Near-Field Focusing Plates

Anthony Grbic[1], Lei Jiang[2], and Roberto Merlin[2]

[1] Department of Electrical Engineering and Computer Science,
University of Michigan, Ann Arbor, 48109-2122,
e-mail: agrbic@umich.edu.
[2] Department of Physics, University of Michigan, Ann Arbor,
48109-1040.

Manipulating and focusing the electromagnetic near-field has attracted significant attention in recent years. Much of the current interest stems from the "perfect lens" concept introduced by John Pendry in 2000 (J.B. Pendry, Phys. Rev. Lett., 85, 3966-3969, 2000). Pendry showed that a planar slab of negative refractive index material can manipulate the near-field in such a way that it achieves perfect imaging: a perfect reconstruction of the source's near and far-field. He also predicted that the near-field could be focused with only a negative permittivity slab. Since that time a number of experimental demonstrations of subwavelength focusing using negative refractive index and negative permittivity slabs have been reported.

More recently, a new approach to manipulating and focusing the electromagnetic near-field using patterned (grating-like) surfaces was introduced and developed in (R. Merlin, Science, 317, 927-929, 2007), (A. Grbic, R. Merlin, arXiv:0708.0049v1, 1-11, 2007). The proposed surfaces have been referred to as evanescent-field lenses or near-field focusing plates. A near-field focusing plate can be thought of as an impedance sheet with a modulated surface reactance. Depending on its design, it can focus the field of a plane wave or finite source incident from one side of the sheet to the other side, with subwavelength resolution. The reactance of a near-field plate can be designed to vary in one or two dimensions depending on whether focusing to a line or spot is desired. Such plates are completely passive, consisting of only inductive and capacitive impedance elements. At microwave frequencies, the inductive surface impedances could be implemented as metallic strips/wires and the capacitive surface impedances as metallic patches printed on a substrate. At optical frequencies, near-field plates consisting of nanofabricated plasmonic structures and dielectric structures could also be envisioned.

In this presentation, near-field focusing plates will be introduced. Their ability to form a subwavelength focus will be verified theoretically and experimentally. Experimental results will be shown for a near-field plate that achieves subwavelength focusing at a frequency of 1 GHz. The experimental near-field plate focuses the electromagnetic field emanating from a S-polarized cylindrical source (vertical line current) to a subwavelength focus equal to $\lambda_o/10$ along a focal plane that is located $\lambda_o/15$ from the plate. The experimental plate simply consists of an array of printed interdigitated capacitors.