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Supplementary data

Fabrication and optical properties of periodical structures based on water-developable and tunable $La_{0.7}Sr_{0.3}MnO_3$ resist

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$La_{0.7}Sr_{0.3}MnO_3$ electron beam resist is capable to exhibit both positive and negative resist behaviors depending on the electron beam dosage, so the height and the depth in different patterns will vary with the electron dosage. Therefore, our dual function $La_{0.7}Sr_{0.3}MnO_3$ resist exhibits additional unique characteristic that can modulate the optical reflectance properties of photonic crystals by only changing the electron dose with a fixed column diameter and lattice constant. However, in the absorption properties measurements, our $La_{0.7}Sr_{0.3}MnO_3$ resist also exhibits interesting behavior. **Fig (a)** shows the absorption spectra of patterned $La_{0.7}Sr_{0.3}MnO_3$ fabricated with different electron doses using a fixed design of 500 nm diameter and 1000 nm lattice constant. Each curve represents a sample obtained at specific electron irradiation as shown in the right side of the curve. The thickness of the $La_{0.7}Sr_{0.3}MnO_3$ resist coated on the silicon wafer substrate was about 200 nm. The sample size is 50 × 50μm. By increasing the electron beam irradiation, we can obtain different geometries of patterned $La_{0.7}Sr_{0.3}MnO_3$ that result in the changes of absorption spectra. The height of the regular honeycomb array of the $La_{0.7}Sr_{0.3}MnO_3$ pillars in **Fig. (b)** is 15 nm, and the depth of the positive pattern of the regular honeycomb array 60 nm as shown in **Fig. (c)**. Finally, the height of the regular honeycomb array of the $La_{0.7}Sr_{0.3}MnO_3$ pillars with high electron dosage (**Fig. (e)**) is 75 nm. First of all, the negative patterned $La_{0.7}Sr_{0.3}MnO_3$ irradiated by 1.6 and 3.2 mC/cm^2 show low absorption properties (curve A01 and curve A02) in the low dose region (I) due to the resist contains $La_{0.7}Sr_{0.3}MnO_3$ precursor salt with crosslinked polyvinyl alcohol (PVA). When the positive patterned $La_{0.7}Sr_{0.3}MnO_3$ was obtained by increasing electron beam dosage

in the range from 22.4 to 32.0 mC/cm^2, the absorption intensities are increasing gradually at 420 nm as shown in the medium dose region (II) (curve A04 ~ curve A07) which is due to a larger amount of resist remaining after developing as compared with region (I). Nevertheless, the patterned $La_{0.7}Sr_{0.3}MnO_3$ in the medium-high region (□) was transformed from positive pattern to negative pattern gradually, when the electron beam dosage was increased to the range of 48.0 ~ 96.0 mC/cm^2. The intensities of the absorption peaks at 425 nm in the region (□) are also increasing gradually (curve A08 to curve A10). These behaviors are due to the changes of compositions of the resist as shown from Fig (c) to **Fig (d)**. In other words, the centre area of air column in patterned $La_{0.7}Sr_{0.3}MnO_3$ sample is $La_{0.7}Sr_{0.3}MnO_3$ component without PVA and it increases gradually on curve A08 to curve A10. Finally, the negative patterned $La_{0.7}Sr_{0.3}MnO_3$ without PVA was obtained in region (□) with the electron beam dosage range of 240.0 ~ 304.0 mC/cm^2, and their absorption spectra are shown in curve A11 ~ curve A13, respectively. The maximum absorption peaks are about at 500 nm. The absorption is high due to the presence of pure $La_{0.7}Sr_{0.3}MnO_3$. This unique absorption feature of the periodic structure of $La_{0.7}Sr_{0.3}MnO_3$ is due to its material composition varying with electron beam dose, and the material compositions are the main factor affects the total refractive index of periodic structure of $La_{0.7}Sr_{0.3}MnO_3$ as well.

