Searching for refractory plasmonic materials: the structural and optical properties of Au₃Zr intermetallic thin films

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Abstract

Optical properties of refractory intermetallic thin films of Au₃Zr were experimentally investigated for the first time, which show distinctive plasmonic properties in the visible and near infrared region. The films were fabricated through DC magnetron sputtering at various deposition temperature ranging from room temperature to 427°C and annealed at different vacuum levels. Both the structural and optical properties are found to be critically dependent on deposition temperature and anneal conditions. Films deposited between 205-320°C are shown to exhibit lower negative permittivity and better thermal stability, which could be linked to specific crystalline orientations. The films are stable when annealed at 10⁻⁸ Torr, but are partially oxidized when annealed at 10⁻⁶ Torr, suggesting oxidization could be a restricting issue for high-temperature applications in ambient environment.

Full Text

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Figures

Figure 1

XRD spectra of Au_3Zr films fabricated at different deposition temperatures denoted by the numbers (in the unit of Celsius). Solid lines indicate the expected peak positions calculated from the lattice parameters in literature

Figure 2

Williamson-Hall analysis of the XRD results. (a) Williamson-Hall plots of films deposited at various temperatures denoted by the numbers ($^{\circ}\text{C}$). (b) The average grain size (circles), strain (triangles) and resistivity (squares) of the Au₃Zr films as a function of deposition temperature

Figure 3

Optical properties of Au₃Zr thin films deposited at various temperatures. (a-b) Real (n) and imaginary (k) part of refractive index. (c-d) Real (ϵ') and imaginary (ϵ'') part of permittivity

Figure 4

Measured (solid) and calculated (dashed) optical reflectance spectra of Au₃Zr thin films fabricated at various deposition temperatures

Figure 5

Effects of in-situ anneal. Comparison of XRD spectra of Au₃Zr films deposited at (a) room temperature (RT) and (b) 426°C and 439oC, with and without in-situ anneal, respectively

Figure 6

The effects of in-situ anneal on the optical properties. Real and imaginary refractive index of Au₃Zr films with and with-out the in-situ anneal. (a) films deposited at RT, (b) films deposited at 426oC (in-situ annealed sample) and 439oC (without in-situ anneal)

Figure 7

XRD spectra of Au₃Zr films annealed in a vacuum oven (1.5×10^{-6} Torr) at 497°C for 1 hour. The number of each spectrum indicates the deposition temperature (°C)

Supplementary Files

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