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Case ID:M16-114P^
Published: 2/26/2020

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Phosphorus Doped Diamond Electrode with Tunable Low Work Function for Emitter and Collector Applications

Low work function electrodes have the potential to advance and enable technologies that rely on electron transfer, such as electron sources utilizing thermionic electron emitters. Conventional electron sources based on metallic cathodes operate at temperatures exceeding 1000°C. Lowering the operating temperature would lead to a simpler design, reduced power demand, and a lighter and smaller payload for operation in mobile terrestrial and satellite applications. Materials with high temperature stability, high thermal conductivity, and high electron mobility, such as diamonds, offer a promising alternative for these applications. Therefore, there is a need for further development of these materials to lower the work function for electron source and energy conversion technologies.

Researchers at Arizona State University have developed a method for creating thin layers of phosphorus-doped diamonds with controlled doping concentration in single crystal nitrogen-doped diamonds (100). These films allow for the preparation of ultra-low thermionic emitters with a tunable work function. The nitrogen-doped single crystal substrate allows electrical conduction that improves with temperature and is suitable for electron sources operating at elevated temperatures. This material exhibits one of the lowest work functions reported and the lowest work function for materials operating at temperatures exceeding 800°C.

Potential Applications

- Electron sources
- Energy conversion
- Telecommunications
- Thermionic emitters
- Solar thermal

Benefits and Advantages

- Improved Work Function –
  - Provides improved layer for thermionic emission devices with an ultra-low and tunable work function, and has the lowest work function for materials operating at temperatures exceeding 800°C.
  - A finishing step further lowers of the work function or emission barrier by using pure hydrogen plasma to establish a hydrogen passivated surface that induces a negative electron affinity (NEA) characteristics.
- Versatile –
  - Provides significantly higher electron current densities at lower temperatures than conventional cathodes.
  - Only known material that can maintain a low emission barrier across a wide

temperature range (up to 950°C).

- Tunable - Able to control and fine-tune the work function by adjusting the phosphorus doping, without adsorbates or coatings.

For more information about the inventor(s) and their research, please see

Dr. Robert Nemanich's directory webpage