

# Siemens Competition

## Math : Science : Technology

### National Finalist

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**Mentor:** Melissa Waldron, Liberty High School

**Project Title:** *Computational Study of Random Nanowire Networks: Optimization of Conductivity through Orientation*

Transparent conductors are ubiquitous in modern electronic devices. The majority of devices use Indium Tin Oxide (ITO) for this purpose. ITO, however, is plagued by issues including material scarcity, high manufacturing costs, and brittleness. Random metal nanowire films show potential as transparent conductors, but their performance must be improved before large-scale displacement of ITO can occur. In this study, nanowire orientation was investigated as a method for optimizing performance of random metal nanowire films. A computational model was developed to generate random nanowire networks and calculate their electrical conductivity. The model was then used to investigate the effects of nanowire orientation on network conductivity using three different distributions: normal, uniform, and discrete bimodal. For all three, conductivity is maximized for an optimal degree of restriction, corresponding to standard deviations of  $35^\circ$ ,  $33^\circ$ , and  $21^\circ$ , respectively. For the first two distributions, conductivity increases with respect to the isotropic control by 25% and 20%, respectively. Surprisingly, the bimodal distribution showed no such enhancement, emphasizing the crucial role of randomness in orientation effects. These results are expected to support wider adoption of metal nanowire networks as transparent conductors, which will reduce costs and accelerate development of electronic devices.