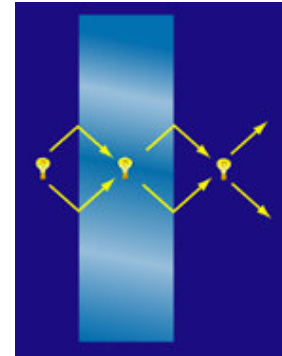
#### Project Summary:

Negative Refractive Index Metamaterials (NRIM) theoretically proposed by Russian physicist Veselago in 1968 and experimentally verified by a group of researchers at the University of California at San Diego, Smith et al, in 2001 issue of Science. It has been rightly called as metamaterials (in Greek “meta” means “beyond”). The so called metamaterials or “beyond materials” has very unusual properties which do not occur in naturally occurring materials. Some of them are: (a) it follows the left handed rule of electromagnetism thereby electromagnetic waves instead of moving forward moves backward (b) reverse Doppler effect which makes a train-whistle sound higher in pitch as it approaches and lower in pitch as it recedes (c) all natural materials have positive refractive index, epsilon and  $\mu$ . But in these materials these parameters are all negative. Lens made up of these materials will diverge where the normal lens converge.



(see left figure) An electromagnetic source incident on a slab of transparent normal material appears closer to an observer on the other side.

(see right figure) An electromagnetic source incident on a slab of transparent NRIM appears to emanate from the opposite side of the slab (same side as the observer).



After experimental verifications of NRIM in 2001, researchers throughout the world are trying to demystify how to realize and find the possible applications of these “beyond materials”. The possible applications of NRIM are in making faster and smaller chips, perfect lens which are flat, compact and broadband wireless and microwave circuits which fits right on the printed circuit board, smart antennas which can scan beams in all directions, etc. Our research group is trying to compose a novel waveguide based NRIM and would like to share this newly discovered NRIM to everyone at the COE Technology Exhibition.