SCANNING HOT PROBE TECHNIQUE FOR NANOSTRUCTURED FILMS THERMOELECTRIC PROPERTIES CHARACTERIZATION

by

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ABSTRACT

Beginning around 1990, a combination of factors – notably environmental concerns regarding refrigerant fluids and interest in cooling electronics – led to renewed activity in the science and technology of alternative refrigeration. Thermoelectric cooling is the most well established of these technologies. Scanning probe microscopy(SPM) techniques have enabled direct observation of physical phenomena with high spatial resolution. A variety of novel SPM-based measurement techniques have been developed to investigate electronic , optical, thermal, mechanical, chemical, and acoustic properties of nanoscale devices and structures. One of such techniques is the Scanning Thermal Microscopy(SThM). The SThM can measure temperature and thermophysical properties with micro-nano scale spatial resolution. The ability of thermally probing micro-nano scale phenomena has made SThM a powerful tool for studying fundamental thermophysis and for characterizing micro-nano scale devices and materials. The SThM has demonstrated applications in materials, microelectronic, and pharmaceutical research and development.A variety of SThM methods have been explored since the invention of the scanning tunneling microscope(STM) and the atomic force microscope(AFM).This work reports on thermoelectric measurements in nanostructured thin films using a scanning hot probe technique. In this method a resistively heated thermal probe of an Atomic Force Microscope (AFM) is brought in contact with the sample surface giving rise to a temperature gradient and a Seebeck voltage in the specimen. The average temperature rise of the probe is determined from the change in its electrical resistance. The heat transfer rate between the probe and the sample is estimated using a heat transfer model that takes into account the major heat transfer mechanisms in the system. The heat transfer mechanism between tip sample was investigated in detail. The relative contribution of solid-solid contact , water meniscus, and air to the heat transfer mechanism was determined for the kind of tip that we have used in our experiments. It came out that for our tip the main heat transfer mechanisms is through the water meniscus. The effective contact area radius between tip and sample is 2 microns. The thermal conductivity is determined from the measured thermal resistance of the film.

The Seebeck coefficient value is calculated using the measured temperature drop and the Seebeck voltage in the plane of the sample. The method is calibrated on glass and bismuth telluride substrates. The Seebeck coefficient is calculated and validated by measurements on BiTe bulk sample. After this the Seebeck coefficient was measured on a BiTe nanoparticles thin film deposited on glass. The thermal conductivity for the same film was measured. Experimental results are presented for the thermal resistance and Seebeck coefficient of thermoelectric films composed of bismuth telluride and lead telluride nanoparticles and nanorods deposited on a glass substrates.