

## **Nonlinear split-ring resonators for tunable metamaterials**

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We take the first steps toward the creation of fully *controlled and tunable nonlinear metamaterial* systems through the study of the tunability and self-induced nonlinear response of a single split-ring resonator (SRR). To achieve our goals, we add a variable-capacitance diode to the SRR resonant structure. Tunability of the diode capacitance is achieved by varying the width of its specifically doped P-N junction, and associated depletion layer, through the application of a DC bias voltage, or more attractively, through the self-action of the diode with increased applied electromagnetic energy, giving rise to dramatic self-induced nonlinear effects. Using this methodology, we *experimentally establish* a qualitative measure of the tunability of an SRR, and confirm earlier predictions [1] for the dynamic control over the properties of SRRs by varying the intensity of the incident electromagnetic signal.

Nonlinearly coupled SRR arrays provide a rich range of phenomena, including tunable transmission and power limiting, due to nonlinear frequency detuning and excitation of non-symmetric states in the structure. We demonstrate these effects experimentally for a system of coupled nonlinear SRRs and suggest further extension of our results to more complicated 2D and 3D geometries.

[1] A. A. Zharov, I. V. Shadrivov, and Yu. S. Kivshar, Phys. Rev. Lett. 91, 037401–4 (2003).

