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OPTICAL ANTENNAS-FILTERS ON DIFFERENT SPHERICAL MICRORESONATORS FOR USE IN ACCESS POINTS

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ОПТИЧНІ АНТЕНИ-ФІЛЬТРИ НА РІЗНИХ ТИПАХ СФЕРИЧНИХ МІКРОРЕЗОНАТОРІВ ДЛЯ ВИКОРИСТАННЯ В ТОЧКАХ ДОСТУПУ

Пропонується новий тип оптичних антен, побудованих на декількох підрешітках Діелектричних Резонаторів (ДР) різних видів. Показано, що запропоновані антени дозволяють вирішити актуальні завдання розширювання частотних смуг.

Встановлено, що антени на різних підрешітках ДР можуть робити в декількох режимах, кожний із яких характеризується збудженням заданої підсистеми резонаторів. Це додатково дозволяє керувати діаграмою спрямованості. Показано також, що вибір параметрів - типів коливань, а також числа резонаторів, дозволяє ефективно розширяти смугу пропускання антени.

Вперше розглядуються характеристики розсіювання та діаграми спрямованості антен-фільтрів, одночасно побудованих на Діелектричних Резонаторах з коливаннями шепочучей галереї, та на резонаторах з основними типами власних коливань.

Представлені результати є основою для подальшого моделювання і оптимізації широкого класу антен для побудови точок доступу сучасних систем оптичного зв'язку та Інтернету речей.

In works [1 - 3] a new class of microwave antennas was investigated for simultaneously performing the functions of spatial distribution of the radiation field and at the same time frequency filtering. The obtained results and design principles cannot be transferred to shorter-wave – infrared, optical frequency ranges due to the known shortcomings of physical materials. In this paper a new principle of the antenna-filters design in the optical range, based on usage of coupled sublattices of different types microresonators is proposed. A new kind of the antenna, containing several different lattices of dielectric resonators is proposed. In this case one of the sublattices consists of microresonators with whispering gallery oscillations (WGM), this sub lattice forms frequency band of the antenna. The second sub lattice consists of microresonators with lower modes and forms the spatial distribution of the radiation field in the wave zone.

The main difficulty in calculating such antennas lies in the very high degree of degeneration of the higher types of natural oscillations of the DRs. As an example, the results of modeling a new linear optical antenna [3 – 6] built on two types of spherical microresonators are given. (Fig. 1, a).

