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WAVEGUIDE DISTRIBUTION OF COUPLED DIELECTRIC RESONATOR MODES IN THE UNIFORM LATTICCES

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ХВИЛЕВОДНИЙ РОЗПОДІЛ КОЛИВАНЬ ЗВЯЗАНИХ ДІЕЛЕКТРИЧНИХ РЕЗОНАТОРІВ В ОДНОРІДНИХ РЕШИТКАХ

Вперше досліджено явище формування "хвилеводних" коливань в однорідних решітках діелектричних резонаторів.

Structures consisting of a large number of resonators have interesting properties that are absent in homogeneous materials. The purpose of this report is to consider a new property of DR gratings that form waveguide structures at particular frequencies of forced oscillations. Interestingly, such waveguide channels may be form in a homogeneous lattice.

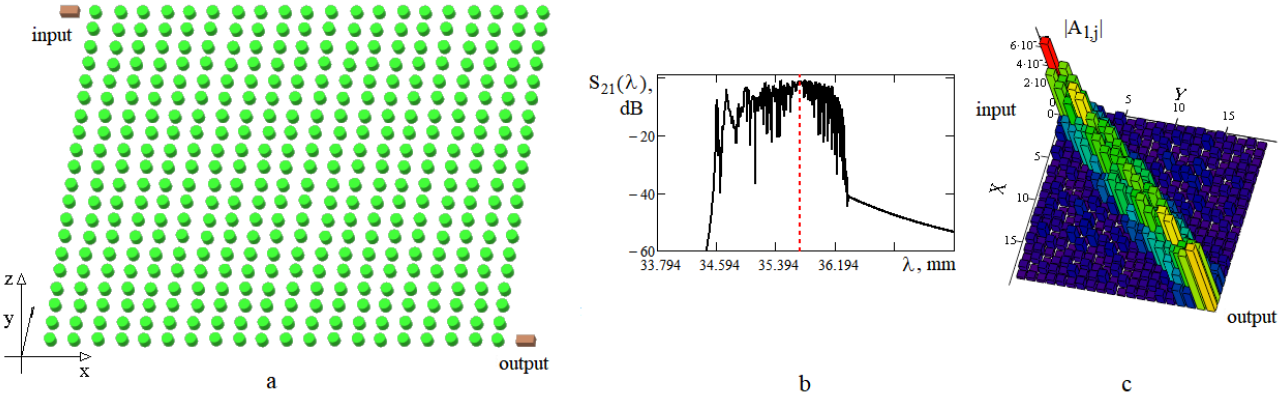
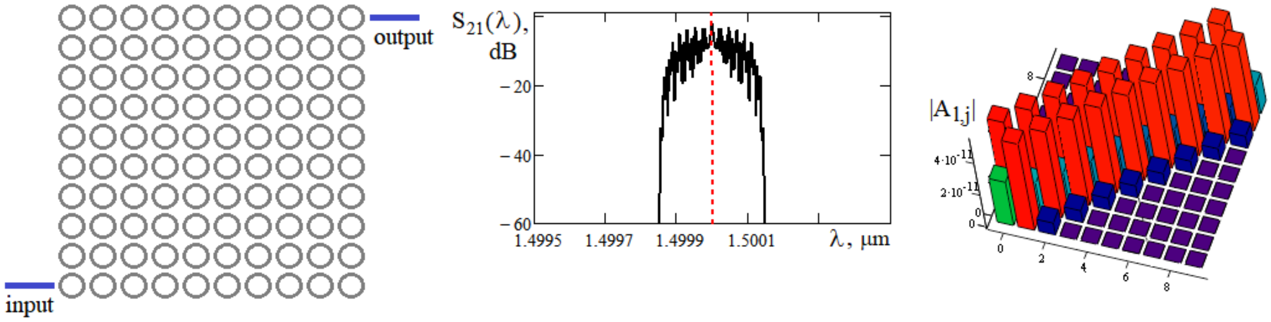


Fig. 1. Square lattice of cylindrical DRs with incoming and outgoing transmission lines (a). Dependence of the transfer coefficient between the input and output lines on the wavelength of a lattice of 400 DRs with H_{101} magnetic oscillations (b). Waveguide distribution of coupled modes on $\lambda = 35,718$ mm (c).

In this paper, we consider the conditions under which the DR coupled oscillations of a similar type are formed.

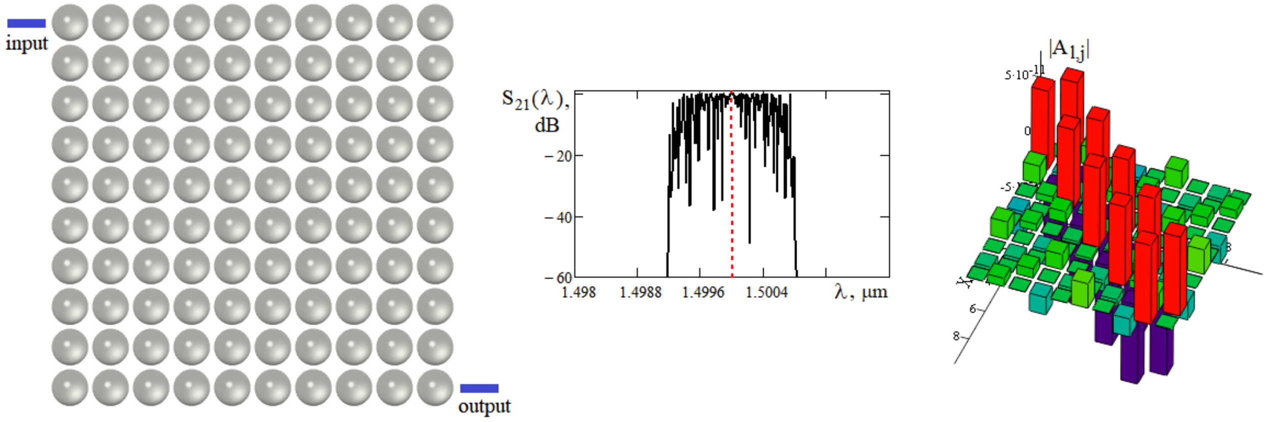
The formation of a waveguide channel was first observed on a flat square lattice of cylindrical DRs with magnetic azimuthally uniform oscillations H_{101} (Fig. 1, a). The dielectric permittivity of the DRs $\varepsilon_{1r} = 81$; $1/\mathrm{tg}\delta = 10^5$; $\Delta = L/2r_0 = 0,44$; the coupling coefficient between the DR and transmission line $k_L = 0,02$. The coupling coefficients between the resonators was calculated by the formulas [1]. In fig. 1 shows the amplitude-frequency response of the lattice S_{21} coefficient of transmission between input (1) and output port (2). The red line marks the wavelength at which the formation of waveguide oscillations is detected. In fig. 1, c shows the distribution of the amplitude modulus of the DRs in the lattice at the wavelength of waveguide resonant oscillations.



