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New method of fabrication of resonant photonic photonic band gap structures based on the polymer films containing multivalent rare-earth metal cations formed by stepwise alternate adsorption of metal cations and polyanions.

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The last years have witnessed an intense investigation of light propagation in periodic structures. These structures are usually referred to as photonic band gap (PBG) crystals. These crystals have many practical applications in optics and technology.

In this presentation we describe the method of fabrication of PBG materials that may have periodic modulation of refraction index, absorption coefficient and the nonlinearity as well.

The method is based on the layer-by-layer self-assembly technique that has been widely studied for the purpose of surface modification and for the construction of new inorganic, hybrid organic/inorganic and polymer-based materials with nanoscale-controlled structure and properties. In this contribution we present results of a study of polymeric films and the multilayer structures on its basis with very high content of multivalent metal cations formed by taking advantage of stepwise coordination of polyanion and multivalent metal cations, in particularly, trivalent rare-earth metal cations The method of film fabrication is based on the layer-by-layer assembly and alternate adsorption of metal cations and polyelectrolite molecules containing negatively charged ligand groups to form condensed supramolecular structure with integrated complexes of metal cations In this approach multivalent metal cations are intrinsically structure-forming component without which resulting material can not be formed Such films dissolved slowly being placed in an aqueous electrolite solution. The purposeful variations of polymer morphology, its functional groups chemical specificity and structure give possibilities for effective property-driven design of metal cation complexes in such material and effective material property tailoring The interactions of a number of rare-earth metal cations (Gd^{3+}, Er^{3+}, Nd^{3+}) with polyanions (poly(styrenesulfonate), poly(acrylic acid)) have been studied and corresponding polymeric films with very high rare-earth cations content (about 70-80% weight) were successfully formed.

Layer-by layer film growth procedure in this method is relatively simple and manufacturable, and allows for the systematic effective nanometer-scale level control of chemical content, composition, functionality, metal cation complexes structure and film thickness This structure, in turn, determines film properties of interest (optical, electronic, mechanical, etc.). As a result, such polymer rare-earth-doped film materials can be perspective for various photonic applications.

We studied films with different rare-earth metal cations and the one dimensional PBG structures based on the self-assembled films using the steady-state linear optical methods. We also studied its nonlinear optical properties using Second Harmonic and Sum-frequency Generation techniques using tunable femtosecond laser sources

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Metal-Oxide-Semiconductor Light-Emitting Diodes at Si Bandgap Energy

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Silicon is the most popular material for electronics industry. However, its applications in optics and optoelectronics are not as popular, mainly limited by the indirect-bandgap characteristics of silicon. Due to the mature fabrication processing technology, it is highly desired to make Si emit light. Although many methods had been invented to generate electroluminescence from Si [1], significant modification is usually required among them. In this work, we report a simple way of electroluminescence from Si. The structure is the same as the conventional metal-oxide-semiconductor (MOS) structure. The oxide is very thin so that carriers could tunnel through the oxide and make the device behave like a diode. Under forward bias, the MOS structure emit light at bandgap energy of Si. Increasing applied voltages, the emission at Si bandgap energy gradually vanishes and, meanwhile, shifts to wavelengths longer than 1200 nm. Fig. 1 shows a spectrum measure from MOS on n-type Si. The MOS structures made on both n-type and p-type Si have similar light-emitting behaviors. The simplicity of emitting light from both p-type and n-type silicon should make silicon an extremely powerful material for applications both in optics and electronics. The details of the emission and physics will be discussed in the presentation.

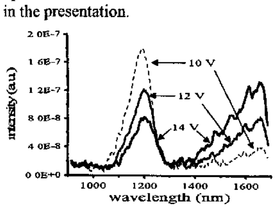

Fig. 1 Emission spectrum of MOS on n-type Si.

References: [1] S. S. Iyer and Y.-H. Xie, "Light emission from Si," Science 260, 40-46, (1993).