for the as-grown sample with $N_s=5.9(1) \times 10^{11}$ cm$^{-2}$ where $\mu=250(77)$ cm$^2$/Vs. The highest $N_s$ was found after purging the sample with nitrogen for 6 hours with $N_s=2.43(4) \times 10^{12}$ cm$^{-2}$ where $\mu=1604(23)$ cm$^2$/Vs. These significant changes are attributed to a redox-reaction of oxygen and water at the graphene surface which results in the extraction of electrons from graphene [3]. This will be discussed in detail in our presentation. We further observe that this doping mechanism is only partially reversible at room temperature upon removal of oxygen, carbon dioxide, and water by purging the cell with nitrogen. In conclusion, we demonstrate in-situ THz-

OHE as a new and powerful technique to determine ambient-dependent doping mechanisms which is illustrated here using monolayer epitaxial graphene on Si-face 4H-SiC.


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investigated the band gap and the infrared-active phonons. Cochralski-grown LSAT wafers with (001) surface orientation were obtained commercially (MTI Corp., Richmond, CA). Single-sided polished wafers were used for spectroscopic ellipsometry and two-sided polished wafers with 0.5 mm thickness for transmission. Between 0.8 and 6.5 eV, we measured the normal-incidence transmission and the ellipsometric angles from 60° to 80° incidence in 2° steps on a J.A. Woollam variable angle of incidence ellipsometer with a computer-controlled Brewster waveplate compensator. We also measured in the mid-IR on a rotating compensator FTIR ellipsometer. Transmission measurements show a steep rise of the absorption coefficient (α) between 4.6 and 4.8 eV, where LSAT becomes opaque. Fitting the ellipsometry data with a model containing two Tauc-Lorentz oscillators and 19 Å surface roughness thickness yields an excellent fit to the data. The Tauc gap is 4.9 eV and the high-frequency dielectric constant ε∞ = 4.0. Plotting d2 versus photon energy yields a direct band gap of 5.8 eV. An Urbach tail extends towards lower energies. The resulting dielectric function is in agreement with previous ellipsometry and minimum-deviation prism measurements. The mid-IR dielectric function shows four ε± peaks due to TO phonon absorption. The loss function shows four LO peaks. A fifth TO phonon was seen at 155 cm⁻¹ in far-IR ellipsometry. An ideal ABO₃ perovskite has only three IR-active TO phonons. FCC ordering on the B-site as in Sr₂Al₃O₇ adds a fourth phonon. We argue that the TO phonons at 155 and 283 cm⁻¹ are vibrations of the tetrahedra against the La/Sr sublattices, respectively (mode splitting due to disorder). On the other hand, the 397 and 442 cm⁻¹ modes are B-O bending modes due ordering in the Al/Ta sublattice. Finally, a B-O stretch mode at 66 cm⁻¹ and broad two-phonon absorption at 765 cm⁻¹ are also found. Fitting the spectra with a factorized TO/LO model yields better results than a sum of Lorentzians, because the individual TO/LO pairs are not well separated. The presence of FCC ordering was also confirmed with x-ray diffraction. We will also discuss temperature dependent ellipsometry and transmission measurements.

10:00am EL+AS+EM+MIFrM6 A New Constant of Product of Electronic Scattering Time and Resistivity in Thin Silver Refractive Index Calculation from Ellipsometry and Resistivity Measurements, Guowen Ding, C. Clovero, D. Schweigert, M. Le, Intermolecular, Inc.

The optical and electrical response of metal thin films is highly affected by electronic scattering with the interfaces and defects. We are able to successfully model the electrical resistivity and near infrared (IR) optical response using a thickness dependent electronic scattering time. We investigated Ag films thickness in the range of 3 nm to 74 nm and determined that the product of electronic scattering time (τr) and resistivity (ρ) remains constant regardless of the thickness (τrxρ=c), with a value of 59±2 μΩ cm·s for Ag films. As a result, determining the constant c for a given thin film will allow to calculate the properties of the film over a large range of wavelengths while limiting the number of measurements. Our findings enable us to develop a theoretical framework to determine the optical response of metal thin films in the near IR by using single waveguide ellipsometer measurements. An excellent agreement is found between experimental measurements and predicted values. We first reported this constant τrxρ=c for silver, and we posit that such constant concept could be applied for other conducting films. Application of the model presented here will allow rapid characterization of the IR optical response of metal thin films, with important application in a broad spectrum of fundamental and industrial applications, including optical coatings, low-emissivity windows and semiconductor industry.


TNO is realizing EUV Beamline 2 (EBL2), a facility to investigate the effects of Extreme Ultra-Violet (EUV) radiation on surfaces to enable future EUV High Volume Manufacturing (HVM) production. In this facility, samples with sizes up to 152x152x20 mm (6° EUV reticles) can be exposed to EUV radiation of up to 500W equivalent at intermediate focus (IF) under realistic environmental conditions and analyzed by in-situ ellipsometry and XPS. EBL2 consists of EUV source, automated handling system, beam line and an exposure chamber with an in-situ dual wavelength Mueller-matrix imaging ellipsometer. Light from the dual wavelength light source (405 & 640nm) enters the exposure chamber through a polarizer, configurable retarder and a vacuum window producing a defined polarization state. After reflecting off of the sample, the light exits the exposure chamber through a vacuum window, configurable retarder and polarizer. The sample position is imaged on two camera’s, one for each wavelength. By combining all combinations of 4 polarization illumination states with 4 analyzer states the full Mueller matrix of the sample can be recovered.

Calibration is performed in-situ with two insertable polarizers and two different calibration samples. The calibration procedure does not require prior knowledge of the polarizer orientation nor of the calibration samples. This presentation will focus on the design and realization of the ellipsometer and will also touch upon the process of interpreting the data. EBL2 will be publicly accessible as a test facility for EUV lithography related research after qualification, which is expected to be finished end of Q1 2017.

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