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**Direct Observation of Cooperative Doping Mechanisms at Grain Boundaries in Ca-doped  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$**  ROBERT KLIE, Brookhaven National Laboratory, MARIA VARELA, ALBERTO FRANCESCHETTI, Oak Ridge National Laboratory, YIMEI ZHU, Brookhaven National Laboratory, SOKRATES PANTELIDES, Vanderbilt University, STEPHEN PENNYCOOK, Oak Ridge National Laboratory — Atomic-column resolved electron energy-loss spectroscopy (EELS) was used to study the effects of Ca-doping on the local atomic and electronic structure of grain boundaries in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ . Grain boundary doping with Ca has been shown to increase the grain boundary critical current, and it has been previously suggested that  $\text{Ca}^{2+}$  substitutes for  $\text{Y}^{3+}$  thus providing additional holes. We have performed atomic-column resolved EELS of the grain boundary dislocation cores and we will show that in the highly strained regions of the grain boundary plane Ca segregates to Cu and Ba sites, where it does not provide holes directly. However, due to the resulting strain relief, the oxygen deficiency in the vicinity of the grain boundary is reduced and the hole concentration increased. The results demonstrate that to improve grain boundary  $J_c$ , ionic size may be more important than the electronic nature of the impurity.

Robert Klie  
Brookhaven National Laboratory

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