Contribution ID: **9** Type: **Oral (30 minutes)**

Stochastic model of breakdown nucleation under intense electric fields

Tuesday 22 May 2018 09:30 (30 minutes)

Plastic response due to dislocation activity under intense electric fields is proposed as a source of breakdown. A model is formulated based on stochastic multiplication and arrest under the stress generated by the field. A critical transition in dislocation population is suggested as the cause of protrusion formation leading to subsequent arcing. The model is studied using Monte Carlo simulations and theoretical analysis, yielding a simplified dependence of breakdown rates on the electric field.

After presenting the underlying principles of the model, we discuss its latest developments. Sample analysis performed by our research group is used to determine the values of constants in the model, and results from the model are compared to experimental breakdown times in order to calibrate the unknown remaining parameters of the model and then to validate it.

A number of experimental setups are proposed, which can further test the validity of the model and its predictions. this provides an opportunity to establish the model in order to develop methods of limiting dislocation mobility, as well as of establishing prebreakdown warning signals through the evolution of the dislocation population.

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Session Classification: Modeling and Simulations