Fabrication of perfect plasmonic absorbers for blue and near-ultraviolet lights using double-layer wire-grid structures

Atsushi Motogaito (motogaito@elec.mie-u.ac.jp)
Mie University https://orcid.org/0000-0002-7387-8469
Ryoga Tanaka
Mie University
Kazumasa Hiramatsu
Mie University

Research

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Abstract

This study proposes using double-layer wire-grid structures to create narrow-band, perfect plasmonic absorbers, which depend on polarization, for the short-wavelength visible and near-ultraviolet regions of the electromagnetic spectrum. A rigorous coupled-wave analysis reveals that the maximum absorption attained using Ag and Al is ~90% at 450 nm and 375 nm. Experiments using Ag yielded results similar to those predicted by simulations. These results demonstrate that narrow-band perfect plasmonic absorbers, which depend on the polarization, can be realized at 450 nm and 375 nm using Ag or Al.

Full Text

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Figures

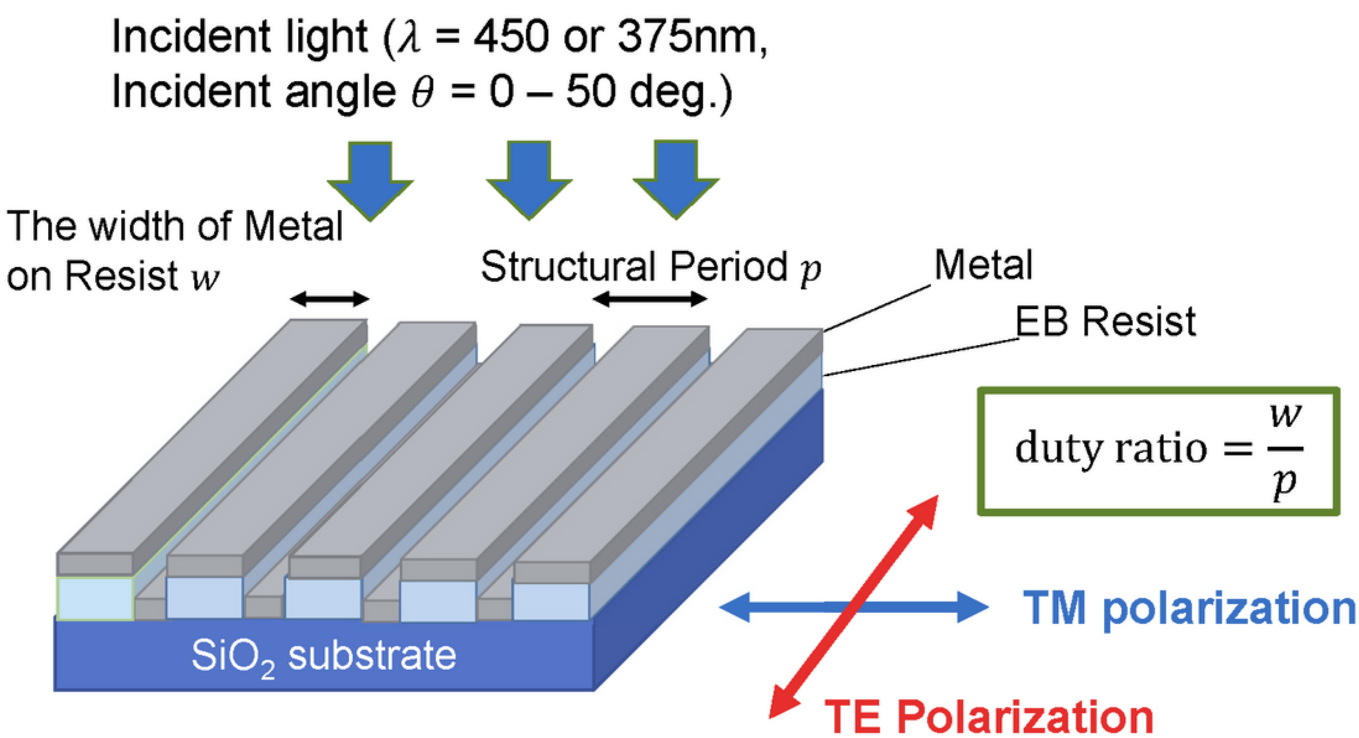

Figure 1

The schematic of the wire-grid structure. This structure comprises metal and electron-beam (EB) resist layer on the SiO2 substrate. Parameters p and w are structural period and the width of metal on the resist layer, respectively. w/p is the duty ratio of the periodical structure. The parameter h is the thickness of the

EB resist layer. The details of these values are shown in Table 1. The wavelength λ is between 450 and 375 nm. The incident angle θ is between 0o and 50o.

