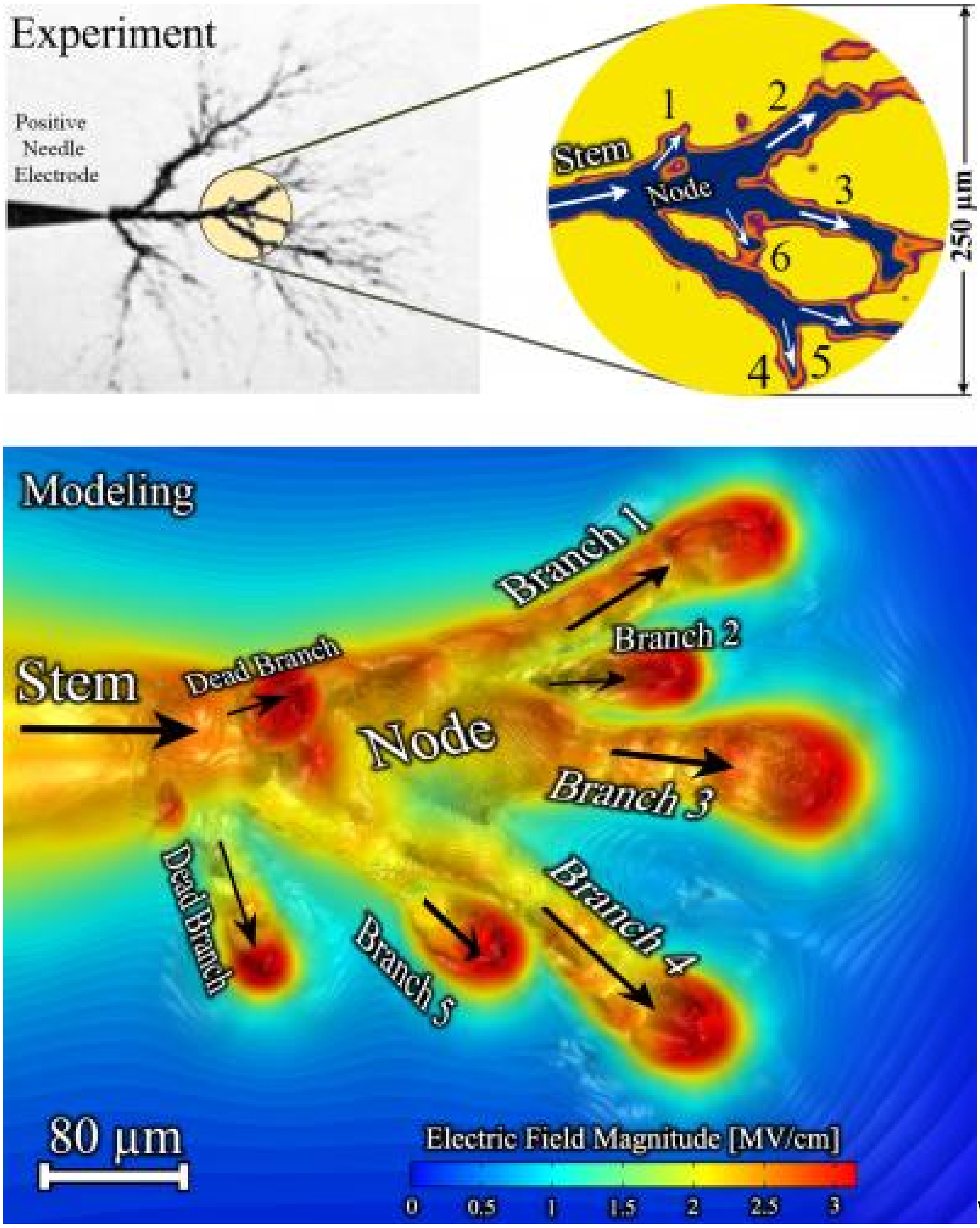
3-D models of electrical streamers

EurekAlert!

New work, described in Journal of Applied Physics, may be key to avoiding large-scale power outages



WASHINGTON D.C. September 27, 2013 -- Streamers may be great for decorating a child's party, but in dielectrics, they are the primary origin of electric breakdown. They can cause catastrophic damage to electrical equipment, harm the surrounding environment, and lead to large-scale power outages.

Understanding streamers and the mechanisms behind their initiation, acceleration and branching is necessary to devise better solutions to avoid them. As recently reported in the *Journal of Applied Physics*, a team of researchers at MIT have developed an accurate 3-D model of streamer propagation that qualitatively and quantitatively describes the streamer development, an advance that may impact applications such as medical imaging, aerospace engineering, power transmission, atmospheric sensing, natural sciences, sensing technologies and large-scale industry.

Whether we realize it or not, every one of us experiences streamers in a phenomenon called electrostatic discharge. When you touch a piece of woolen cloth or a metallic object like the body of your car, it is very likely that you sense a tiny streamer discharge which is sometimes painful. These sparks may be the most common streamers that human beings experience in daily life. More than just being annoying, such streamers can be powerful enough to damage expensive electronic devices and even cause fires.

In their new paper, Jouya Jadidian and his team at the Massachusetts Institute of Technology (MIT) took a comprehensive approach to their study of streamers.

"Our modeling results are understandable even for someone without advanced knowledge of physics, since we have generated very intuitive 3-D plots of streamer tree structures that helps streamer branching mechanisms to be simply inferred," he said.

The model also relates the physical attributes of streamers to tangible circuit parameters measured in ordinary laboratories such as voltage, current and time-delay. The results have proven highly accurate given an extraordinary resemblance between modeling results and experimental images taken from the light emitting streamers. Jadidian's research in this area has been awarded the IEEE Guenther Award and the Chorafas Foundation Award in 2013.

The development of this model involves some real challenges. Although 3-D imagery in gases is doable using current technology, streamer imaging in liquid dielectrics is extremely difficult. Creating a comprehensive 3-D streamer model also imposes significant numerical burden that requires very efficient modeling code and powerful computational tools. "The molecular structure and behavior of liquids are more complex than gases and solids, and even in the purest liquids, there are trace amounts of impurities that make it difficult to isolate the mechanisms behind electrical breakdown," Jadidian explained.

The next step in this research is applying these findings to challenges such as reducing the size of large medical machines such as MRIs and large power equipment such as power transformers, improving insulation materials, and identifying future potential of novel plasma treatment technologies such as industrial and medical sterilization of food, surgical equipment and even a surgeon's hands using plasmas.

The model offers great promise said Jadidian, "Another outcome of this research would be optimization of novel dielectric materials such as nanofluids that could suppress and even avoid streamer branching and consequently limit streamer acceleration and lowering the chance of electrical failure."

Original release:
http://www.eurekalert.org/pub_releases/2013-09/aiop-3mo092613.php [1]

Links:
[1] http://www.eurekalert.org/pub_releases/2013-09/aiop-3mo092613.php