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Different Approaches to Modeling the LANSCE H$^-$ Ion Source Filament Performance

Ilija N. Draganic, James F. O'Hara and Lawrence J. Rybarcyk

Los Alamos National Laboratory, Los Alamos, NM, 87544, USA

Corresponding Author: Ilija Draganic, e-mail address:draganic@lanl.gov

An overview of different approaches to modeling of hot tungsten filament performance in the LANSCE H$^-$ surface converter ion source is presented. The most critical components in this negative ion source are two specially shaped wire filaments heated up to the working temperature range of 2600 °K to 2700 °K during normal beam production. In order to prevent catastrophic filament failures (creation of hot spots, wire breaking, excessive filament deflection towards source body etc.) and to improve understanding of the material erosion processes, we have simulated the filament performance using three different models:

The first semi-empirical model is based on the wire temperature calculation using monitored DC heating currents and initial wire diameters [1]. Results of temperature calculations, relative ohmic resistance changes, thermal evaporation mass rates, and reduction of wire diameters are averaged along the length of wire in this model [2].

The second model is based on a finite element analysis taking into account geometric features of the ion source, filament shapes and positions. The Solidworks Simulation FEA code was used to calculate the steady-state temperature profile along the filament including additional ohmic heating due to the pulsed arc discharge current. This model addresses an asymmetric heating process which indicated the filament peak temperature would move in the direction corresponding to the load asymmetry [2].

The third filament model is an extended analytical approach based on previous filament simulation efforts at LANL [3]. New analytical model and numerical simulations offer a very precise time evaluation of filament characteristics (temperature and wire diameter profiles, tungsten mass evaporation rate, thermionic electron emission, etc.) during ion source operations for beam production cycles of four weeks (28 days). New simulations extrapolate source performance under different operational conditions, giving a better understanding of the measured observables and providing directions for future experiments.

Results of all models were compared with recorded EPICS data taken during the LANSCE beam production cycles. The models were used to support the recent successful transition from the beam pulse repetition rate of 60Hz to 120 Hz or during the increase of linac duty factor from 5 % to 10 %.

References

1) H. A. Jones and I. Langmuir, "The Characteristics of Tungsten Filaments as Function of Temperature" *General Electric Review,* **30**, part I p310, part II p354, part III p408, (1927).
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3) E. Chacon-Golcher, "Erosion and Failure of Tungsten Filament", LANL report LA-UR-08-5251 (2008).