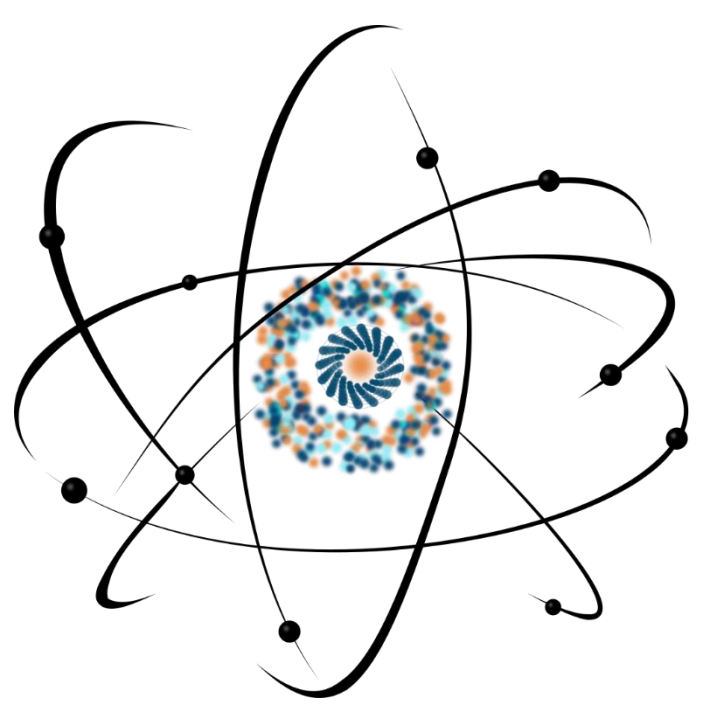




PEDOT:PSS polymer matrices reinforced with carbon nanotubes: electrical and structural properties

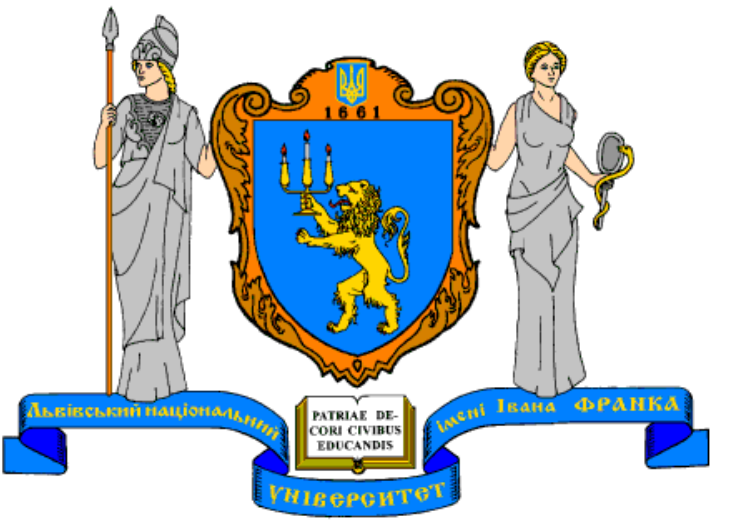
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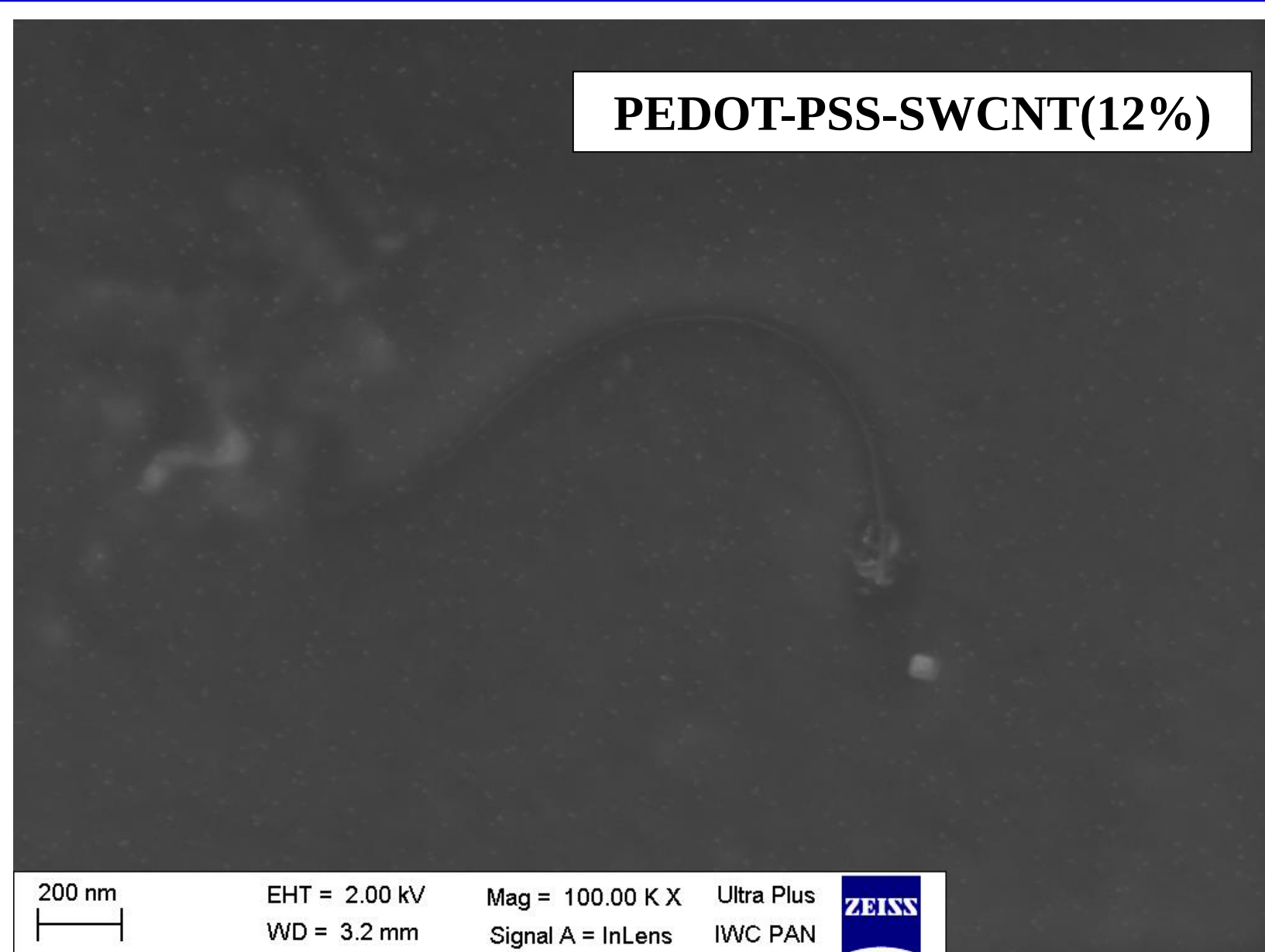