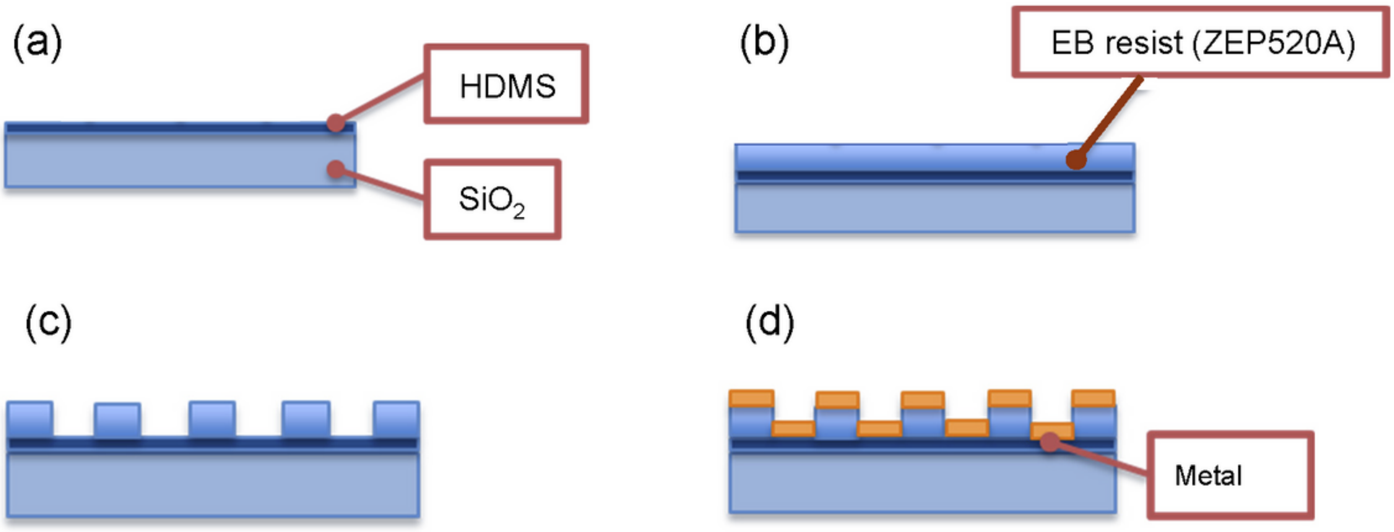

Figure 2

The procedure used in fabricating the double-layer wire-grid structure. (a) Cleaning the SiO2 substrate and spin coating Hexamethyl disilazane. (b) Spin coating 308 the electron-beam (EB) resist and antistatic agent. (c) Patterning using EB lithography and developing the EB resist. (d) Sputtering metal (Ag).

