scholarship

Team creates long-sought-for flat lens

A new way of looking

BY BRIAN LEE

Srinivas Sridhar's holiday card is sure to leave a lasting impression. The e-card he's been sending to friends depicts work by Sridhar and colleagues Patanjali Parimi, Wentao Lu and Plarenta Vodo — a scientific discovery they published in the journal Nature that landed in the year-end edition of Science magazine as one of the top breakthroughs of 2003.

The phenomenon was unearthed during the summer, when the quartet demonstrated that a new kind of material could be used to produce a lens with flat surfaces that operates at microwave frequencies. It solidified a hypothesis of flat-plane imaging that's kicked around for more than 30 years.

"We're thrilled," said Sridhar of the selection by Science.

Sridhar, who directs the Electronic Materials Research Institute and is the university's Arts and Sciences distinguished professor in physics, said he learned of the selection in Science while surfing the Internet over the December break. "It's a big honor — not just for us, but for the entire university," he said.

Explaining his team's breakthrough, Sridhar pointed to a pair of eyeglasses. "See how the lens is curved?" he asked. "Well, that's because all positive refractive index materials have to have curved surfaces to focus. Hence, ordinary lenses, made of ordinary materials, have to be curved to focus.

"But we have what's called a material with a negative refractive index. It bends electromagnetic waves the opposite way, compared to ordinary materials," Sridhar said.

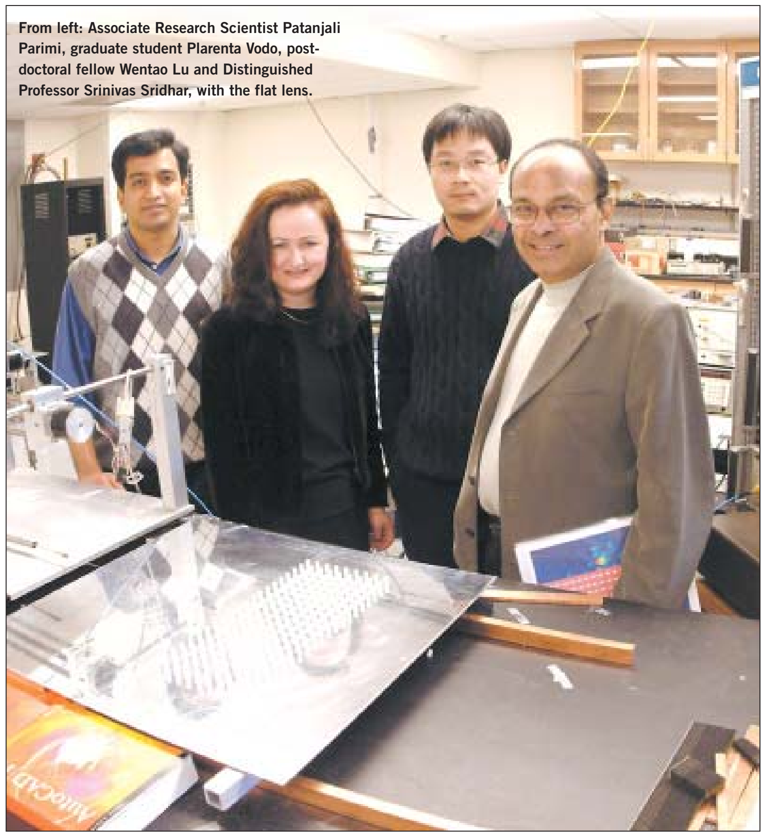
The group was able to demonstrate negative refraction by firing a beam of microwaves at a photonic crystal made of alumina (aluminum oxide) rods, each perhaps an inch long. The lens focused electromagnetic waves at microwave frequencies and produced an image.

The advance here is the "design of a photonic crystal that has suitable dispersion characteristics to achieve negative refraction over a wide range of angles," Sridhar wrote in November's edition of Nature.

Last year the Northeastern team, along with groups at Harvard/MIT and Boeing, also demonstrated negative refraction in a different kind of material.

"But," said Sridhar, "we've come up with our own approach using photonic crystals. This material has lower absorption and can be designed accurately — both features which were crucial for the successful fabrication of the microwave lens."

The lens is not an ordinary plane of glass. "It's not homogenous material," Sridhar said. "It's made of cylindrical rods of material placed periodically. What happens is that the periodic arrangement bends the waves from the source, which is placed on one side. It then focuses them into an image on the other side."



From left: Associate Research Scientist Patanjali Parimi, graduate student Plarenta Vodo, post-doctoral fellow Wentao Lu and Distinguished Professor Srinivas Sridhar, with the flat lens.

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This, Sridhar said, allows control of electromagnetic wave propagation, which could lead to new approaches to a variety of applications from microwave and optical frequencies.

"It gives a whole new approach to image formation, and it could lead to new concepts in imaging systems. It could lead to lenses that are more powerful because the new lenses do not have a central optical axis, and there's no limitation due to aperture size," he said. "Another thing is that negative index materials allow you to beat the sub-wavelength resolution limit of current optics and current imaging devices."

The breakthrough work was funded by the National Science Foundation and the Air Force Research Laboratories.

"The Air Force was looking for someone to do research in this area, and we've had a longstanding connection with them," said Sridhar. "We had been working with microwaves, and recently there was an exciting discovery about this topic. The Air Force knew we were working on related topics. We soon realized we could do this unique experiment. We've only been working on this particular experiment for about a year."

Sridhar says the group will seek to commercialize its discovery while targeting practical applications.

Some immediate applications of negative-index materials include scanning photon-tunneling microscopy, ultrahigh-sensitive phase shifters, leaky-wave antennas and optical switches based on negative refraction.

It could eventually be used to build new components for optical and microwave telecommunications equipment.