Abstract

Electrical properties of single- and multi-walled carbon nanotubes composites were investigated in the range of 50 to 200 K. It is established that composite films with multi-walled nanotubes loading show lower resistances as compared to their single-walled counterpart.

Electrical properties of single- and multi-walled carbon nanotubes composites were investigated in the range of 50 to 200 K. It is established that composite films with multi-walled nanotubes loading show lower resistances as compared to their single-walled counterpart. Composite films were obtained with water suspension (1%) of poly-3,4-ethyldioxythiophene, stabilized with a surface-active anionic substance. Single-walled carbon nanotubes (SWCNTs) with 90 wt.% and average diameter near 1 nm and multi-walled carbon nanotubes (MWNTs) with 95 wt% with mean outside diameter of 65 nm and mean inside diameter near 10 nm were used as nanofillers. Suspension described above was compounded with PEDOT:PSS polymer solution and ultrasonically processed during 4 h. After processing, mixture was deposited on glass substrate by drop-casting liquid on the substrate and centrifugation. After drying at room temperature for 48 h, composite films of PEDOT:PSS/nanotubes were shaped on the glass. Thicknesses of obtained films were near 20 μm . By varying the ratio between PEDOT:PSS solution and suspension of nanotubes, films with different concentration of nanotubes (12 wt% and 16 wt%) were fabricated. Electrical contacts were deposited on the film surface with conductive paint at the opposite side of the sample (coplanar, or lateral geometry), the distance between the contacts being set to 3 mm.