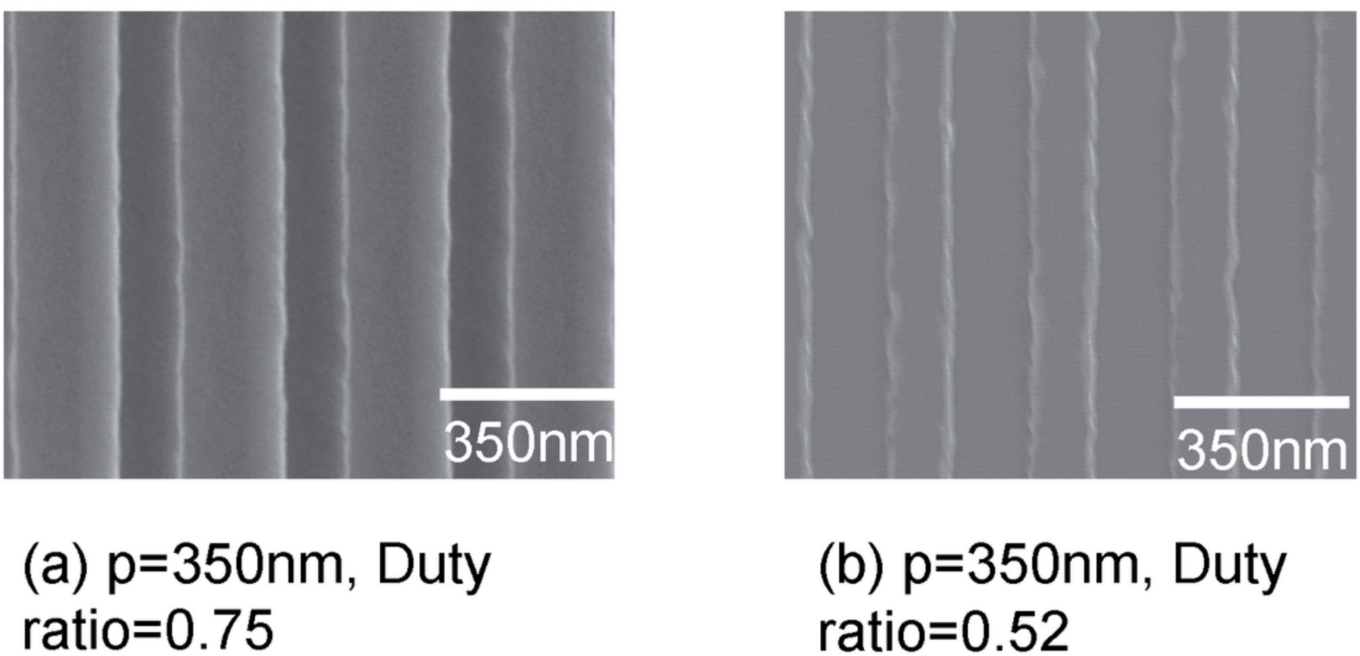

Figure 3

Surface SEM image of the patterns fabricated by electron-beam lithography. (a) For p = 350 nm, duty ratio w/p = 0.75. (b) For p = 350 nm, duty ratio w/p = 0.52.

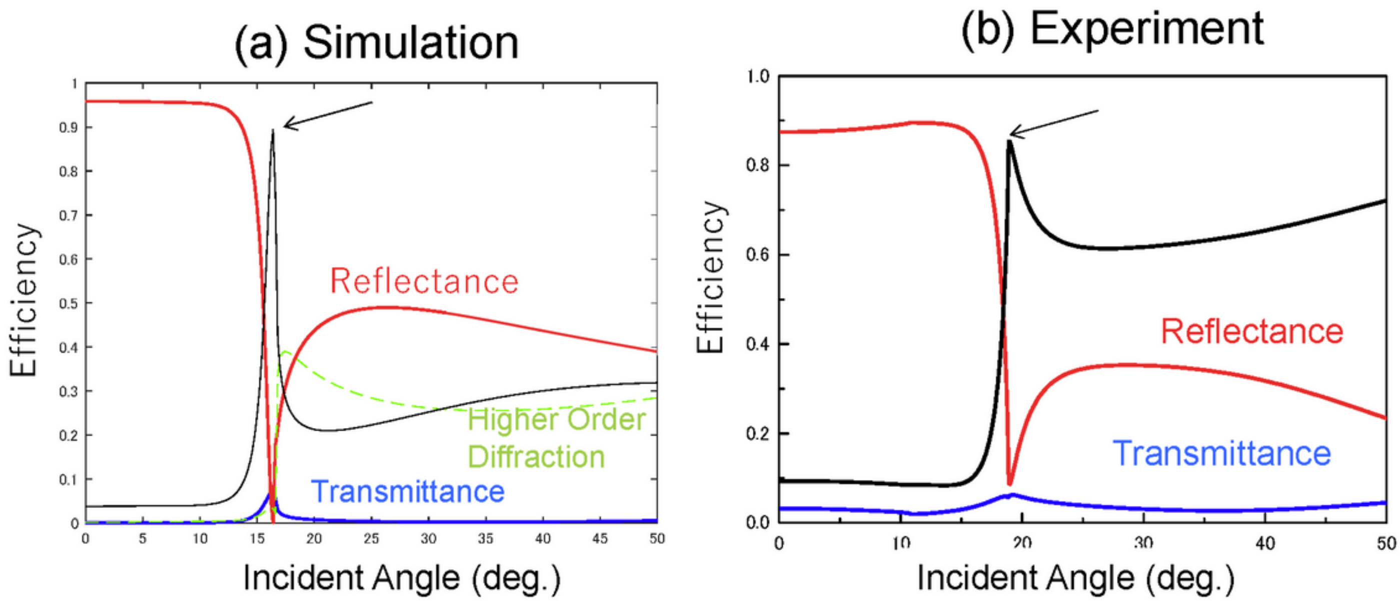

Figure 4

Angular spectra for the angle-of-incidence dependence of the transmittance, reflectance, and absorptance (λ = 450 nm, p = 350 nm, and duty ratio w/p = 0.75). (a) Simulation result and (b) experimental result. The arrow means the peak angle of the absorptance and the dip angle of the reflectance.

