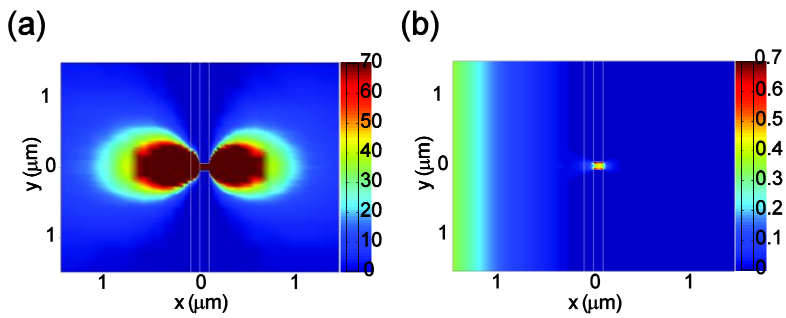

Fig. 5. Averaged horizontal electric field for λ = 34.48 μm calculated by finite difference time domain (FDTD) method to investigate the physical origin of enhanced nonlinear response of nanoresonators. The incident wave comes from the left to the right. (a) patterned sample with insulating state of VO_2 (b) patterned sample with metal state of VO_2. For the patterned film case, nanoresonators attract surrounding waves and funnel them to the other side making enhanced transmission at the insulating state of VO_2 while most of the beam reflects back at the surface when the VO_2 film is in the metallic state.

3. Conclusion

In conclusion, we have demonstrated that VO_2 thin film with nm-width rectangular apertures comprises a new class of metamaterial achieving orders of magnitudes improvement in extinction with modest photo-excitation power, overcoming multiple-interference in thin-films. Strongly localized near field in the resonators induces the enhanced far-field transmission for the insulating VO_2 while the resonators are completely inoperative when the underlying VO_2 film becomes fully metallic, making perfect transmission control possible. Corresponding giant enhanced nonlinear response $\Delta\alpha L$ reaches 0.7 with 350-nm-width patterned sample, despite ultrathin film thickness. Room temperature carrier lifetime of the order of picosecond for VO_2 [22,23] strongly suggests the potential use of nano-patterned VO_2 thin films for all-optical switching having huge dynamic range. Our new scheme bridges the gap between thin film technology, nanotechnology and active metamaterials research.

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