SEM image



Low temperature AC electrical study

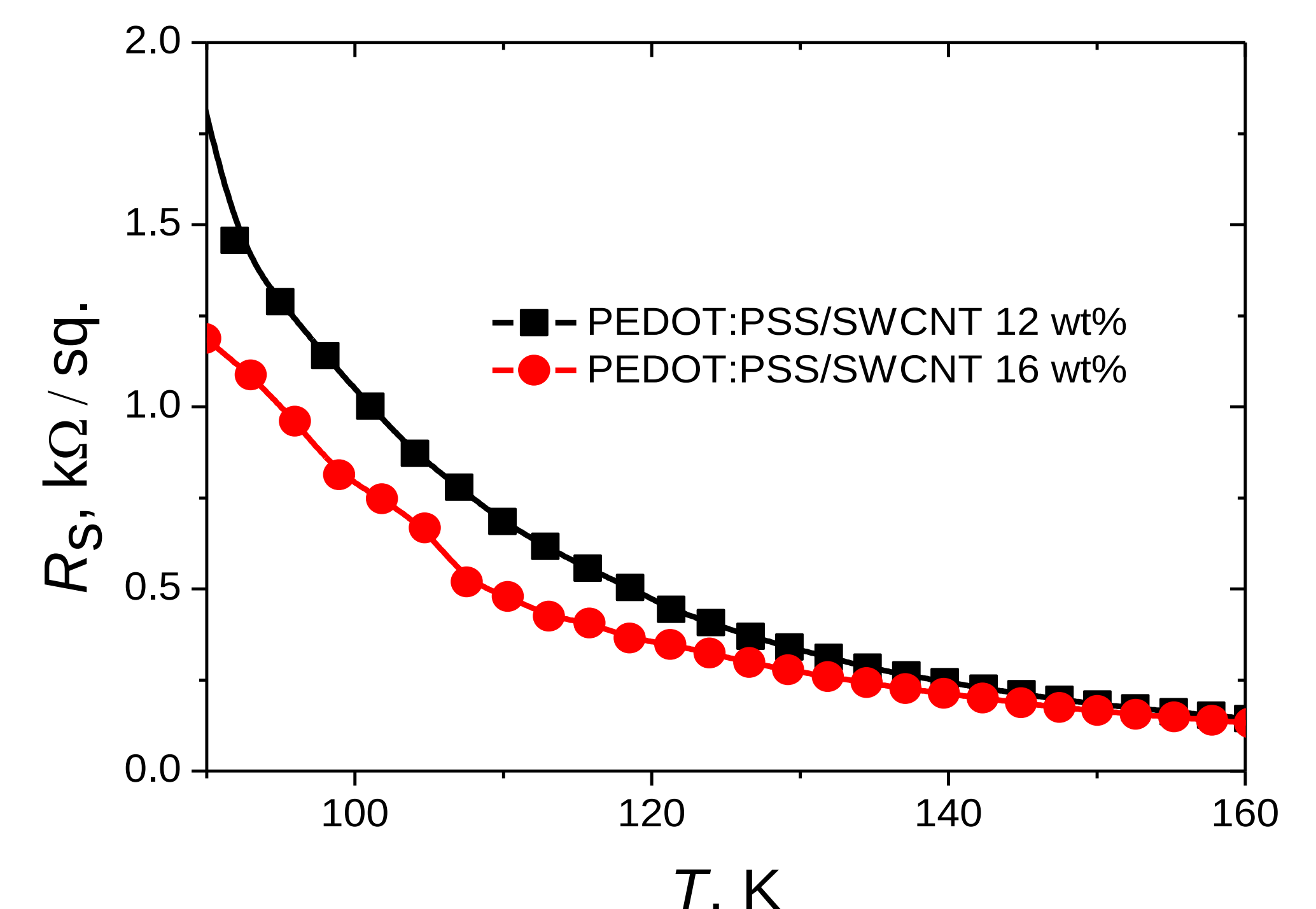
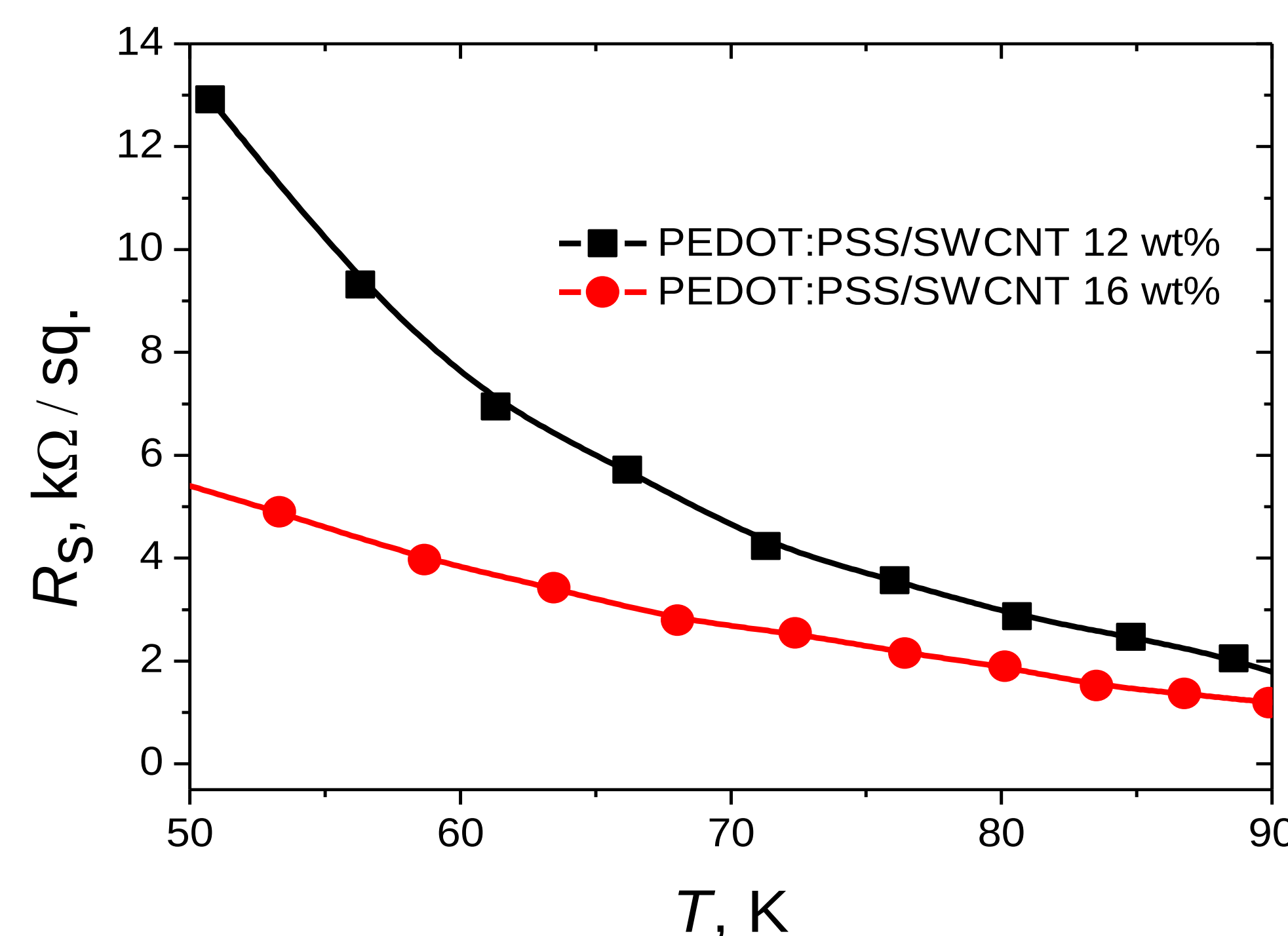
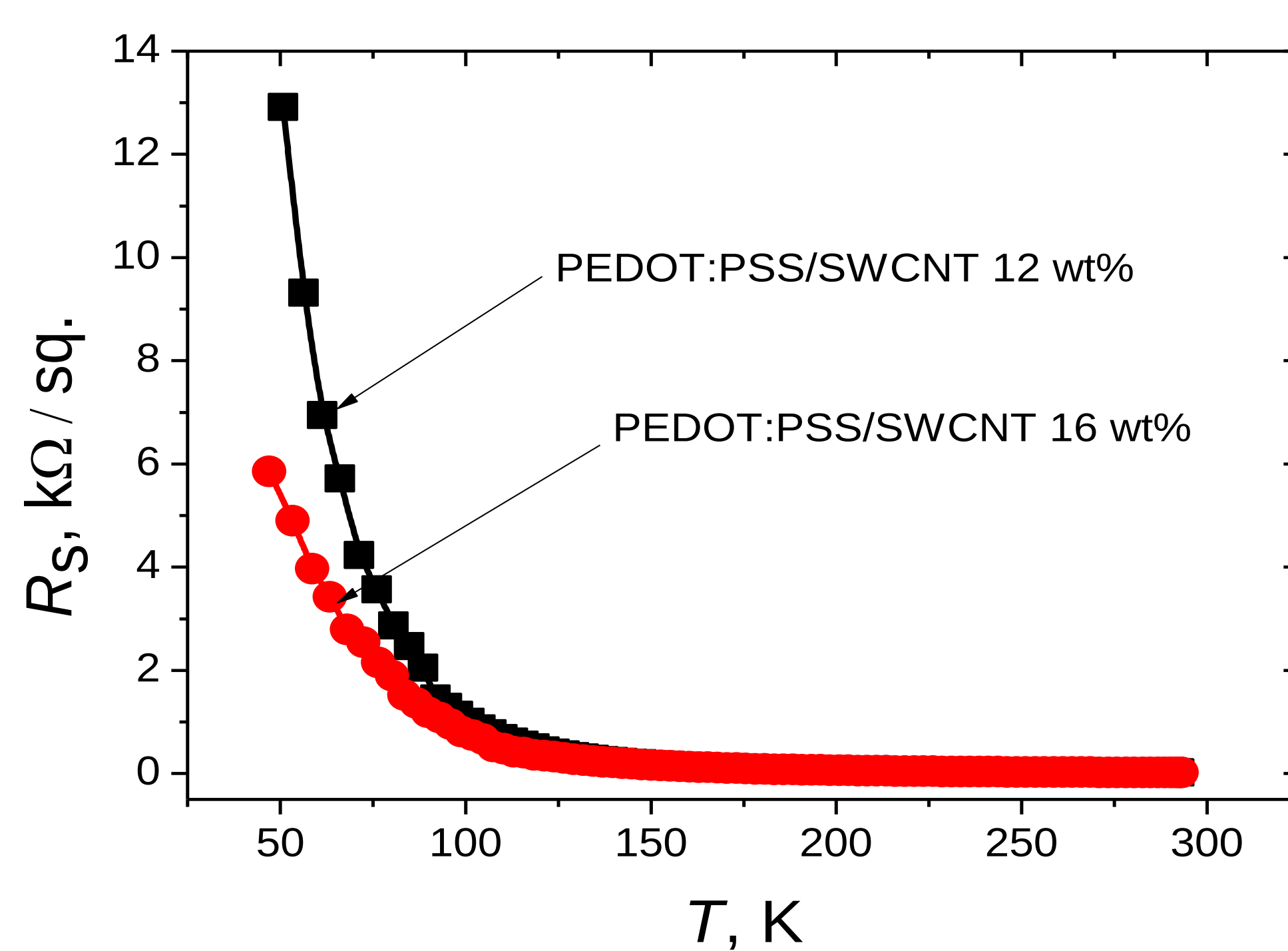
Electrical tests were carried out exploiting E7-20 RLC meter capable of measuring impedances in the range of 10–5 to 109 Ohms using 1 V excitation signal from 40 mV to 1 V at frequencies ranging from 25 Hz up to 1 MHz. Temperature experiments were carried out utilizing custom cryostat equipped with the DE-202A closed cycle cryocooler. Temperature control functions were conducted by Cryocon 32 temperature regulator.