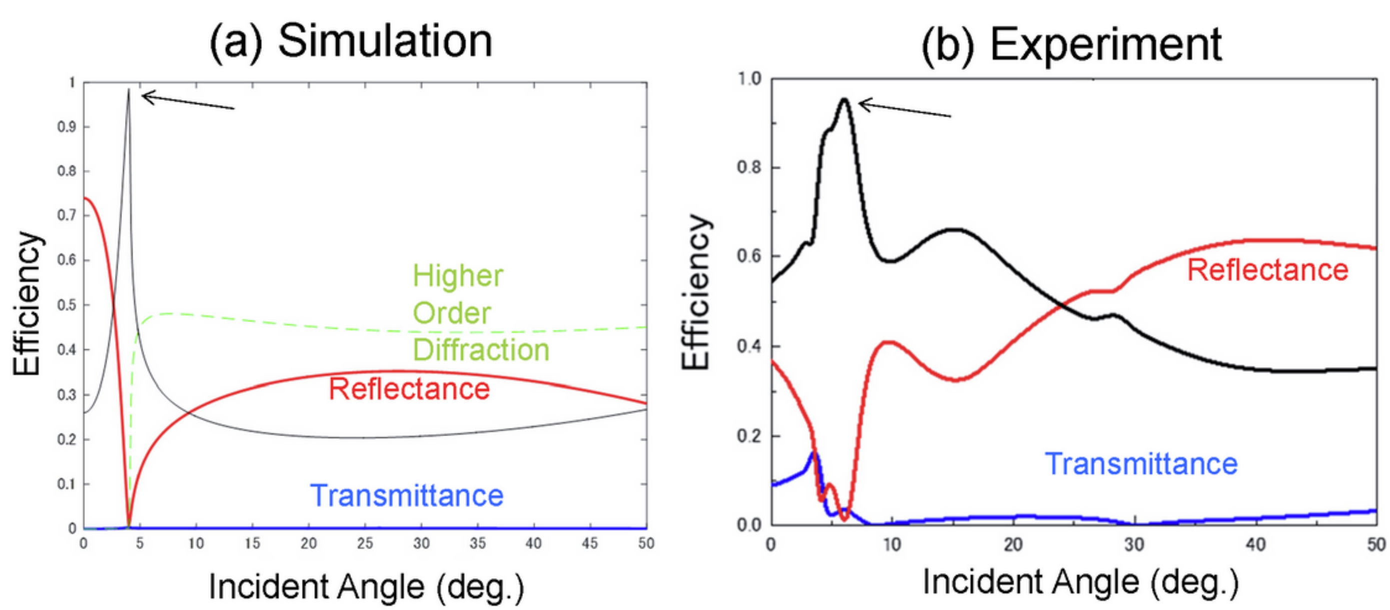

Figure 5

Angular spectra for the angle-of-incidence dependence of the transmittance, reflectance, and absorptance (λ = 375 nm, p = 350 nm, duty ratio w/p = 0.52). (a) Simulation and (b) experimental. The arrow means the peak angle of the absorptance and the dip angle of the reflectance.

