Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Fabrication of suspended few-layer black phosphorus nanopores and nanoribbons via electron beam nanosculpting PAUL MASIH DAS, Department of Physics and Astronomy, University of Pennsylvania, GOPINATH DANDA, Department of Electrical and Systems Engineering, University of Pennsylvania, WILLIAM PARKIN, Department of Physics and Astronomy, University of Pennsylvania, ANDREW CUPO, NEERAV KHARCHE, Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, XI LING, SHENGXI HUANG, MILDRED DRESSELHAUS, Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, VINCENT MEUNIER, Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, MARIJA DRNDIC, Department of Physics and Astronomy, University of Pennsylvania — We present nanopores, nanoribbons, and nanogaps in suspended few-layer black phosphorus (BP) flakes that have been realized using in situ transmission electron microscope nanosculpting. Few-layer BP flakes were first produced through a liquid exfoliation procedure and suspended on holey SiN_x membranes. We investigate the structural characteristics of few-layer BP and further show the time-dependent properties of various nanostructures under exposure to an electron beam. It is shown that high-resolution structural modification of nanopores and nanoribbons can be achieved with nanometer-scale precision on timescales of a few minutes. We also used density functional theory to provide a model for the observed anisotropy in edge formation by computing energy barriers for various edge geometries.

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Date submitted: 05 Nov 2015 Electronic form version 1.4