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High temperature stable ZrN-based thin films for plasmonic applications

Jean-Francois PIERSON, Marius GIPPERICH, Zil FERNANDEZ, David PILLOUD, Thomas EASWARAKHANTHAN, Hervé RINNERT

Institut Jean Lamour, NANCY, France

jean-francois.pierson@univ-lorraine.fr

Silver and gold nanoparticles are well-known materials for plasmonic applications. However, their optical properties (of these metals) are strongly modified at high temperatures. To overcome this problem, metal nitrides (TiN and ZrN) are suitable materials for high temperature plasmonic applications. Recently, it has been demonstrated that the plasmonic response of TiN- and ZrN-based materials is tunable in the infrared region by addition of a third element. The present contribution aims to show the effect of Y addition on the optical and electrical properties of reactively co-sputtered (Zr,Y)N films.
The maximal value of the Y/(Zr+Y) ratio has been limited to approx. 50 at. %. The progressive addition of Y atoms into the ZrN films does not induce any change in the film structure. A linear increase of the lattice constant as a function of the Y content has been evidenced by X-ray diffraction indicating that yttrium atoms substitute zirconium ones in the rocksalt-like cubic structure. A drastic change of the electrical and optical behaviors has been observed when the Y content exceeds 30 at. %. At low Y content the films exhibit a metallic-like behavior with low electrical resistivity and a strong absorption band in the visible range whereas a semiconductor-like behavior is evidenced at high Y content. For the films exhibiting a metallic behavior, the plasmon wavelength evolves linearly with the yttrium content. The spectra of the real and imaginary parts of the film dielectric function deduced from ellipsometry confirm the above conclusions. Finally, the evolution of the films' optical properties as a function of the temperature in the 25-400 °C range has been studied. Even after air annealing at 400°C, there is no change in the films' reflectance. The same behavior has been also noticed for the electrical properties. These results clearly show that (Zr,Y)N films are suitable for plasmonic applications.

Keywords
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