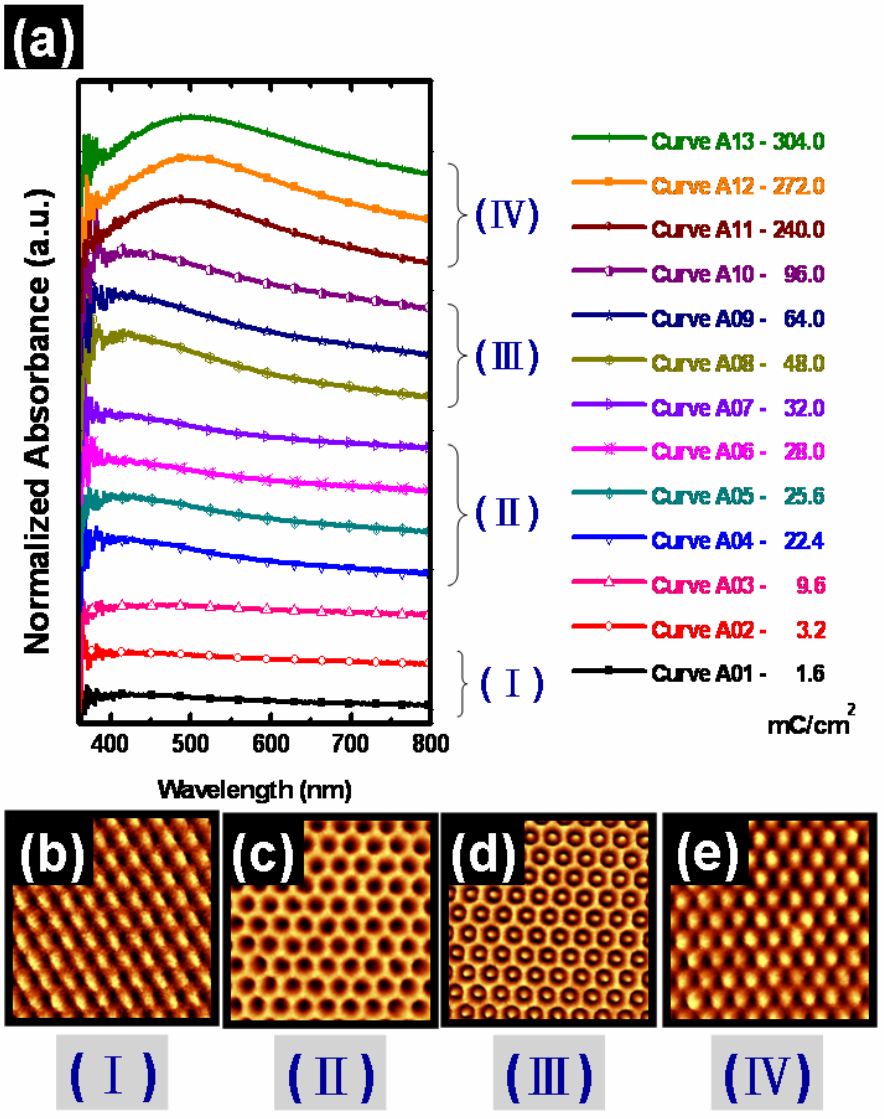

Fig. (a) Absorption spectra of patterned $La_{0.7}Sr_{0.3}MnO_3$ are changed by varying the electron beam dosage, and the design pattern is fixed at 1000 nm lattice constant and 500 nm diameters. Four ranges of electron beam dose are used. Low dose region (I):1.6~3.2mC/cm^2, medium dose region (II):22.4~32.0 mC/cm^2, medium-high dose region (III):48.0~96.0mC/cm^2, and high dose region (IV): 240~304.0 mC/cm^2. Below images are the confocal microscopy image of patterned $La_{0.7}Sr_{0.3}MnO_3$ with different electron beam dose, low dose **(b)**, medium dose region **(c)**, medium-high dose **(d)**, and high dose **(e)**.