a b c

Fig. 2. Square lattice of optical microresonators (a). S-matrix coefficient between the input and output lines (b). Waveguide distribution of coupled modes on $\lambda = 1{,}5$ μm (c).

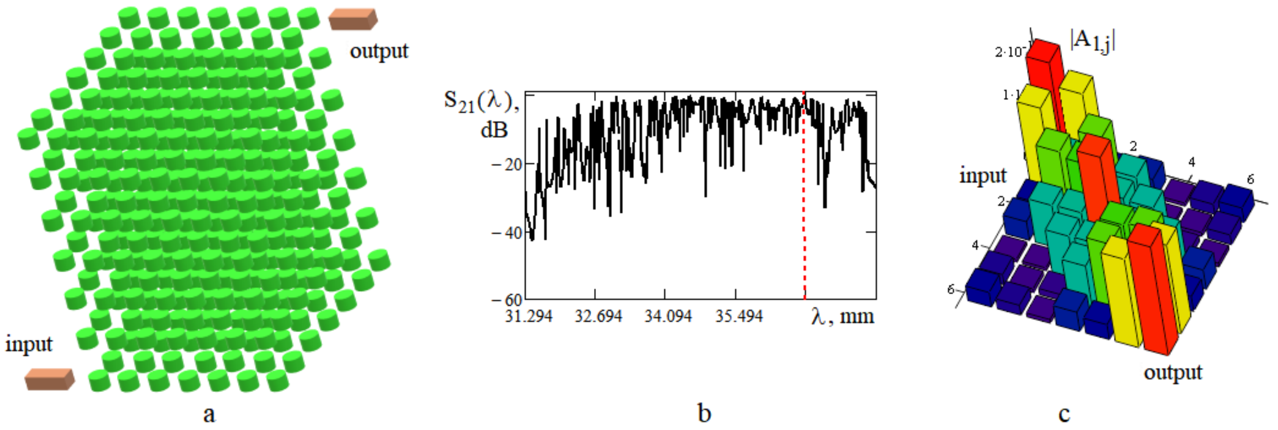
The results of the calculation of the dependence of S_{21} on a square lattice of ring microresonators (Fig. 2, a), according to [1], are shown in Fig. 2, b. The red line also marks the wavelength at which the formation of waveguide oscillations is detected. Open space coupling coefficient of each microresonator $k_{OS} = 10^{-6}$; the coupling coefficient between adjacent microresonators was $k_{j,j+1} = 5\cdot10^{-5}$; The coupling coefficient between the microresonators of the grating and the input (output) transmission line $k_L = 3\cdot10^{-4}$. Fig. 2, c shows the distribution of the amplitude modulus of the DRs in the lattice at center wavelengths.



a b c

Fig. 3. Square lattice of spherical microresonators (a) with H_{mm1} (m=30) magnetic oscillations (a). The transfer coefficient between the input and output lines (b). Waveguide distribution of coupled microresonator modes on $\lambda = 1{,}5$ μm (c).

In Fig. 3 shows the results of calculation of scattering on a square lattice of coupled spherical microresonators with magnetic oscillations H_{mm1}. The coupling coefficients between the microresonators was calculated by using the results [1].



a

b

c

Fig. 4. 3-dimensional square lattice of DRs (a). S-matrix coefficient between the input and output lines of a lattice of 7x7x7 DRs with H_{101} magnetic oscillations (b). Waveguide distribution modes in 4 layer on $\lambda = 36{,}873$mm (c).

A similar phenomenon is observed in 3-dimensional lattices. In Fig. 4, a shows a square lattice of cylindrical DRs with magnetic oscillations H_{101}. The distribution of the S matrix by wavelengths is shown in Fig. 4, b. The waveguide distribution of amplitudes was observed in each layer on the wavelength indicated by the dashed line (Fig. 4, b). Thus, we can conclude that in this case a planar waveguide is formed in the diagonal plane of the lattice. Figure 4, c shows example of distribution of the amplitude modulus in the 4 layer of the DRs lattice.

As can be seen from the data obtained, we have discovered a new phenomenon of waveguide distributions of the DR coupled modes in homogeneous two and three-dimensional square lattices. This phenomenon is quite universal in nature, since it was observed on gratings consisting of different types of resonators with different types of oscillations. In this case, the observed distribution of amplitudes is associated with forced oscillations and, in contrast to the natural oscillations of the lattice (Bloch states), is observed only at certain wavelengths. At other wavelengths, the distribution of the field is more complex.

In the future, the examined properties of the DR lattices can be used in the design of different elements of optical communication systems.

References

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