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Analysis of Laser Influence on Field Enhancement and Heating of the Specimen in Pulsed Laser Atom Probe Tomography

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Atom probe tomography (APT) is a technique capable of concurrently determining three dimensional material structure and chemistry at near atomic resolution which has seen expanding use in science and engineering fields [1,2]. 3D computer reconstructions of the positions of atoms in the analyzed region of the specimen allow detailed investigation of the structure and chemistry of a specimen on the near atomic scale. APT works on the phenomenon of field evaporation, by which an electric field is used to ionize and subsequently desorb surface atoms of the specimen in an ultra high vacuum [3]. Specimens are created in a sharp needle shape to enhance the electric field around them, and cryogenically cooled to control their temperature. Traditionally the time and rate of field evaporated atoms was controlled by utilizing a pulsed voltage to a counter electrode to increase the electric field around the specimen just enough to have a single atom field evaporate. Recent advances have integrated a pulsed laser to take the place of the pulsed voltage in atom probe microscope design. The use of a pulsed laser has allowed the APT technique to expand into analysis of new types of materials that were previously not conducive to APT [4]. However, the details of how the pulsed laser interacts with the needle shaped specimen are not well understood. Here the interactions of the laser and specimen were modeled using a high-frequency structure simulator, a full-wave high-frequency 3D finite element modeler of Maxwell's equations. Special focus was given to the increase of the electric field by the incident laser pulse and to the heating of the specimen by the laser as these factors have great influence on how field evaporation takes place. Parameters of the model that were varied were specimen temperature, laser pulse energy, specimen tip radius, and specimen shank angle. Their influence on the electric field enhancement and heating of the specimen was analyzed.

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