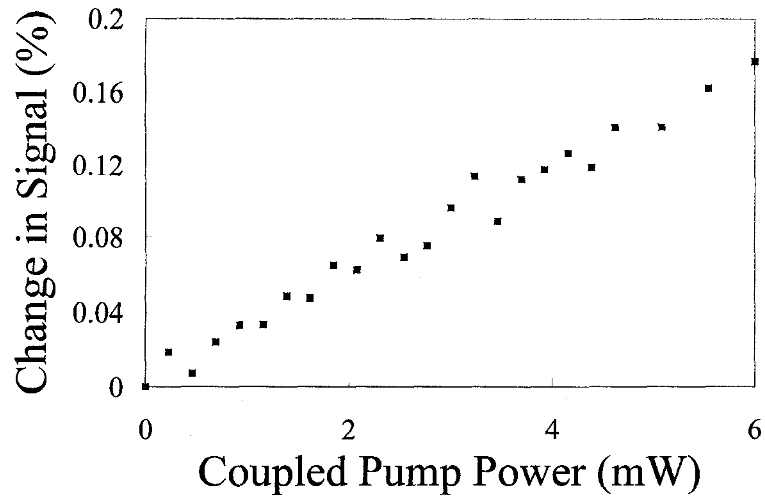
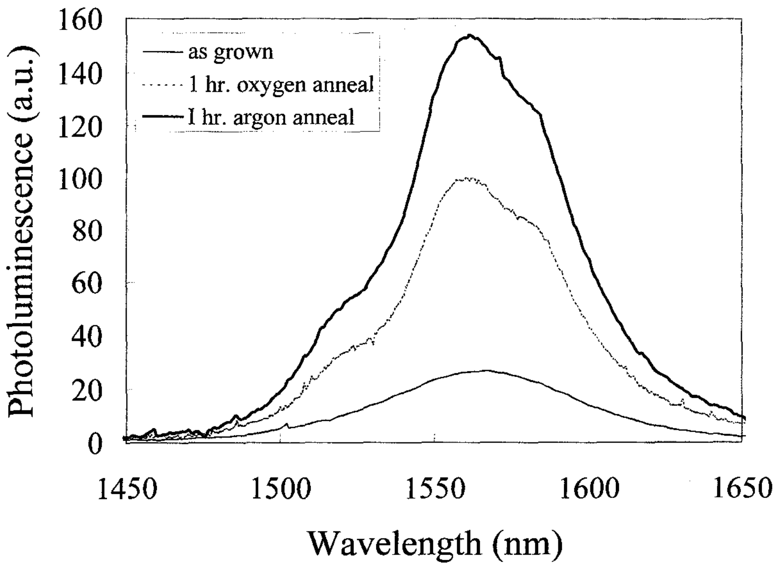


CTuN3 Fig. 2. Change in λ'= 1.54-μm signal versus coupled λ = 1.65-μm pump power in a 2.2-mm-long, 5-μm-wide Er:$BaTiO_3$ waveguide fabricated from the same film shown in Fig. 1. A 1 h post-growth oxygen anneal at 700°C was performed on the film prior to waveguide fabrication.



CTuN3 Fig. 3. Photoluminescence (PL) intensity versus wavelength for different post-growth anneal times and atmospheres. The lowest curve is the relative PL intensity of the as grown film, the middle curve represents the relative PL the intensity after a 1 h O_2 anneal, and the highest curve represents the relative PL intensity after a subsequent 1 h argon anneal. (anneal temperature = 700°C, film [Er] ~4×10^{20}).

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CTuN4 **3:15 pm**

Controlling surface plasmons on metallodielectric photonic crystals

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Any metal surface will support surface plasmons, or surface waves. These are waves that are evanescent in both the metal and the air, and are confined to the interface between the two media. They cannot propagate into the conductive metal, yet they cannot escape into the air due to total internal reflection. Surface modes occur over a broad range of frequencies spanning from DC up to a cutoff frequency, usually in the ultraviolet. They play an unfortunate role at microwave frequencies, where they can cause unwanted losses in antennas, due to radiation along the surface of the metal ground plane. However, it is possible to create bandgaps in the surface modes using the principles of photonic crystals. This has already been demonstrated at optical frequencies using corrugated silver films.[1] With the advent of wide bandgap, metallodielectric photonic crystals, it is possible to engineer the surface, and eliminate the surface modes over a range of microwave frequencies. In effect, the photonic crystal serves as an artificial metal, capable of filling the role of an antenna ground plane, without the unwanted surface modes.

Photonic crystals are periodic, dielectric and/or metallic structures that are the photonic analog of semiconductors.[2] The periodicity of the lattice gives rise to a bandgap, or range of frequencies within which electromagnetic waves are forbidden. In conventional, all-dielectric photonic crystals, the valence-band modes occupy the high dielectric material, while the conduction-band modes inhabit the low dielectric material. The width of the bandgap is limited by the dielectric contrast between the two media. Recently, metallodielectric photonic crystals have emerged, which incorporate large capacitive coupling between metal regions.[3] The capacitors act as a material with a very high effective dielectric constant, explaining the unusually wide bandgaps that are achievable with these structures. The frequencies of the conduction-band and valence-band edges can be tuned independently by varying the lattice constant, and the capacitance, respectively. Within the bandgap, these structures expel microwave radiation just as metals do, and in general, like metals they also support surface modes.

The surface modes can never be completely eliminated. However, they can be controlled by engineering the properties of the crystal surface. To extend the analogy with semiconductors, this is similar to surface passivation. The surface states are still there, but they are shifted in frequency, so that they no longer fall within the band gap. With the proper surface configuration, we can create a structure with a surface mode bandgap that overlaps the bulk bandgap. This is accomplished by altering the last layer of the structure, to tune the frequency of the surface modes. We have succeeded in demonstrating such a structure, in which the surface modes are absent over a range of 35–50 GHz.

Given that surface modes occupy only a thin layer of the crystal, the technique can be extended to the case of a metal sheet covered with only a few layers of photonic crystal material. Such a structure would be thin and lightweight, and would maintain its reflective properties without unwanted surface modes, providing the ideal ground plane for such applications as microwave patch antennas and arrays.

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