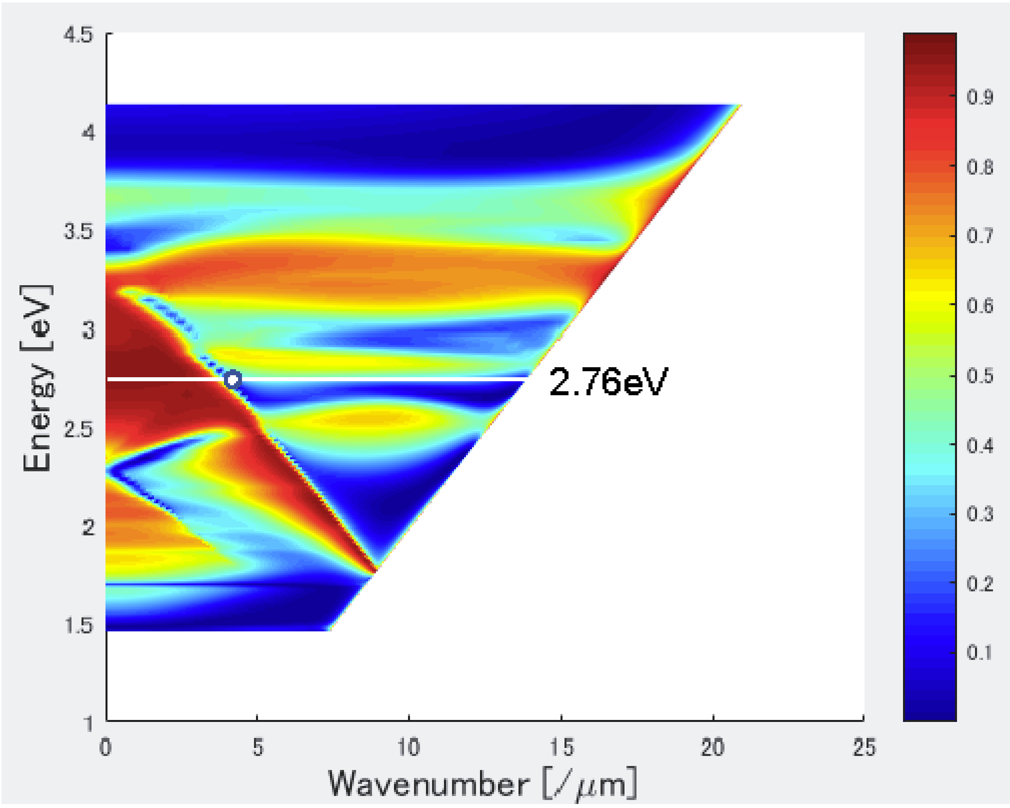

Figure 6

A color map of the reflectance calculated using RCWA method for a grating period p of 350 nm, duty ratio w/p of 0.75, an 80-nm-thick Ag layer, and the wavelength λ of 450 nm as a function of wavenumber and energy. The color bar shows the magnitude of the reflectance.