The low-temperature conduction mechanisms follow the activation-type formula, that in terms of resistances can be expressed as

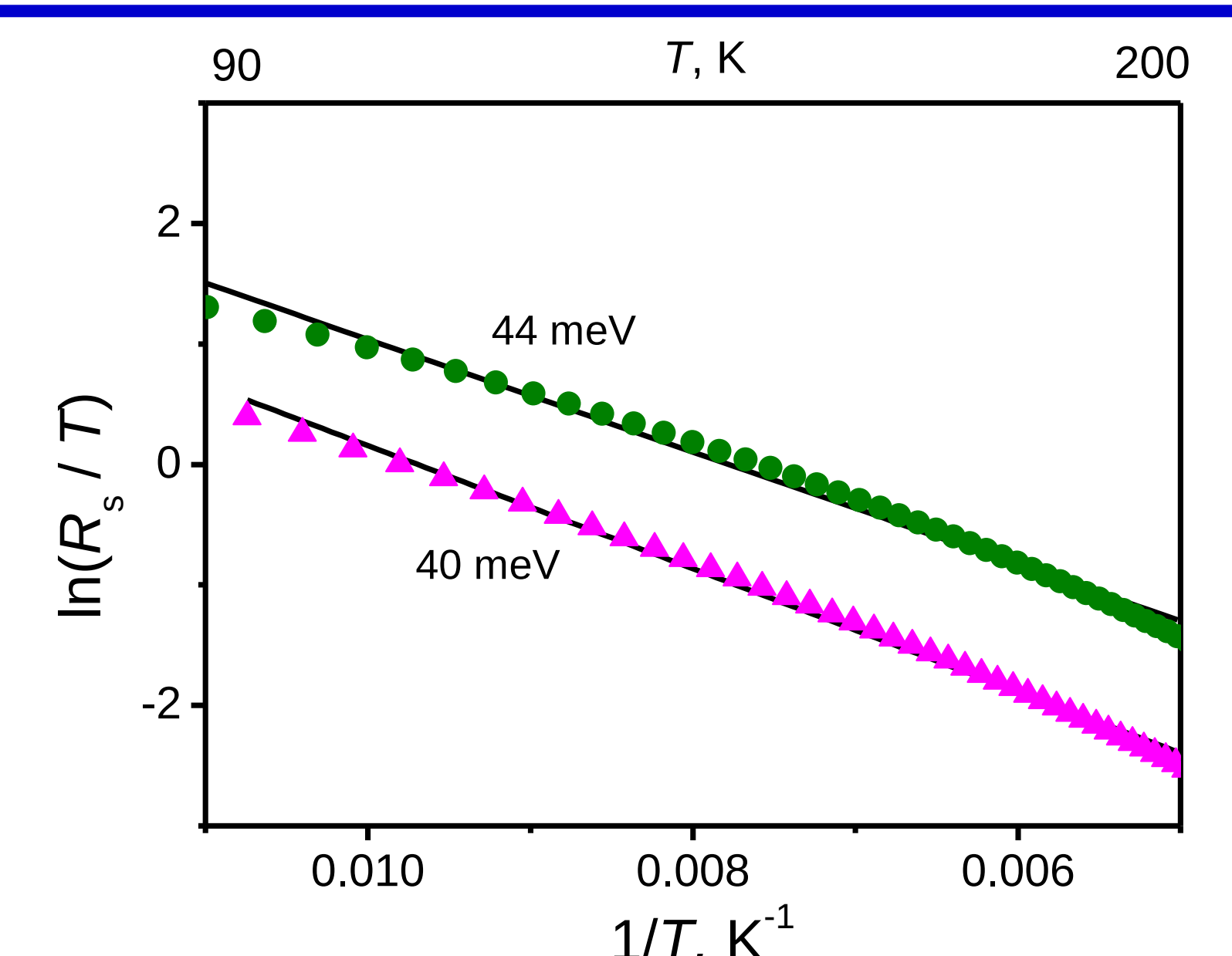
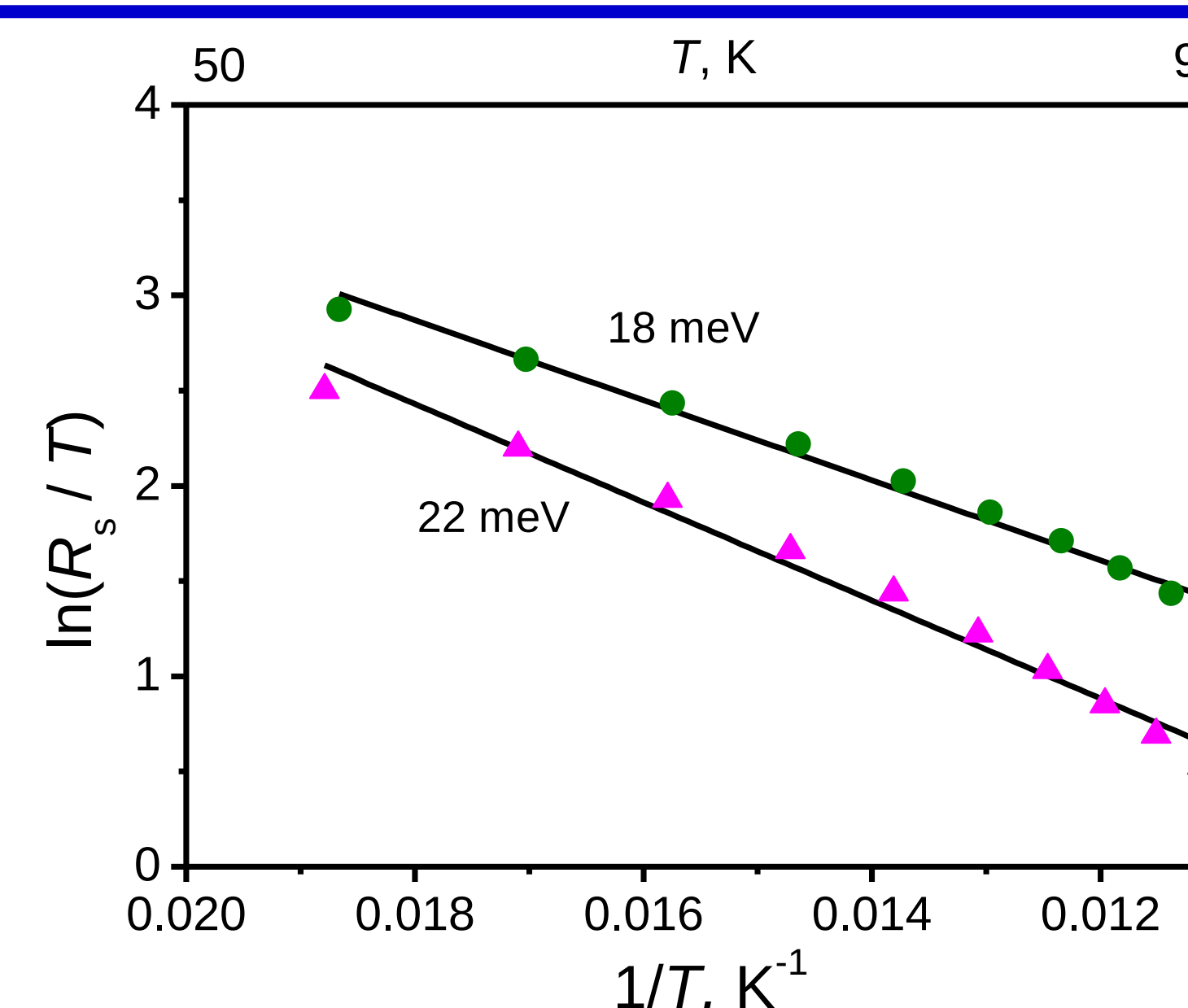
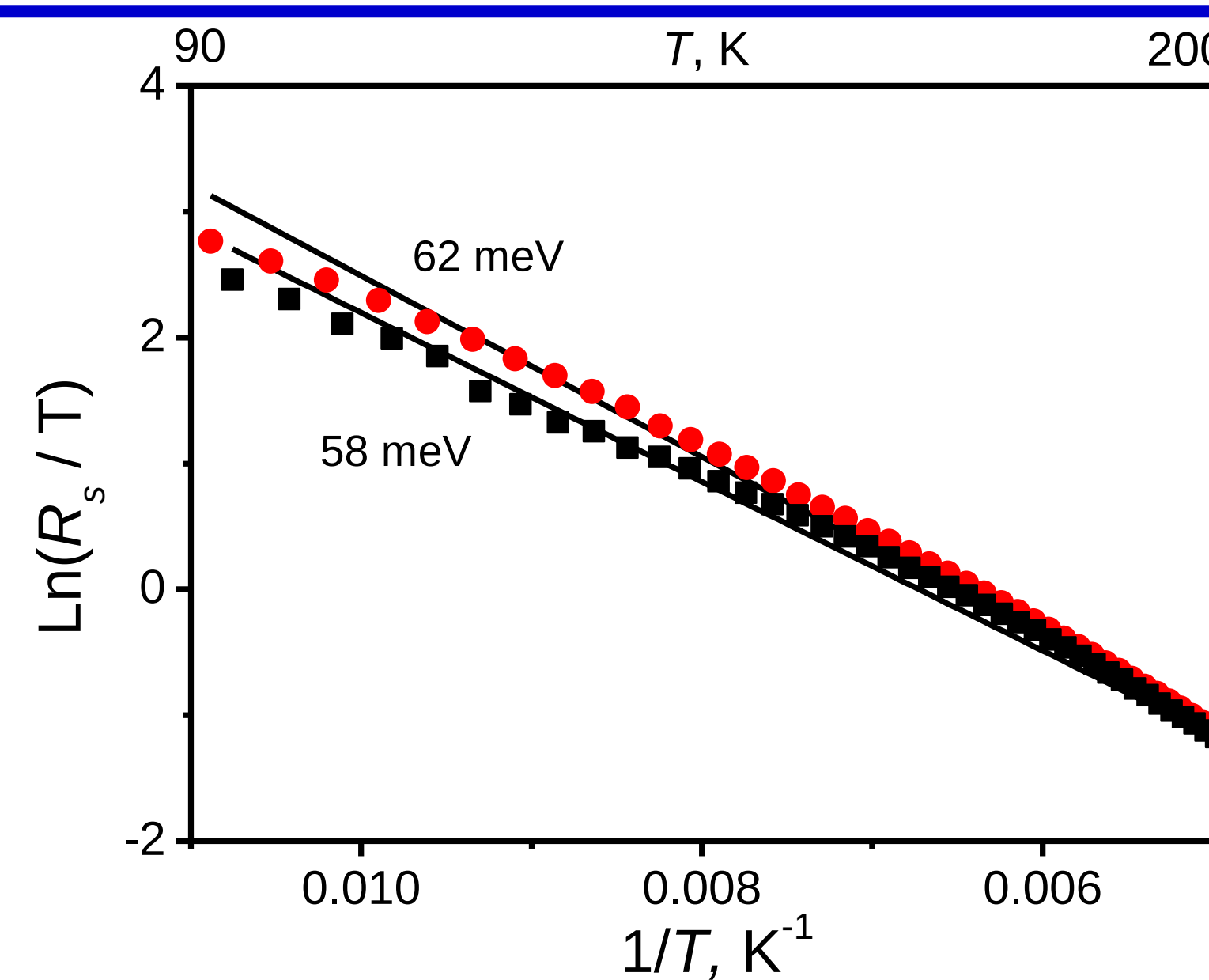
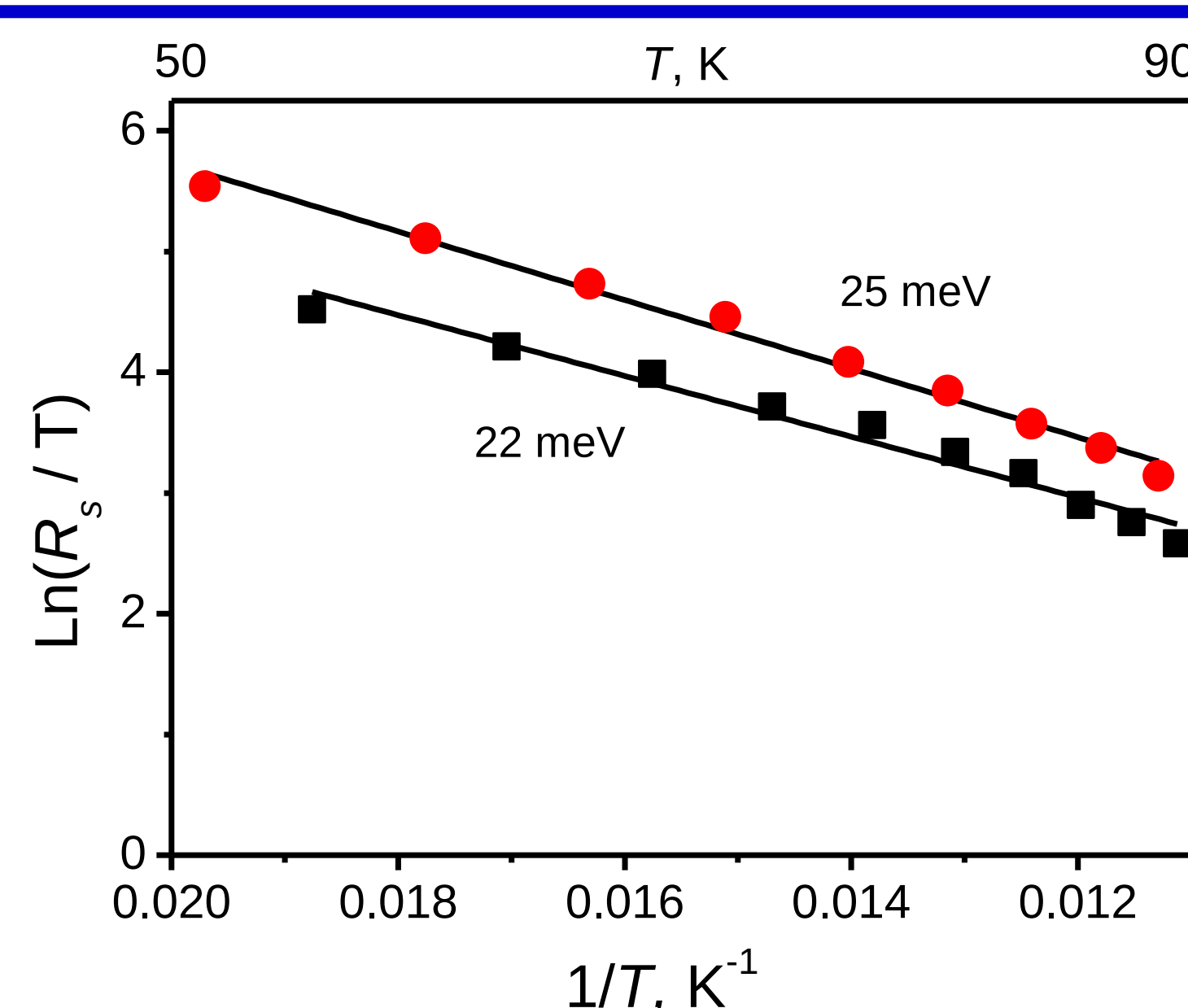
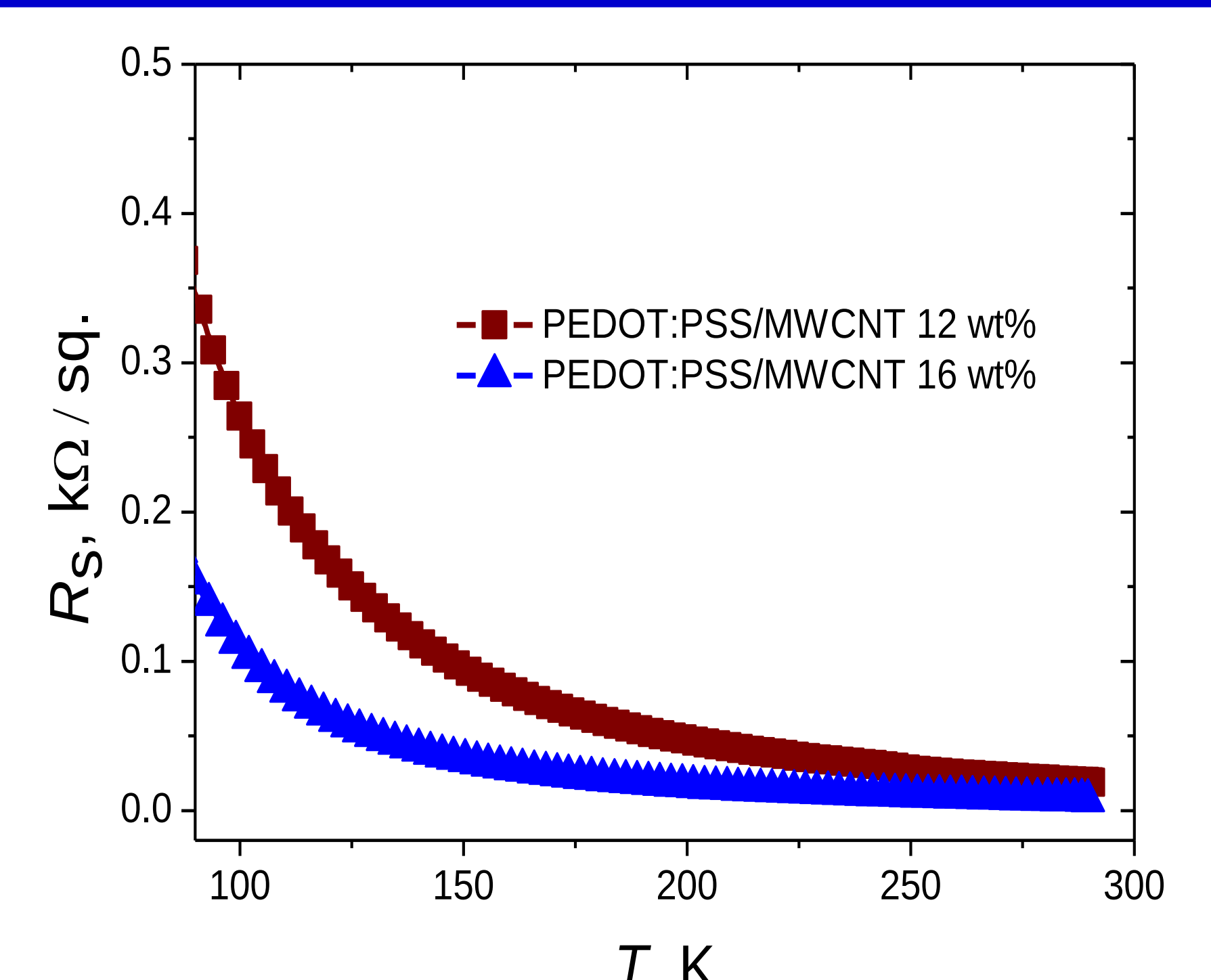
