Contribution ID: **8** Type: **not specified**

Compact Linear Collider: Investigation of electrical breakdown phenomena using multiscale and multiphysics simulations

Many high electric field applications, for example, Compact Linear Collider in CERN are significantly limited by the presence of the phenomenon of electrical breakdowns. In case of sufficiently high applied electric field, even in ultra high vacuum conditions, electrical discharge appears, induces disturbances into the operating regime of the device, causes material damage and generally, limits significantly operation of the device. Phenomenon itself is known for long time, however, it's exact initiation mechanisms still remain elusive. Current hypotheses suggest, that electric field influence leads to a formation of field enhancing nanoscale tip. This tip will initiate significant field emission currents, evaporation of netural atoms, formation of plasma and finally –complete electrical breakdown. In current talk we explore these hypotheses of electric field assisted surface diffusion as the initiation mechanism of the field emitters by the studies conducted using multi-physics-multi scale simulation framework FEMOCS calclulations with nanoscale materials exposed to high field.

FEMOCS is a unique software that allows multiscale computer simulations, combining atomistic and electromagnetic field analyses together with heat transport calculations for the development of nanoelectronics, nanomaterials and nanoelectromechanical systems (NEMS). The software has been developed to solve materials technology problems of CERN particle accelerator designs, but also has applications in ITER, space applications and high-tech R&D.

The functionality of FEMOCS centers on nanostructure changes of materials in severe conditions by providing of a computational framework that combines Finite Element Analysis (FEA), atomistic simulations such as Molecular Dynamics (MD) and kinetic Monte Carlo (KMC), and Particle In Cell models, to investigate the effect of high electric fields on surface interactions.

In current talk, we will provide overview of application of FEMOCS in CLIC breakdown studies, it's development status and availability of involved technologies for wider use in field emission related applications.

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