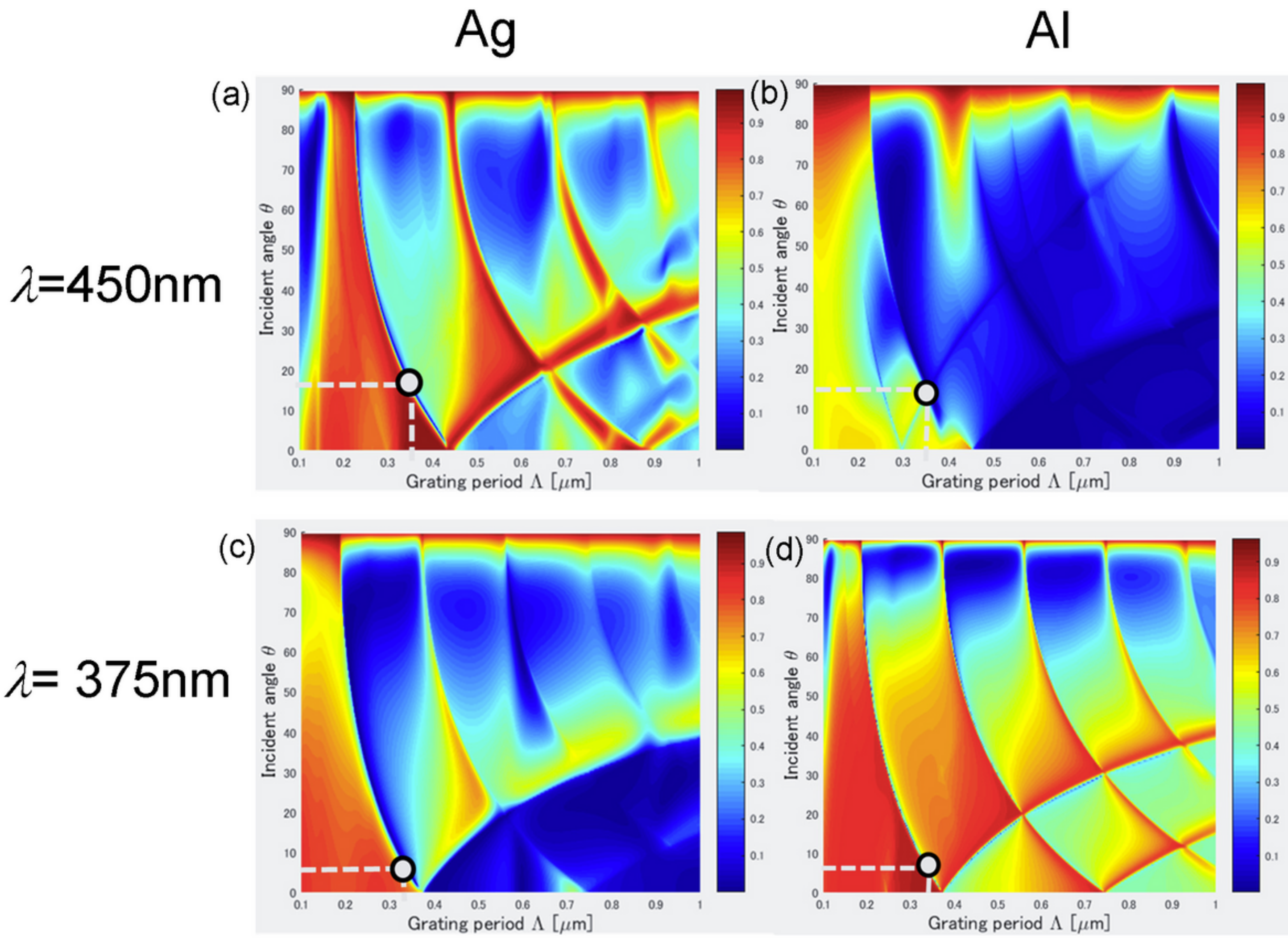

Figure 7

The color maps of the reflectance calculated using RCWA method. The color bar shows the magnitude of the reflectance. (a) For λ = 450 nm, Ag. (b) For λ = 450 nm, Al. (c) For λ = 375 nm, Ag. (d) For λ = 375 nm, Al. The detail structural 326 parameter is shown in Table 1.

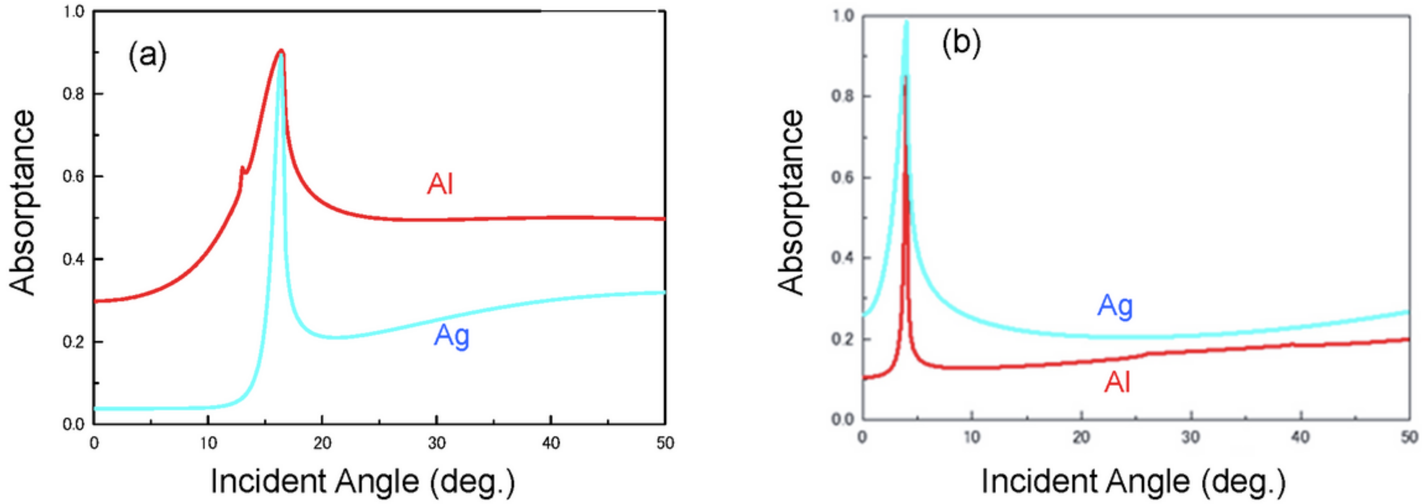

Figure 8

The absorptance spectra at (a) λ = 450 nm and (b) λ = 375 nm. The red and blue curves are the absorptance for Al- and Ag-double-layer wire-grid structures, respectively.

