

ABSTRACT:

Engineering Diamond NEA Surfaces for Thermionic Energy Conversion: A Competitor to Photovoltaics?

R. Zulkharnay¹

¹School of Chemistry, University of Bristol, Bristol BS8 1TS, UK.

Over the past few years, significant effort has been devoted to achieving diamond surfaces with negative electron affinity (NEA) that remains stable under ambient conditions and at high temperatures. Consequently, thermionic emission from NEA diamond can occur at temperatures around 600 °C, compared with the 1500-2000 °C typically required for metals. Results from many groups worldwide suggest that NEA is maximised when the adsorbate is small, highly electropositive, and readily forms stable bonds with C and O. Various metal terminations, such as Li, Mg, Al, Ti, V, Ni, and Zn, have been studied both theoretically and experimentally, affording varying degrees of thermal stability and emission efficiency [1].

A metal that meets the criteria mentioned above, but has only recently been studied, is scandium. A series of recent papers suggests that 0.25 monolayer (ML) Sc-terminated bare and oxidised diamond (100) surfaces may be among the most promising reported for diamond electron emission [2-4]. These surfaces produce low work function, highly NEA characteristics, are stable to ~800 °C, permit high emission yield at low temperatures (~500 °C), resist degradation, are unaffected by air exposure, and are compatible with thermionic solar converters. In this talk, we briefly review metal-oxide terminations for NEA diamond surfaces as candidates for thermionic devices. We then discuss new results with ScO terminations and speculate on whether this technology could become a viable competitor to photovoltaic (PV) solar cells.

[1] M.C. James, et al., Carbon 171, 532 (2021).

[2] R. Zulkharnay, et al., Carbon 196, 176 (2022).

[3] R. Zulkharnay, et al., J. Mater. Chem. A 11, 13432 (2023).

[4] R. Zulkharnay, et al., Small 20, 2405408 (2024).