# Electrical percolation in incandescent lamps' tungsten wires


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Tungsten wires in incandescent lamps are one of the oldest bulk nanometals in nanotechnology. Using severe plastic deformation (SPD) techniques before the 1960's, an application driven thermo-mechanical technology of tungsten wires morphology solved many problems of the devices (incandescent lamps). The optimum solution found with highly elongated clusters of W-grains and nano-vacancies. The nano-vacancies in the order of 100nm are filling with potassium impurities upon heating forming a percolation system of a W-metal and a dielectric K-nanobubbles. Low weight percentage w% (<<0.01%), potassium based, nanosize solid impurities transform into nanobubbles upon weak heating. This potassium solid-(63.5°C)-liquid-(759°C)-gas phase transition results into a huge volumetric v% increase due to solid-gas volume expansion. The fine control of insulating nanobubbles' volume percentage due to the DC electrical heating and the AC electrical measurement of the complex impedance ***Z*** (= $Z_r + jZ_i$ ) allows the investigation of percolation problems, with the controlled variable being the nano-size of the insulating phase. Upon initial heating, the real component $Z_r$ of the complex impedance ***Z*** represents both the Joule effect and an abrupt-additional increase due to a virtual decrease in metallic tungsten wires' diameter. Also, the imaginary component $Z_i$ of ***Z*** represents the abrupt increase in nanobubbles' size of insulating phase, resulting in a volume percentage v% increase. The heating evolution versus electrical power P, of the calculated lumped parameters ($R_1//R_2C$) in an equivalent circuit (Fig.1). Using normalized (%) electrical parameters Hp, Hv and Hi (Hp for power P, Hv for voltage V, and Hi for current i), almost all devices present universal electrical behavior. A percolation regime is found from 0 to 1% of power P having a percolation threshold at 1% (LogHp=0, in Fig.2), just before visual light appears at 2 to 3%. New “particles”, the photons, affect strongly the percolation problem and this new (2nd) percolation regime will be addressed in a future presentation.

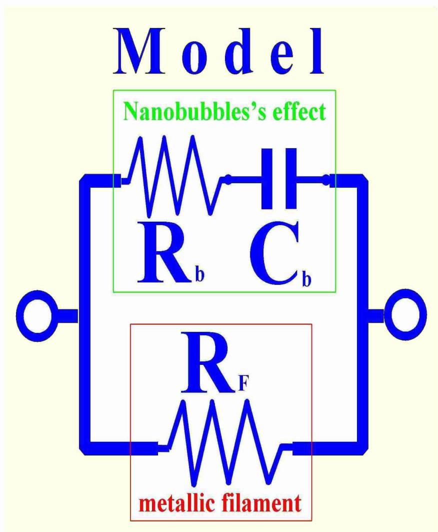


Fig.1: Equivalent circuit
(a simple 3-elements model)

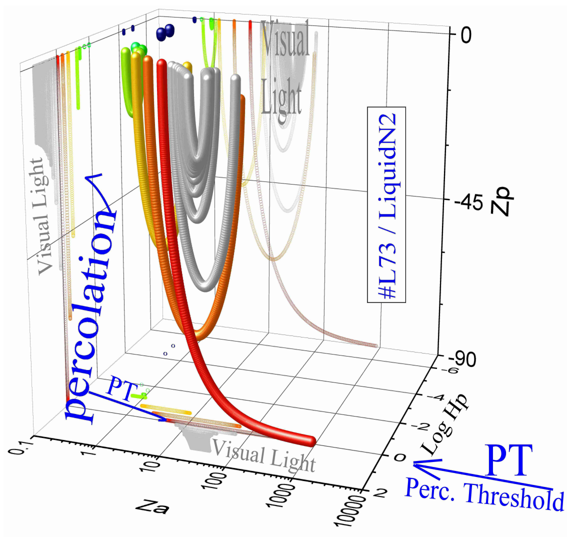


Fig.2: Complex impedance ***Z*** of a W-wire. The Z-phase (Zp) shows the percolation regime (0% up to 1% of power P).