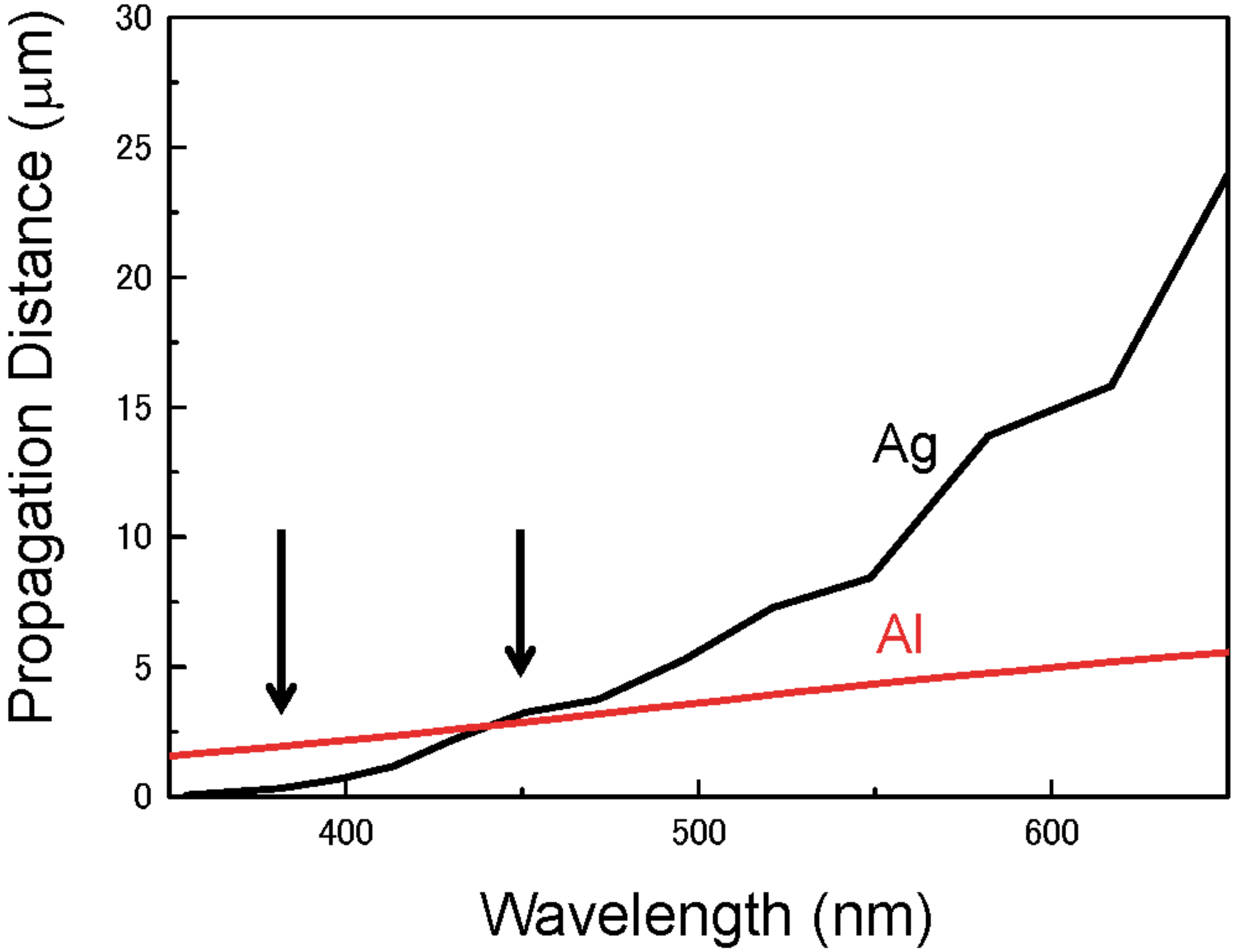

Figure 9

Calculations of the wavelength-dependence of the propagation length of the surface plasmons for Ag and Al. The arrows indicate λ = 375 nm and 450 nm.