Title:	Measurement of Electrical, Thermal, and Photo-Conductivity of Nanomaterials
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Abstract:	Basic understanding of electron and phonon transport mechanisms in nanomaterials can open doors for many applications. Many intrinsic and extrinsic factors contribute to these transport mechanisms in nanomaterials. Surface and interface are one of the important factors and play a very critical role in electron and phonon transport in nanomaterials. In this thesis, electrical, thermal and photo-conductivity is investigated and especial attention is given on the surface or interface effect to optimize performance of many potential devices. Thermal conductivity plays a significant role in many areas such as thermoelectrics, nano and microelectronics, insulation, and related fields, especially when high operating temperatures are achieved, efficient thermal management becomes crucial. The steady increase of interest for nanomaterials in thermal physics and for thermoelectrics has motivated the development of accurate thermal conductivity measurement techniques. Numerous static or dynamic methods have been developed to measure the thermal conductivity of new materials such as 3ω, transient hot wire,thermoreflectance, or steady- state methods. Among the different approaches mentioned above for determining thermal conductivity, the Transient Hot-Wire (THW) method possesses some unique advantages. It is capable of accurately measuring the thermal conductivity of Solids, liquids and gases. THW measurement method can be carried out much faster by reducing equilibrium time to a few seconds. THW setup is designed to measure the thermal conductivity of nanofluids at room temperature. The role of nanofluids in thermal management, exchange, and insulations is gaining tremendous attention in biological and clinical applications. Surfactants on the nanoparticle surface play an important role in the dispersion and stability of the nanoparticles in the fluid. Hence to deepen the understanding of the role of surfactants associated with nanoparticles in different fluid mediums, it is essential to study their cumulative properties. In this work, monodispersed nanoparticles (Fe 3 O 4) were synthesized and stabilized with different surfactants (citric acid/oleic acid) and dispersed in different mediums (water/toluene) at different concentrations. The thermal conductivity of iron oxide nanofluids has been studied theoretically as well as experimentally using a self-made Transient hot wire (THW) measurement setup. The thermal conductivity of water is found to be reduced by 67% by adding nanoparticles coated with citric acid whereas 4% enhancement occurs for toluene when oleic acid-coated nanoparticles are added. In this work, increasing/decreasing of thermal conductivity has been related to surface properties of nanoparticles and polarity of the base fluid which has been supported by theoretical work [1]. The tunable electrical conductivity in the conducting polymer is one of the significant advantages for focusing on these materials for flexible electronics and electrical applications. In this work, the polyaniline electrical conductivity is tuned by doping with different dopant materials, varying doping concentrations, and different morphologies. The experimental measurement was done on the pellets using the van der Pauw method. The experimental electrical conductivity results are correlated with the optical band gaps and their corresponding electronic transitions. Increasing the doping concentration from 0 to 1.0 M HCl increases electrical conductivity five-fold from 1.98 to 10.2 S/cm. The measured electrical conductivity is larger for the polyaniline nano-whisker and nanofiber (~2 S/cm) samples than for the sample with highly entangled polymer chains (0.26 S/cm). Moreover, it was found that the polyanilinenanofibers with ordered polymer chains show larger electrical conductivity (1.75 and 1.27 S/cm) as compared with the disordered polymer chains (0.22 S/cm) [2]. The phenomenon of ‘persistent photoconductivity (PPC)’ has gained tremendous attention because of its prospective applications in the field of optoelectronics. PPC was well studied in semiconductor materials. Another important class of materials showing potential persistent photocurrent is “oxides”. Among oxides, STO can be considered an important member of the perovskite oxide family which exhibits many novel phenomena and is a prime candidate for device applications. In this work, studied the effect of the light illumination for an insulating (3 unit cell of LaVO3(LVO) on SrTiO3(STO)) and a conducting (5u.c. of LVO on STO) oxide interface using different wavelengths of light 405 nm and 532. For the insulating interface, under light illumination transient photoconductivity (TPC) has been observed from 76K to 300K. The conducting interface shows small PPC under only 405nm illumination but zero PPC under 532nm illumination. [3] In the other work, the effect of light illumination on the transport properties was studied on 2-D electron gas at the conducting interface of EuO and KTaO 3 using different wavelengths (405 nm, 532 nm, 705 nm) of light. This conducting interface showed wavelength, power, and carrier density-dependent PPC at 76K and 300K. [4] List of Publications (Included in thesis) [1] Ajit Singh, Ramanujam Lenin, Naimat Kalim Bari, Chirodeep Bakli, and Chandan Bera. "Mechanistic insights into surface contribution towards heat transfer in a nanofluid." Nanoscale Advances 2, no. 8 (2020): 3507-3513 . [2] Lenin, Ramanujam, Ajit Singh, and Chandan Bera. "Effect of dopants and morphology on the electrical properties of polyaniline for various applications." 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[2] Sourav Sen, Ajit Singh, Kamalakannan Kailasam, Chandan Bera, Sangita Roy “Recent developments in biomass-derived cellulose aerogel materials for thermal insulation application: a review” (Recently Accepted) [3] Sourav Sen, Ajit Singh, Kamalakannan Kailasam, Chandan Bera, Sangita Roy. “Biomass derived nanofibrillar cellulose and iron oxide-based nanohybrids for thermal insulation application”. (Communicated) [4] Deepika Rani, Ajit Singh, Ritu Ladhi, Labhini Singla, Angshuman Roy Choudhury, Kuldeep Bhasin, Chandan Bera, Monika Singh, “Nano-channel mediated Electrical and Photoconductivity of Metal Organic Nanotube” .
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