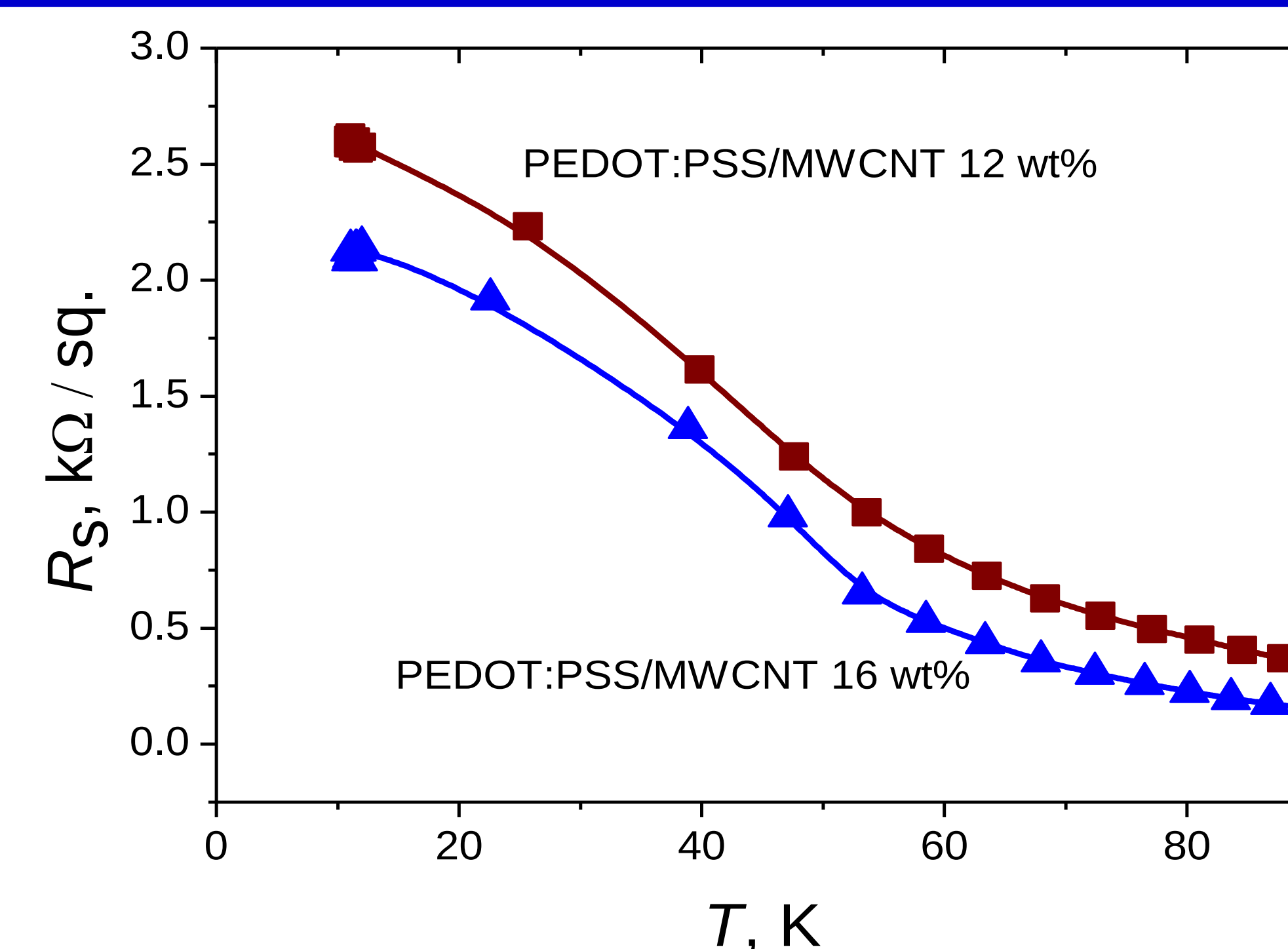
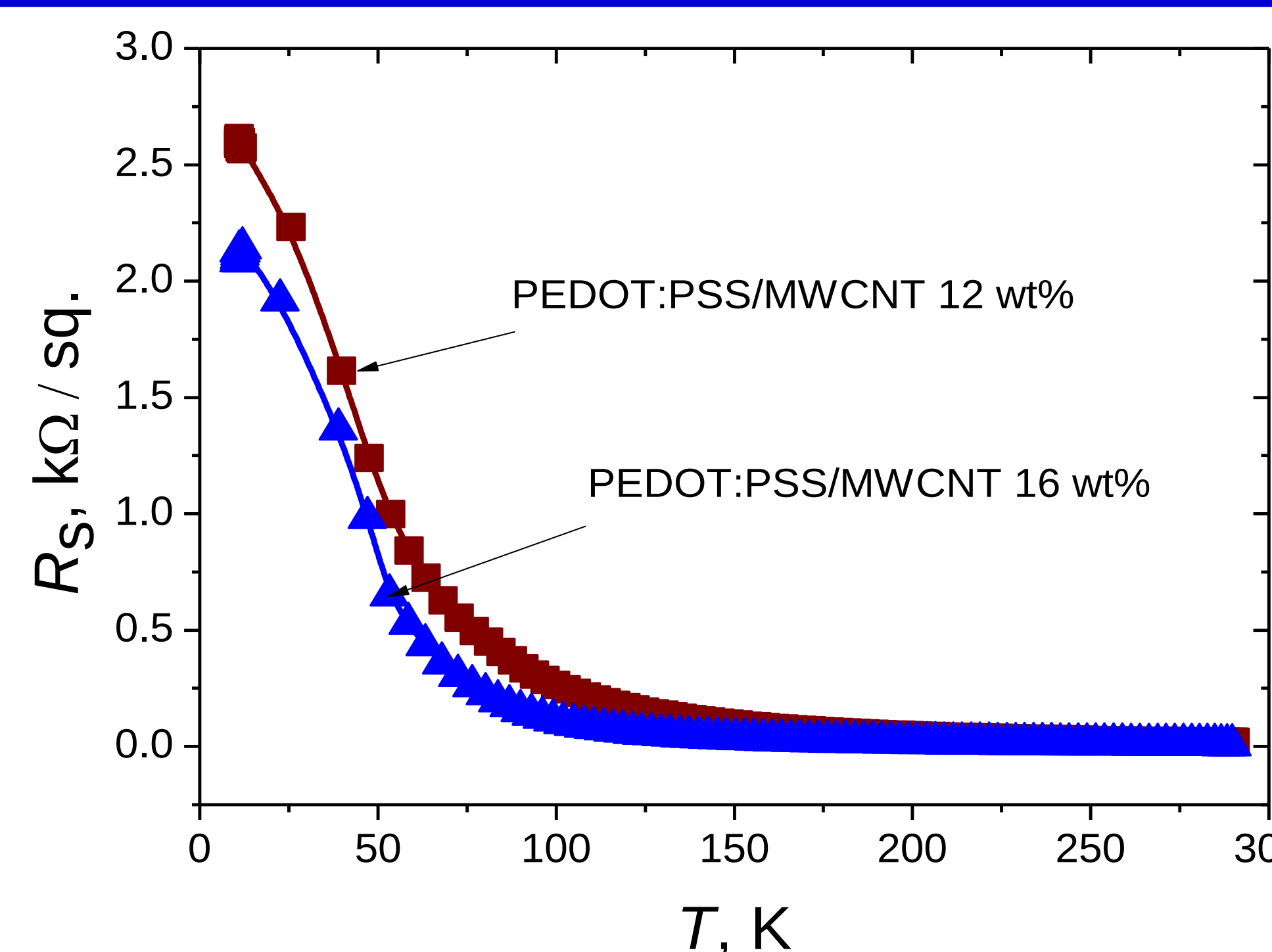
$$R_s \approx T \cdot \exp\left(\frac{eE_a}{kT}\right)$$

where e is the elementary charge, k is Boltzmann's constant. The plot of $\ln(R_s/T)$ as the function of the reciprocal temperature and the least-squares approximation procedure allows to find the activation energy from the inclinations of the fitting lines.

Dependencies of sheet resistances on temperature for PEDOT:PSS/SWCNT composite films measured in cooling regime



Dependencies of sheet resistances on temperature for PEDOT:PSS/MWCNT composite films measured in cooling regime



Arrhenius plots for PEDOT:PSS/SWCNT composite films. Circles denote experimental points for 12 wt% SWCNT loading; squares denote experimental points for 16 wt% SWCNT loading. Solid lines represent linear fitting

Arrhenius plots for PEDOT:PSS/MWCNT composite films. Circles denote experimental points for 12 wt% MWCNT loading; triangles denote experimental points for 16 wt% MWCNT loading. Solid lines represent linear fitting.