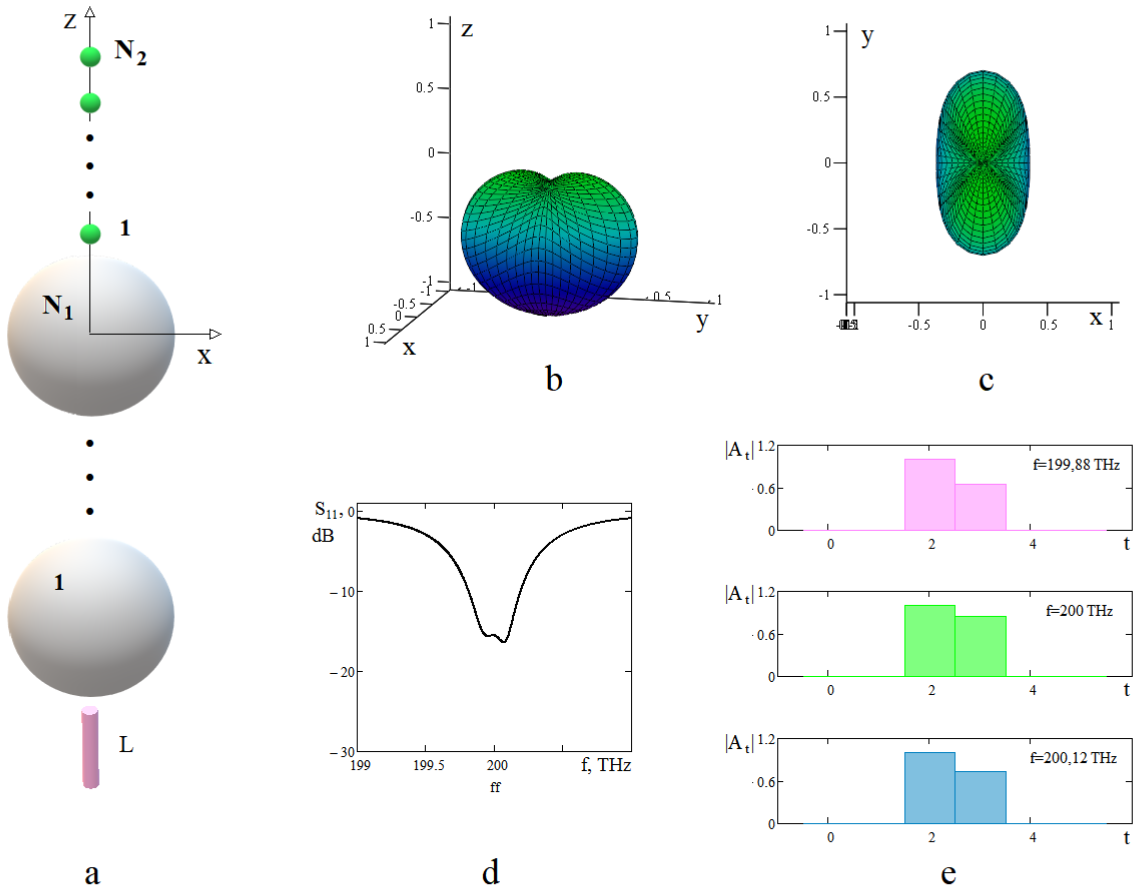

Fig. 1. One-dimensional dielectric antenna (b - e) made on two sublattices of spherical DR: with WGM oscillations $H_{25,1,1}$ $(1,2,...,N_1)$; and DR with $H_{1,1,1}$ oscillations $(1,2,...,N_2)$. Radiation characteristics of a 6-cavity antenna ($N_1 = 2; N_2 = 4$) $f_0 = 200$ THz; 1 DR coupling coefficients with a transmission line L: $\tilde{k}_L = 4,5 \cdot 10^{-3}$; permittivity of resonators $\varepsilon_{1r} = 2,25$; dielectric loss Q-factor of 1 sublattices resonators: $Q_1^D = 10^7$; dielectric loss Q-factor of 2 sublattices resonators: $\varepsilon_{2r} = 25$; dielectric loss Q-factor $Q_2^D = 10^3$. Relative distance between 2 sublattices resonators $k_0 \Delta z_{1,2} = \pi / 2$; Antenna Directivity Diagram (b, c); input reflection coefficient frequency response (d); amplitude modules of forced oscillations of the DR lattice at different frequencies of the operating band (e) ($t = 0,1,..., N_1 + N_2 - 1$).

The conducted studies have shown that in the sublattices of various DRs, conditions can be created under which the coupling element of the antenna with the transmission line effectively excites only the oscillations of the low-Q microresonators of the sublattice (Fig. 1, e; Fig. 2, d). At that, the lattice consisting from high-Q DRs, forms the antenna bandwidth (Fig. 1, d; Fig. 2, c).

At the same time, it has also been shown that changing one or several of the antenna parameters, for example frequency, in some cases can lead to a significant restructuring of its radiation pattern. (Fig. 2, a, b). The restructuring of the antenna's directional pattern is caused by a partial redistribution of the amplitudes of the field of the coupled oscillations of the "radiating" sublattice (Fig. 2, d).

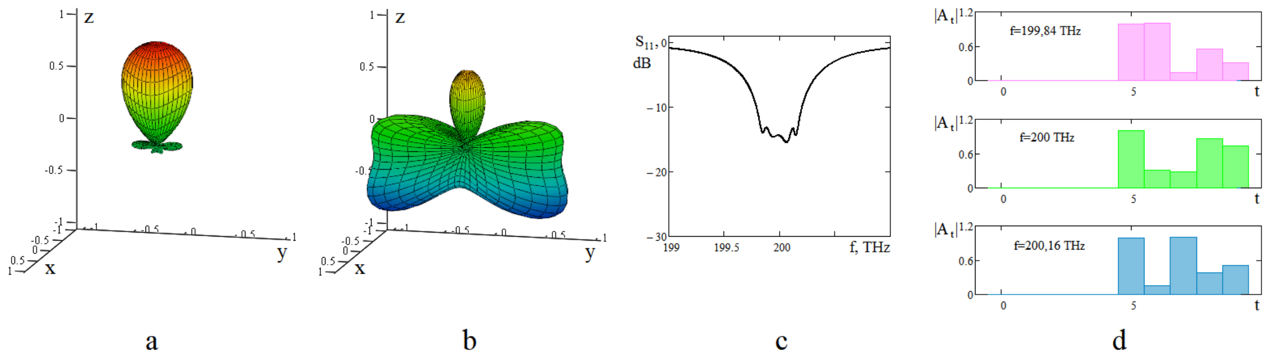

Fig. 2. Radiation characteristics of a one-dimensional 10-resonator dielectric antenna (Fig. 1, a: $N_1 = 5$; $N_2 = 5$) (the parameters of the resonators and antenna are the same as on Fig.1) Antenna Directivity Diagram (a, b); input reflection coefficient frequency response (c); amplitude modules of forced oscillations of the DR lattice at different frequencies (d) ($t = 0,1,...,N_1 + N_2 - 1$).

The obtained research results demonstrate the possibility of constructing a new class of dielectric antenna-filters in the optical wavelength range, performed on the basis of application of sublattices build on different microresonators, characterized by a controlled frequency band and directional characteristics. Presented results are the basis for further modeling and optimization of a wide class of antennas for building access points of modern optical communication systems, as well as IOT.

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