Takeo Tomiyama, J Material Sci Eng 2018, Volume 7
DOI: 10.4172/2169-0022-C5-104

Optical anisotropy studies of silver nanowire/polymer composite films

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Silver nanowire (AgNW) networks are one of the promising candidates as a next-generation transparent electrode material, given their high optical transparency and low electrical resistivity. AgNW networks based transparent conductive film can be fabricated by cost effective wet coating methods and exhibits better flexibility than the widely used indium tin oxide. The optical and electrical properties of AgNW networks have been extensively investigated in the past decade, both experimentally and theoretically. Previous researchers have discussed some aspects of optical properties such as transparency and haze, but have not presented a comprehensive study concerning optical constants (refractive index n and extinction coefficient k) of the AgNWs network. We have developed an AgNW/photosensitive polymer composite film that allows conductive patterning on a range of base materials. The composite films fabricated by roll-to-roll die coating exhibited optical and electrical anisotropy depending on the coating conditions. These problems motivated us to study the relation between the optical anisotropy, the electrical anisotropy and the orientation of AgNWs in the polymer matrix. To clarify the relation between the optical anisotropy, the electrical anisotropy and the orientation of AgNWs, the orthogonal optical constants of the composite films were determined by Mueller matrix spectroscopic ellipsometry. The orthogonal optical constants revealed the plasmonic natures of AgNW ensembles, and their anisotropy is correlated to the morphology of the composite film, where the long axis of AgNW is preferably oriented in the lengthwise film direction. We have demonstrated that the ellipsometric data analysis used in this study is effective to gain insight into the anisotropic optical properties of metal nanowires networks.

Recent Publications

1. Shengrong Ye, Aaron R Rathmell, Zuofeng Chen, Ian E Stewart and Benjamin J Wiley (2014) Metal nanowire networks: The next generation of transparent conductors. Adv. mater. 26(39):6670–6687.
2. G Khanarian, J Joo, X Q Liu, P Eastman, D Werner, K O'Connell and P Trefonas (2013) The optical and electrical properties of silver nanowire mesh films. J. Appl. Phys. 114:024302.
3. Rose M Mutiso, Michelle C Sherrott, Aaron R Rathmell, Benjamin J Wiley and Karen I Winey (2013) Integrating simulations and experiments to predict sheet resistance and optical transmittance in nanowire films for transparent conductors. ACS Nano 7(9):7654–7663.
4. Milind Jagota and Nelson Tansu (2015) Conductivity of nanowire arrays under random and ordered orientation configurations. Scientific Reports 5:10219.
5. Takeo Tomiyama and Hiroshi Yamazaki (2017) Optical anisotropy studies of silver nanowire/polymer composite films with Mueller matrix ellipsometry. Applied Surface Science 421:831-836.

Biography

Takeo Tomiyama received his MS degree in Chemistry from Gakushuin University, Japan. He has been working at Hitachi Chemical Co., Ltd. His current research interests include the development and characterization of optical materials for information display applications.

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