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Advances in Doped Diamond Electron Emitters for Thermionic Energy Conversion. Franz A. Koeck[1], Jeff Sharp[2] and Robert J. Nemanich[1]; [1]Arizona State University, Tempe, Arizona; [2]Marlow Industries, Inc., Dallas, Texas.

Direct conversion of heat into electricity presents means of providing compact, stand-alone power generators as well as waste heat recovery which increases overall systems efficiency. A vacuum thermionic energy converter utilizes an electron emitter separated from a collector by a vacuum gap. This thermal barrier can significantly increase device efficiency where operating temperature can be defined by controlling emission parameters, i.e work function and Richardson constant of the emitter. Our approach employs doped diamond thin films in a stacked structure prepared on a surface treated metallic substrate. This process accomplishes two critical results: a low effective work function and an increased value for Richardson's constant. Key component of the emitter is a nitrogen incorporated UNCD sub-layer which effectuates a low work function of the top, nitrogen - doped, NEA diamond layer. Additionally, diminished device resistance due to the network of high density, nitrogen incorporated, graphitic grain boundaries in the UNCD layer can establish an increased emission current density and its relation to Richardson's constant. While a theoretical approach quantifies this emission parameter at 120 A/cm^2K^2 a more accurate characterization can identify parameters which govern its effective value. We will present results from stacked, doped diamond emitters prepared by plasma assisted chemical vapor deposition on molybdenum substrates utilizing metallic interstitial layers to enhance device performance. Evaluation of the emitter with respect to the Richardson formalism presents a low work function of 1.2 eV and an effective Richardson constant of 16 $A/cm^2 K^2$ corresponding to an emission current density of 7.7 mA/cm^2 at 400 °C. Such reproducible devices approach an emission current density of 40 mA/cm^2 at 500 °C. In a thermionic energy converter configuration the electron source is opposed from a similar collector by a vacuum gap. Conventional limitations due to space charge effects at the emitter are alleviated by our approach of surface ionization where gaseous species with suitable electron affinity are introduced into the interelectrode gap to enhance charge transfer between emitter and collector. This research was funded by the Office of Naval Research.