ELECTRON EMISSION FROM HAFNIUM CARBIDE

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Past research has studied single-crystal transition metal carbides operating in thermionic or field emission modes.[1] In particular, hafnium carbide cathodes have properties making them attractive candidates for stable emission sources in moderate to good vacuum applications. The use of HfC or ZrC with a (310) orientation provides a relatively low work function emitting surface (3.4 eV) that has a very low evaporation rate, is resistant to ion bombardment and sputtering[2], has a high melting point (~4200 K), and has a very low surface mobility. As field emission sources they can operate at high current densities and using the mini Vogel mount can withstand many thousands of flash heating cycles. The robustness of this material has been demonstrated in field emission, photo-field, and thermionic studies.

We report on field emission from (310) oriented single crystal hafnium carbide. These crystals are electrochemically etched and Vogel mounted to enable flash cleaning and operation at elevated temperatures as needed. Typical clean field emission patterns from a (100) oriented carbide emitter show four symmetrical lobes of emission corresponding to the (210) and (310) crystallographic areas. We have operated these emitters at room temperature over large ranges of pressures and compiled data on emission stability. We have achieved stable, 300 K emission for hour periods in UHV. Through use of a relatively simple analog feedback circuit we have achieved even greater stability without gas processing and have done so for pressures from UHV to 1 x 10^{-7} Torr. In UHV operation at 300 K these cathodes have a low energy spread making them attractive when compared to Zr/O/W Schottky sources for several applications. Recent work by others has shown the viability of using our HfC(310) as a photo-field source where the etched field emitter is driven by both a dc electric field and short laser pulses. Uses here could include sources for accelerators and to enable time-resolved imaging.

HfC can be used as a large area thermal source for high total currents. For small spot sources, they can be used in FE mode where single etched emitters have operated as heated dc sources for thousands of hours at several mA of emission current. CFE sources have been shown to produce tens of mA operated in pulsed mode.

1. W.A. Mackie, J.L. Morrissey, C.H. Hinrichs, and P.R. Davis, *Journal of Vacuum Science and Technology A*, **10** (4) 2852 (1992).
2. W.A. Mackie, Tianbao Xie, M.R. Matthews, B.P. Routh, Jr., and P.R. Davis, *Journal of Vacuum Science and Technology B*, **16** (4), Jul/Aug (1998).