Optical coupling of short-range ordered nanopores through surface plasmons

Tokyo Inst. Tech.[1]. ^O^Vu Thi Dung[1], Naoki Yamamoto[1], Takumi Sannomiya[1]

E-mail: vu.t.ab@m.titech.ac.jp

Introduction

Plasmonic devices such as nanopore biosensors require resonance conditions of surface plasmon polaritons (SPPs) at planar metal/dielectric interfaces or localized surface plasmons (LSP). For plasmonic nanopores (or nanoholes), their optical resonances are typically determined by the inter-pore distances with respect to the SPP wavelength. Short-range ordered nanopores can readily be fabricated through self-assembly processes and suited for large area production. However, the inter-pore distance varies locally, thus the resonance. Here in this study, we investigate the local resonances of short-range-ordered nanopores.

Method

Short-range ordered (SRO) nanopores are fabricated in AlN-Au-AlN trilayer films by combining colloidal lithography and film transfer technique. Taking advantage of the non-uniform distribution of the nanopores in the SRO structure, scanning transmission electron microscopy (STEM) combined with cathodoluminescence (CL) is used to map the radiative electromagnetic local density of state, offering accessibility to interested small regions. Besides, the optical properties of such plasmon nanopore arrays were characterized by optical transmission spectroscope.

Results

Cathodoluminescence (CL) photon map indicated that the resonance sensitively depends on center-to-center distance between the nanopores, distributing multiple plasmon resonance modes. The narrow nearest-neighbor distance distribution of the pore exhibits a higher energy resonance while the wider distance distribution leads to light confining at lower energy. In particular, the plasmon peak position, height and width of the CL spectra and the concentration of pores in the certain areas have a great correlation, which was analyzed using a Matlab program. Analogously, compared to the SRO nanopores with high density of pores per unit area, nanopores of the low density presented a red-shift and significant broaden peak from the transmission spectra, demonstrating the optical resonant interaction decided by inter-pores distances.

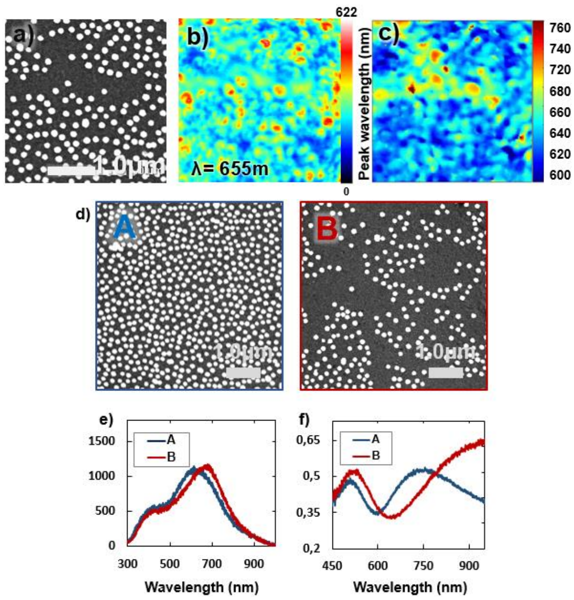

Fig.1. *a: STEM bright-field image of the SRO plasmonic nanopores. b: CL map obtained at plasmon resonance wavelength of λ= 655 nm. c: Peak position image. d: STEM images of samples with high density of pores (A) and low density of pores (B). e, f: CL and transmission spectra of samples A and B.*